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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION 1894–95.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXIV.

Wednesday, 21st November 1894.—Professor H. Alleyne Nicholson, F.L.S., F.G.S., retiring President, in the Chair.

The retiring President delivered the following opening address:—

Gentlemen,—Three years ago the Society did me the great honour of placing me in the Chair. I felt grave doubts at the time as to the propriety of my accepting this honour, knowing that it would not be possible for me—if from geographical causes only—to take as active a part in the work of the Society as I ought to do. I cannot say that these doubts have been removed in course of time; but I must ask you to believe that I have always taken the warmest interest in the progress and success of the Society, and that my shortcomings, however great, have largely depended upon causes beyond my control.

I had hoped on the present occasion to have laid before you something that might in some degree have justified your choice of me as President. I greatly regret to say, however, that, owing in part to a prolonged illness, and in part to the heavy pressure of official duties, I have not found it possible to select for my address to-night any subject involving protracted original investigation. Under these circumstances, I thought it best to confine my efforts to taking a general view of some subject of interest alike to geologists and biologists, and I have therefore elected to place before you my views as to the present aspect and position of the well-known doctrine of the "Permanence of the Ocean-Basins," or, to speak more correctly, of the abysses of these basins.

Even if the Science of Geology had no existence, if the structure of the earth's crust were absolutely unknown to us, nevertheless the researches of the zoologist and botanist would have convinced us that the present distribution of land and water could by no means have existed unchanged since the beginning of terrestrial history. Were it otherwise—were the present configuration of the earth's surface a matter of primordial arrangement, and immutable, then the innumerable problems connected with the distribution of animals and plants would be absolutely insoluble, unless upon the entirely unscientific hypothesis of "special creation."

Geology teaches us, however—by the amplest and clearest evidence—that the present state of things is only the last phase of a long series of mutations, which began with the first formation of the solid crust, and which are still in progress. These changes are generally admitted to be the result of differential movements of the crust, by which certain areas undergo elevation or are pushed up, while others are depressed or sink down. The primary cause of these earth-movements is to be found in the slow contraction of the globe, consequent on the loss of its internal heat by radiation; a subsidiary, but probably very active cause being the transference of material from one area to another, as the result of denudation. Roughly speaking, the elevated areas of the earth's crust are the dry lands, while the depressed areas constitute the ocean-basins.

Whatever differences of opinion may exist upon other points, there is absolute unanimity among geologists in believing that our existing dry lands have been repeatedly under the sea during the course of geological time, while parts, at any rate, of the areas now occupied by the ocean have been in the condition of dry land.

It is not necessary to discuss here whether the repeated submergences of the dry lands above referred to are the result of differential movements of elevation and depression in the earth's crust, or whether they may not be due in part to local alterations in the level of the ocean, as believed by Neumayr. The repeated occurrence of such submergences as a primary fact in geological history, is sufficiently shown by the existence in all the larger land-masses of stratified rocks containing the remains of marine animals. Such marine fossiliferous sediments, which at one time formed the floor of the sea, are found to compose the great bulk of the existing dry lands, contributing very largely to even the loftiest mountain-ranges of the present day; and the fact that they consist of series of formations of different ages, and capable of being arranged in historical sequence, is sufficient proof that the submergence has been repeated more than once.

While all geologists admit that during geological time there has been a repeated interchange of position between the dry lands and the shallow seas bordering these, scientific opinion is not yet agreed as to the extent to which the deeper portions of the oceanic depressions have participated in this interchange. The older geologists, such as Lyell, held that elevation and depression were correlative phenomena, and that the admission that the dry lands had been repeatedly submerged beneath the sea, carried with it the admission that the present oceanic areas must have been repeatedly elevated to form dry land. In this connection it may be pointed out that the above theory by no means implies that an *entire* continent must necessarily be submerged at once, or that a whole ocean-floor should be at once elevated to form dry land. On the contrary, all that we know of earth-movements would lead us to believe that such changes of position, however extensive in their final results, must always have been accomplished bit by bit.

In opposition to the old Lyellian theory, many scientific men at the present day hold the doctrine of what is termed "the permanence of the ocean-basins," a doctrine which implies a greater or less amount of stability in the position of the great continental areas. In considering this theory, it may be as well to remind you of what the present state of things is. Were the earth's surface smooth, there is enough water in the existing seas to give rise to a continuous ocean of about half a mile in depth. As a matter of fact, the terrestrial surface is uneven, some areas being nearer to the earth's centre than others, thus giving rise respectively to the ocean-basins and the continents. The dry lands cover 28 per cent. of the earth's surface, and have a mean elevation of 2250 feet above the sea-level. The ocean covers 72 per cent. of the earth's surface, and has a mean depth of 12,000 feet. Hence the elevated areas are not only of relatively small extent, but they are also of relatively small height, as compared with the area and depth of the oceanic depressions. Again, the continents and continental islands are generally margined by a broad zone of shallow water, showing that they are merely the exposed portions of great terrestrial platforms, the edges of which are covered by the sea. The true border of the proper ocean is the edge of the submarine plateaux upon which the continents stand. At the edge of this the water may be from 100 to 300 fathoms in depth, and then commences a comparatively rapid slope, which leads to the vast regions forming the floor of the deep sea. The floor of the deep sea, lastly, is not absolutely flat, but is undulated, and its depth below the surface varies from 1000 to 4600 fathoms.

Stated in its briefest form, the doctrine of the "permanence of the ocean-basins" holds that though our existing dry lands must have been repeatedly submerged below the level of the sea, such submergence was never to great depths, and was, in any given period, of an altogether partial character. It is held, therefore, that our existing continents have been built up bit by bit, by partial submergence beneath the sea at different places and at different times; but that, *on the whole,* they have retained their present places since the beginning of geological time. As a corollary to this, it is held that the existing deep seas—*i.e.*, areas now covered by water of more than 1000 fathoms in depth—have been permanent features in the physical configuration of the earth's surface, and that the abysses of the ocean-floor have not been up-raised to form dry land since the oldest fossiliferous rocks were laid down.

This doctrine is based upon a vast number of very complex data, and carries with it conclusions of the most vital import to both geologists and biologists, while it may safely be said that the time for its final solution has not yet arrived. From a merely *theoretical* point of view, it seems very unlikely that while the dry lands have been subjected to repeated movements which must in many instances have involved displacements of many thousands of feet, measured vertically, the ocean-floors should at the same time have been exempted from displacements of a contrary character. Thus, to take one example only, a large portion of the North American continent, including what are now the Rocky Mountains and Appalachians, must have been depressed during Palæozoic time to a depth of 30,000 to 40,000 feet, since it is now covered by a more or less absolutely continuous series of Palæozoic marine sediments of the above thickness (Walcott, *Amer. Geologist,* vol. xii., p. 343). But, if the old Algonkian and pre-Cambrian floor had thus sunk some five or six miles, we can hardly suppose that the foundations of the Atlantic and Pacific had during the same time been free from some corresponding movement. In fact, if we are dealing with a curved surface, such as that of a slowly cooling globe, which is gradually shrinking in such a manner as to produce tangential thrust, it is hardly conceivable that elevation and depression should not be to some extent correlative. If one area sinks, another will tend to be pushed up; though it does not follow that the two movements will be precisely similar in kind or equal in amount. It may be freely admitted that the weight of the oceanic waters would tend in general to increase the stability of the ocean-floors in comparison with the dry lands; but this consideration would not warrant the view that the floor of the deep sea had been wholly exempt from movement since Cambrian times. In fact, the theory of the permanence of the deep ocean-basins really demands that the ocean-floor of these regions should have been constantly *sinking* since Cambrian times, as otherwise there would have been nothing to neutralise the continued accumulation of deep-sea deposits.

As before said, the doctrine of the permanence of the deep oceans carries with it the *virtual* stability of the great continental platforms since Cambrian times, though it allows of a large range of vertical displacement as a local and partial phenomenon in the latter. Many arguments, both geological and biological, of more or less weight, have been brought forward in support of this doctrine, and I propose to review the more important of these as briefly as possible. Most of them may be very shortly dismissed in view of the overwhelming importance of one, which, to my mind, is absolutely vital. The argument to which I allude is, that if the floors of the deep ocean-basins of the present day had ever been raised above the level of the sea in times subsequent to the Cambrian, then we ought to find in the existing dry lands some deposits which could be fairly compared with the known deep-sea deposits of the present day, but that we do not find such. This argument is so far vital to the solution of the controversy, that though the apparent absence of deep-sea deposits in the dry lands would not conclusively prove the doctrine of the permanence of the deep ocean-basins, a single indubitable instance of the occurrence of such a deposit in the dry land would conclusively *disprove* the doctrine as one of universal application; and such instances can, I think, be offered in a number of cases.

The first argument bearing upon the question before us which I propose to notice is that of the virtual stability in position of the existing continental platforms, as implied in the doctrine that our present continents were all sketched out in pre-Cambrian times, and have merely been added to during successive marginal submergences of small depth. This view has been strongly maintained as regards North America by Dana, who regards the present exposures of Laurentian and other Archæan rocks in North America as representing the pre-Cambrian nucleus of the continent, round which the Palæozoic rocks were laid down in apparently regularly succeeding zones or belts. Similarly in the Old World it might be held that the pre-Cambrian nucleus of Europe is to be found in the ridge of Archæan rocks running from the North of Ireland through North-Western Scotland to Scandinavia, and that the present continent was in the main built up in a shallow sea lying to the south-east of this ridge, the denudation of which directly furnished the materials for the formation of the older Palæozoic deposits.

It will be observed that this view is rather one of the permanence of the *continents* during Cambrian and post-Cambrian times, than it is a theory of the permanence of the ocean-basins. Moreover, it must be borne in mind that what Dana means by "*continental permanence*" is (to use his own words) "not the absence of deep subsidences, or of deep continental waters at times—say 2000 or 3000 feet in the interior or on the borders—but the non-occurrence of oceanic depths and alternations with oceanic conditions." In other words, Dana merely asserts that there is no proof that the North American continent was at any period of post-Archæan time occupied in part or wholly by a "deep sea" in the modern hydrographer's sense of this term. Even in this limited sense, Dana's view clearly begs the question, since the discovery of Radiolarian cherts (such as have been recently found in California) would at any time destroy his hypothesis as one of universal application.

In any case, the apparently regular succession of the Palæozoic rocks in zones round Archæan nuclei is by no means necessarily to be interpreted as done by Dana. The mere fact of the presence of marked unconformities in the Palæozoic series is sufficient to prove this. Nor, again, have we any definite proof that the presently visible Archæan exposures of North America and Europe really do represent the nuclei of their respective continents. It is not, indeed, likely that they do represent such continental nuclei, for to establish this view it would be necessary to prove that they had never been deeply submerged in post-Archæan time.

We have, however, on the contrary, every reason to believe that they have been covered by many thousands of feet of marine sediments, which have now been worn away. The present exposures, in fact, are probably the result of the long-continued denudation of great mountain chains—themselves, perhaps, of comparatively recent date; and they do not necessarily indicate anything as to the form and trend of the original continents. On the other hand, judging from the numerous isolated inliers of Archæan rocks in districts remote from the main exposures, it seems probable that an Archæan platform constitutes everywhere the floor upon which the post-Archæan sediments were laid down.

If we may be permitted to speculate, it would seem probable that at the commencement of Cambrian time the European area was occupied by a shallow ocean, studded here and there with larger or smaller masses of Archæan land—the condition, in fact, being that of an archipelago. We have at present no definite evidence of the existence in the European area during Cambrian times of deep-water conditions; but it does not follow that such conditions did not exist elsewhere in regions which have not yet been thoroughly investigated, or which are concealed beneath the waters of our present oceans. Similarly, we have not at present definite evidence of the existence during Cambrian times of any large mass of continental land in either the European or the North American areas. Nevertheless, there is every reason for agreeing with Neumayr when he remarks ("*Erdgeschichte*") that the proof that continents existed in Cambrian, and even in Archæan, time is "so clear and convincing that it is hardly intelligible how anyone could have arrived at a different conclusion."

There is not, in fact, sufficient evidence at present available to compel the acceptance of the sweeping generalisation that throughout Palæozic time the ocean was more uniform in depth and temperature than it is at present, and that the land-masses were small and distributed throughout an all but universal sea. The argument which has been principally relied upon in support of this contention, is that the successive systems of the older Palæozoic rocks contain a shallow-water fauna, in which certain types of life have a remarkably wide range in space. It must be observed, however, that some of these almost cosmopolitan types, such as the Graptolites, were almost certainly pelagic organisms. Moreover, we have now distinct testimony to prove that the older Palæozoic deposits of our existing continents are *not* all of shallow-water origin, as has been generally asserted. On the contrary, we have now definite evidence that rocks which may fairly be compared with the deep-sea deposits of the present day form part of various of the older Palæozoic formations in our existing land-masses, and thus mark the occurrence of oceanic conditions during these ancient periods in the areas now occupied by our continents.

In the next place, we may consider the argument that the geological structure of our existing dry lands shows nothing to warrant a belief in anything more than local and partial submergences, to slight depths, in our present continental areas since the beginning of Cambrian time. In support of this argument, it is urged that the continents are mainly built up of marine deposits which are either of mechanical origin (sands, clays, etc.), and therefore deposited close to a coast-line, or are of organic origin (limestones), and were formed in water of moderate depth. It is also urged that the marine formations of the continents, of all ages, are associated with lacustrine, estuarine, or even terrestrial deposits, showing that the former were laid down in the vicinity of land.

Now, so far as these arguments go to prove that the mass of the existing dry land is formed of materials which have been accumulated in seas of moderate depth, they may be freely accepted, and I do not suppose that any modern geologist would dispute them. At the same time, they neither disprove the past presence of genuine deep-sea conditions in areas now occupied by our great land-masses, nor do they necessarily prove that subsidence has always been "local" or "partial," unless we are to give an exceedingly wide significance to these terms.

Take, for example, the distribution of land and sea at the time of the deposition of the Upper Jurassic Rocks, as worked out by Neumayr. It may not be asserted that the details of this distribution are in all respects accurate—in the nature of the case they cannot be so—but the data already in our possession leave little doubt as to the approximate general correctness of Neumayr's sketch of the geography of the world at this period of geological history. At this time three main masses of continental land appear to have existed. One of these—the "Nearctic" continent—represented the North America of to-day, but stretched eastwards to Greenland and Iceland. A second — the "Brazilian-Ethiopic" continent—embraced almost the whole of South America and Africa, being continuous across what is now the South Atlantic, and sending up a long north-eastern prolongation through Madagascar to become connected with Southern India. A third—the "Sind-Australian" continent —included a large tract of South-Eastern Asia, extending from Northern China through Siam and the great islands of the Indian Archipelago to New Guinea, Australia, and New Zealand. In addition to these primary land-masses, a great continental island (the "Scandinavian Island") occupied the region of Sweden, Norway, Finland, and adjoining districts; and a second (the "Turanian Island") occupied a considerable area round the Sea of Aral. Lastly, scattered islands of various sizes occupied what is now Central and Southern Europe.

Correlative with these changes in the distribution of the great land-masses, we find great differences in the distribution of the marine areas of the Upper Jurassic. The Arctic Ocean of this period was enormously extended, covering the greater part of Siberia and large portions of North-Western America, and being directly and extensively continuous with the Pacific. The deep basin of the South Atlantic had no existence, but was occupied by the central portion of the Brazilian-Ethiopic continent. Lastly, the present Mediterranean was represented by a great meridional "Central Mediterranean" (the "Tethyan Ocean" of some geologists), which stretched across the mid-Atlantic, and became continuous with the Pacific to the west, the Carribbean and Central American areas being now submerged. At the same time, the "Central Mediterranean" surrounded the archipelago of Southern and Central Europe, and sent out long arms into the heart of Asia. One of these arms passed south of the "Scandinavian Island" into the Arctic Ocean, and a second passed to the east of the "Turanian Island" into the same ocean. A third traversed India south of the region now occupied by the Himalaya mountains, and entered the Indian Ocean. Finally, a wide southern prolongation — the "Ethiopian Mediterranean"—occupied the area between the east coast of Africa and the Indo-Madagascar peninsula.

This sketch of the distribution of land and sea in Upper Jurassic times, as restored by Neumayr, exhibits to us a picture enormously different to that shown by our modern maps; and it is hard to see in what sense the changes necessary to bring about such an altered state of matters can be reasonably spoken of as "local" or "partial."

Passing from the Jurassic to the Cretaceous period, we find that in the commencement of the latter epoch the European area, at any rate, was largely in the condition of dry land, with the exception of a few areas covered by extensive brackish-water lakes. Towards the close of the Cretaceous period, however, marine conditions were again established over a large portion of Europe. Thus, at the time of the deposition of the White Chalk, or of deposits having immediate relationships with this, a great part of the European area was covered by the waters of a Mediterranean Sea, the extent of which may be approximately inferred from the present outcrops of the strata in question. Dr W. Fraser Hume, who has specially studied this problem ("The Genesis of the Chalk," *Proc. Geol. Assoc.*, vol. xiii., part 7, 1894), concludes that as from the western outcrop of the Chalk in Antrim "to its eastern exposure at Uralsk, in East Russia, is 2000 miles, and from its northern boundaries in Sweden and Scotland to its final appearance in the south of France, near Nice, is not less than 500 miles, it may fairly be presumed that the Chalk Ocean in Europe covered an area of over 500,000 square miles." He adds that this calculation "is exclusive of any similar deposits in Asia, and ignores the

Chalk observed in the United States, as in the neighbourhood of Kansas City."

I am not going to enter into the much-vexed question as to the conditions under which the White Chalk was laid down, or the probable depth of the Cretaceous Mediterranean above referred to. It is well known that some high authorities regard the Chalk as essentially and strictly a shallow-water formation, while others have maintained its deep-water origin. It seems highly probable that neither of these extreme views is correct. It is tolerably certain that in some regions the Chalk was deposited near a shore-line, while in others it was laid down in water which may fairly be called "deep," though not strictly "abyssal" in depth. Dr W. Fraser Hume, who has carried out an elaborate research into the constitution of the Chalk, with a special view to the solution of this problem (*loc. cit., supra,* and *Chemical and Micro-Mineralogical Researches on the Upper Cretaceous Zones of the South of England,* 1893), comes to the general conclusion that "such evidence as is forthcoming from faunal considerations" would point to the deposition of the Chalk in "an ocean which, if not abysmal, at least possessed depths far exceeding those of many very prominent marine areas." He points out that while we have in such regions as France and Saxony clear evidence that the Upper Cretaceous rocks are of the nature of shallow-water deposits laid down near a shore-line, in other regions, as in Russia, the Chalk is essentially calcareous, and has a thickness of sometimes over 1800 feet, thus indicating very considerable depths of water. Hence he concludes that the Cretaceous Mediterranean may, like the present sea of that name, have possessed in places depths of 1000 fathoms or more.

Another striking illustration of great changes of relative position in the dry land and sea within geologically recent times is afforded by the Nummulitic Series of the Eocene period. This series, as is well known, is essentially calcareous, and, where fully developed, consists of several thousands of feet of massive limestones of undoubted marine origin. The Nummulitic ocean not only occupied the site of the present Mediterranean, and covered the lands immediately contiguous to this, both on the north and south, but was continued through Southern Asia to India, Tibet, and China, and even extended to Japan. The vast area thus indicated is now not only largely in the condition of dry land, but is traversed by many lofty mountain ranges, such as the Alps, Pyrenees, Carpathians, Caucasus, Himalayas, Suleiman Mountains, etc. During Eocene times these ranges had no existence, and we have clear evidence that it was not till Miocene times that the Nummulitic Ocean was largely obliterated, and its sedimentary deposits elevated to form continental land, and to enter into the composition of the greatest mountain chains of Eurasia.

Now, it certainly seems to me to be somewhat of the nature of an abuse of terms to speak of the changes in the distribution of land and water just alluded to as occurring between the beginning of Upper Jurassic and the close of Eocene time, as changes of a "*local*" or "*partial*" kind, or to deal with these as if they merely concerned the "fringes" of our present continents. If it is merely meant that the crust-movements necessary to produce these changes were "local" and "partial," in the sense that they did not affect the entire terrestrial surface, and therefore were not "universal," then, doubtless, the use of these terms may be logically defended. But those who advocate the doctrine of the permanence of the ocean-basins, and to a greater or less extent of the continents also, have generally used these terms in the same sense as that in which one would employ them in speaking of the oscillations of the floor of the Temple of Jupiter Serapis, or the littoral changes of level in Scandinavia and Greenland. For my part, to take one instance only, I cannot see the propriety of speaking of the earth-movements which converted the larger part of the great Nummulitic ocean into elevated land, bearing some of the highest mountain ridges in the world, as being "local." Yet these movements took place in a period as modern as the Tertiary, and they constitute but an episode in that period.

SUPPOSED ABSENCE OF DEEP-SEA DEPOSITS IN THE DRY LAND.

We come now to what is really the crucial argument in the whole question at issue—namely, the argument that we cannot point, in the existing dry lands, to any rocks which can be compared to the known deep-sea deposits at present in course of formation; but that, on the contrary, the dry lands are essentially formed of shallow-water deposits of clearly terrigenous origin. This view has been forcibly expressed by Sir A. Geikie in the 3rd edition of his "Text-Book of Geology," from which I may quote the following passage:—

"It follows from these conditions of sedimentation that representatives of the abysmal deposits of the central oceans are not likely to be met with among the geological formations of past times. Thanks to the great work done by the 'Challenger' Expedition, we know what are the leading characters of the accumulations now forming on the deeper parts of the ocean-floor. So far as we yet know, they have no analogues among the formations of the earth's crust. They differ, indeed, so entirely from any formation which geologists have considered to be of deep-water origin, as to indicate that from early geological times the present great areas of land and sea have remained on the whole where they are, and that the land consists mainly of strata formed of terrestrial debris laid down at successive epochs in the surrounding comparatively shallow seas."

As the views expressed in the above quotation really reach the core of the whole question at issue, and as I am unable to accept them as representing our actual knowledge on the subject, I may be allowed to treat the point with a little detail. In the first place, however, let me remind you what *are* the characteristic deep-water deposits of the present day, as brought out by the researches of the officials of the "Challenger" Expedition and others. In the deepest abysses of the ocean we meet with variously coloured impalpable muds —often spoken of as "red clays"—produced by the decomposition of volcanic materials (ashes and scoriæ), and containing nodules of manganese and occasionally cosmical dust. Then, in water of somewhat less depth we find "Radiolarian Oozes," composed principally of the flinty cases of Radiolarians, and remarkably free from calcareous matter. Again, in depths still less profound, we meet with the well-known Foraminiferal Mud, known to all under the name of "Globigerina Ooze."

These are the three most characteristic deposits of the deep waters of our present oceans, and while not prepared to admit that the deep-water deposits of past geological ages must *necessarily* have been always of the same character, I am willing to take that assumption as the basis of argument, and I shall endeavour to show that we *have* in the existing dry lands deposits in all essential respects similar to these in structure and character, and, therefore, clearly similar in their origin.

There is, however, one consideration which it is most important to bear in mind as preliminary to an impartial approach to this problem. The consideration to which I allude is that true deep-sea deposits must, from the nature of the case, be formed with exceeding slowness, and that, *as a rule,* they are not likely to attain a very great thickness. As a proof of the extraordinary slowness with which deep-sea deposits are often accumulated, we may take the well-known fact that the "red clays" of the abysses of our modern oceans are often charged with the teeth of Tertiary Sharks (*Carcharodon*). As the dredge, at most, but sweeps up a few inches of the mud over which it moves, we must conclude that the total thickness of the deposits laid down, in the areas examined, in these great depths from the earlier part of Tertiary time to the present day can hardly exceed a few feet, and in later Tertiary time not more than a foot. Hence, under no circumstances, could deep-sea deposits form more than a quite insignificant element of the earth's crust, as regards extent and thickness, in comparison with the deposits of shallow water. For the same reason, a few inches of a deep-water deposit might correspond chronologically with many thousands of feet of coarse mechanical shallow-water accumulations in some other region. Moreover, unless the circumstances conducing to its preservation were exceptionally favourable, we could not expect to find a deep-sea deposit in the present dry land occupying more than a very limited area.

The above reasons render it certain that any record that we may have of the deep-sea deposits of past geological ages in our present lands must be of an extremely fragmentary description. Nevertheless, recent researches have shown that the argument in favour of the permanence of the deep ocean-basins, founded upon the supposed absence in the dry lands of any deposits comparable with the modern deep-sea muds, is not supported by the actual facts of the case. On the contrary, we know now of a considerable number of stratified deposits—varying in age from the Ordovician, or perhaps some still older period, to the late Tertiary—which may, with more or less of certainty, be regarded as of deep-water origin; and these bulk as largely in the geological series as, from their mode of formation, they could reasonably be expected to do.

For my present purpose it will be sufficient to restrict my remarks on this point principally to those deposits in the dry lands which admit of comparison with the Radiolarian ooze of the modern deep seas. The occurrence of fossil Radiolarians in late Tertiary deposits, such as the "Barbados Earth," has been known since the time of Ehrenberg. At a later period, the presence of Radiolarians in rocks of Cretaceous age was shown by Zittel (*Zeitschr. d. deutsch. Geol. Gesell.*, 1876); and Dunikowski demonstrated the existence of organisms belonging to the same group in the Lower Lias of Germany (*Denkschr. d. k. Akad. d. Wiss. Wien*, 1882). It is, however, essentially to Rüst that we owe the discovery that various jaspers, cherts, and other siliceous rocks of different geological ages are truly of the nature of fossil Radiolarian oozes. This was fully established by Rüst in his "Memoir on Jurassic Radiolarians" (*Palæontographica*, 1885); and the same observer also recognised the occurrence of similar Radiolarian deposits in rocks of Palæozoic age, though I am not aware that his researches on this subject have yet been published. The first observer, however, to actually publish to the world the discovery of Radiolarians in Palæozoic deposits was Rothpletz, who showed that in unquestionable Silurian rocks in Saxony there occurred certain cherts or "lydites" charged with the remains of Radiolarians (*Zeitschr. d. deutsch. Geol. Gesell.*, 1880). The cherts in question are associated with tuffs and diabases, the latter showing a characteristic and peculiar "spheroidal" structure. Rothpletz further pointed out that cherts of a very similar character occurred in the Ordovician series of the same region, though he was not able to demonstrate the actual presence of the tests of Radiolarians in these.

The occurrence of beds of Radiolarian chert in the Ordovician series of the southern uplands of Scotland was, I think, first noted by myself (*Trans. Edin. Geol. Soc.*, vol. vi., p. 56, 1890); and a detailed account of the forms present in these deposits was given by my friend Dr Hinde, in the same year (*Ann. and Mag. Nat. Hist.*, 1890). The Radiolarian cherts in question are most extensively developed in Lanarkshire, though they seem to be present over a large area in the south of Scotland; and the most important beds occupy a definite zone near the summit of the Glenkiln series. There are, however, other bands (as in Dobb's Linn and at Hartfell), which appear to be placed at higher horizons. As seen in Lanarkshire, the Radiolarian cherts are accompanied by red and green mudstones, which forcibly recall to our minds the red or coloured muds of modern deep-sea deposits. They are also associated with basic lavas, which show the peculiar "spheroidal" structure above referred to. Dr Hinde (*op. cit.*) points out that the Radiolarians of these ancient deposits "do not differ in any striking respect from the existing forms of the group;" and he finally concludes that "this Ordovician chert may, therefore, be fairly considered to be due to the accumulation of the tests of Radiolarians, and is thus a *pure* Radiolarian rock, equally as much as the Tertiary beds of Barbados and the Nicobar Islands, which, according to Hæckel, correspond to the recent Radiolarian ooze, and 'are certainly of deep-sea origin, having probably been deposited at depths greater than 2000 fathoms.'" In this conclusion I fully concur; and I may mention that Dr

Rüst, to whom I had sent specimens, wrote to me in reply saying that he saw no reason to doubt that the rock was a genuine Radiolarian ooze.

It may be objected here that the association of these Radiolarian cherts with beds containing Graptolites would go to show that the former cannot be of deep-water origin. Apart, however, from the fact that we know of no case in which a "pure" Radiolarian deposit has been formed in *shallow* water, it may well be contended that the association with Graptolitic beds is really an additional corroboration of the view that these Ordovician cherts are deep-water accumulations. All the facts which we know about Graptolites would lead us to believe that the normal forms of the group, at any rate, were essentially pelagic organisms. It is only upon this supposition that we can rationally explain the well-known facts as to the restriction of particular species of Graptolites to special, and often exceedingly thin zones of rock, and the extraordinarily wide diffusion of particular types of the group in beds (often of very limited thickness) at identical horizons over areas often geographically very remote. This argument is, of course, quite unaffected by the occasional occurrence of Graptolites in rocks of undoubted shallow-water origin, since pelagic organisms may be, and often are, driven into the vicinity of land by currents or winds. Apart from Graptolites, the only organisms found in the beds directly associated with the Ordovician cherts under consideration are a few minute Brachiopods and some small Crustaceans belonging to the order of the Phyllocarida; and both of these may well have inhabited deep water.

It might, in fact, be contended with considerable probability that a distinctively Graptolitiferous series, such as the "Moffat series" of the south of Scotland, or the "Stockdale series" of the north of England, is essentially a deep-water deposit—even though it were not associated with Radiolarian cherts. It is all but certain, as above said, that the majority of the Graptolites were pelagic organisms, and that their remains are therefore most likely to be found in deep-water deposits; though, under suitable circumstances, they may have been preserved in rocks of shallow-water origin. It is, also, a well-known fact that in distinctively Graptolitiferous beds very few organisms belonging to groups other than the Graptolites occur, and none of these are characteristic shallow-water types. Over and above this, we find Graptolitic beds very commonly associated with rocks which, from their lithological nature, strongly suggest a deep-water origin. I do not allude now to the Radiolarian cherts, but to such rocks as the bands of pale green mudstone associated with the "Skelgill Beds" of the north of England, the "Pale Slates," red or green in colour, of the "Browgill series" of the same area, and the grey or drab "Barren Mudstones" of the Ordovician rocks of the south of Scotland. All these are exceedingly fine-grained green, grey, or red muds, made up chiefly of decomposed volcanic material, often exhibiting stainings or dendrites of manganese, and nearly or quite unfossiliferous. The few fossils which they are known to contain are very small Brachiopods. It does not seem an unreasonable conclusion that these beds correspond with the "red clays" of modern deep seas; and this conclusion is rendered the more probable by the extraordinary persistence over large areas of even thin bands of the deposits in question. That such bands, occupying persistently a given palæontological horizon, must have been deposited with extreme slowness, hardly needs to be insisted upon; and each, though itself but a few inches thick, may represent a time equal to that required for the deposition elsewhere of hundreds of feet of coarse mechanical sediments.

That the occurrence of Radiolarian cherts in rocks of older Palæozoic age is not an isolated phenomenon is shown by the discovery of similar beds in the ancient rocks of Mullion Island in Cornwall, by Mr Howard Fox and Mr Teall (*Quart. Jour. Geol. Soc.*, vol. xlix., p. 199, 1893). These cherts are in many respects similar to the Radiolarian cherts of Lanarkshire; and though, owing to the absence of other fossils than Radiolarians, the evidence as to their age is not conclusive, there is reason to think that they are of about the same horizon as the latter, and are of Ordovician age. It is interesting to note that the Radiolarian cherts of Mullion Island, like those of Saxony and Lanarkshire, are associated with "greenstones," having a characteristic "spheroidal" structure; and Mr Teall even throws out the suggestion that this peculiar structure may perhaps be "characteristic of submarine and possibly deep-sea lavas" ("On Greenstones associated with Radiolarian Cherts," *Trans. Roy. Geol. Soc. of Cornwall*, 1894).

Barrois, again, has recently announced the discovery of Radiolarian cherts in strata of supposed pre-Cambrian age in Brittany (*Comptes Rend. Acad. Sci.*, vol. cxv., p. 326, 1892). There can, therefore, be no doubt as to the wide distribution of these deep-sea cherts in the early Palæozoic rocks of the European area; and there is the absolute certainty that, now attention has been directed to the point, further investigations will show that these peculiar deposits have in reality a much more extended range than would a few years ago have been believed. We arrive thus at the conclusion that, so far from the seas of the Ordovician period having been uniformly shallow, true deep-water conditions prevailed during some portion of this epoch, over, at any rate, an extensive area in Europe. It does not seem to me possible to evade this conclusion, except by the adoption of the wholly illogical position that the Radiolarian oozes of the existing oceans are of deep-water origin, but that, as it is believed that the dry land is wholly made up of shallow-water deposits, therefore all Radiolarian deposits occurring in the dry land—however similar to those of the present day—must, *ex hypothesi,* be also of shallow-water origin.

Leaving the Ordovician and earlier periods, Rothpletz has shown the occurrence of Radiolarians in the Silurian (*loc. cit., supra*), and Rüst has proved that characteristic Radiolarian cherts occur in the Devonian and Carboniferous rocks of Europe; while, as before said, we have ample proof of the existence of Radiolarian deposits in the Mesozoic series. It is, however, in the latter portion of the Tertiary period that we find these Radiolarian deposits most largely developed and most unequivocal in character. Such deposits occur in the Tertiaries of various parts of Southern Europe, in the north of Africa, in the Nicobar Islands, in Australia and New Zealand, and in the West Indies; while further researches will doubtless show that their occurrence is much more common than has been hitherto supposed. So far, therefore, from its being true that we have no evidence in our existing dry lands of any deposits similar to these now being laid down in the abysses of the deep sea, we have ample proof of the presence of such deposits in the Tertiary rocks, at points scattered almost all over the globe. As I said before, the only escape from this conclusion is to assert that while all the known post-Tertiary Radiolarian oozes are of *deep*-sea origin, all the Tertiary and pre-Tertiary Radiolarian oozes are shown, by the simple fact of their occurrence in the dry land, to be of *shallow*-water origin. There is, however, one case in which we have in the dry land—in the island of Barbados—an almost complete series of deposits similar to those now being laid down in our deep oceans; and I shall ask your attention more especially to this, because it has been carefully worked out by Messrs Jukes-Browne and Harrison (*Quart. Jour. Geol. Soc.*, vol. xlviii., p. 170, 1892).

These highly competent observers have shown that the basement-beds of Barbados are sandstones and limestones of Tertiary (Miocene or Pliocene) age. These beds (the so-called "Scotland formation") are *unconformably* overlaid by a series of "oceanic" or deep-water deposits (marls, chalk, etc.), which may reach a thickness of 2000 feet, and which are, in turn, *unconformably* overlaid by a coralline limestone (an elevated coral reef). The Tertiary basement beds must have been deposited in shallow water near a shore-line; and their deposition was followed by elevation of the sea-floor into dry land, the beds being flexured and fractured in the process. This probably occurred in late Tertiary time. Subsidence then set in, the basement-beds undergoing in the process much denudation, and being planed down to an approximately level surface. This subsidence must have gone on till true deep-sea conditions were established—a depth of about 2000 fathoms, at least, being reached—as is shown by the nature of the remarkable deposits which lie discordantly on the truncated edges of the "Scotland" beds. These so-called "oceanic deposits," speaking generally, consist of—

(*a*) Chalky limestones, composed of the tests of Foraminifera, and representing the "Globigerina ooze" of our modern oceans.

(*b*) Siliceous earths ("Barbados earth"), composed of the tests of Radiolarians and Diatoms, together with Sponge-spicules, associated with bands of volcanic ashes. This series—as fully admitted by Hæckel—is in all respects comparable with the "Radiolarian muds" of our modern deep seas.

(*c*) A second series of Foraminiferal limestones.

(*d*) Very finely levigated clays, coloured, mottled, or white, which represent the "red clays" of the abysses of our existing oceans.

At the close of the deposition of the "Oceanic series" just described, elevation again set in, the newly formed deposits undergoing denudation in the process. Progressive elevation of the sea-floor continued till a depth of thirty to forty fathoms was reached, when reef-building corals began to flourish, and the conditions must for a time have been sufficiently stable to allow of the formation of extensive coral-reefs. Elevation again set in, however, and the reefs were ultimately raised to a height of about 1000 feet above the present sea-level; thus forming a capping of coralline limestones, resting *unconformably* upon the "Oceanic series" to a thickness of 150 to 200 feet over about six-sevenths of the entire area of the island. This final elevation undoubtedly took place in the Pleistocene period.

The sequence of events indicated by the successive deposits of Barbados is too clear to admit of misinterpretation. Beyond reasonable doubt, the "Oceanic deposits" are a series of deep-sea muds, in all essential respects comparable with the Globigerina mud, the Radiolarian ooze, and the abyssal clays of our existing deep seas. They were probably laid down in water of at least 2000 fathoms in depth. This conclusion is not only supported by the characters of the Radiolarians, as elucidated by Hæckel, but is further borne out by the discovery by Dr J. W. Gregory, in the Radiolarian marl, of a true deep-sea Urchin, a species of *Cystechinus*, the few modern forms of this genus inhabiting water of from 1000 to 2000 fathoms in depth (*Quart. Jour. Geol. Soc.*, vol. xlv., p. 640, 1889).

Others of the West Indian Islands have been shown to contain deposits similar to those of Barbados. We are, therefore, justified in concluding that in the West Indian region we have an area which in late Tertiary times was covered by a truly "deep" sea, in the strictest sense of this term, but which has undergone elevation within Quaternary time, and is now partially in the condition of dry land.

We have thus a clear and undeniable instance of the occurrence of genuine deep-sea deposits forming a portion of our existing dry land; and this fact appears to me to be impossible of reconciliation with the doctrine of "the permanence of the ocean-basins." It is a case in which a single positive proof, even if it stood absolutely alone, outweighs any accumulation of merely negative evidence; since the essence of the theory in question is that *no* deep-sea floor has been raised above the level of the sea since the beginning of Cambrian time, and that, therefore, we *cannot* have any deep-sea deposits in any portion of our existing dry lands. It may be added, however, that, as a matter of fact, the case of Barbados does *not* stand alone. We have already evidence of a very similar sequence of phenomena in other regions (as, for example, in the Solomon Islands); and we have every reason to believe all the known Radiolarian deposits of Tertiary age mark the position of former deep seas, while we may extend this conclusion with great confidence to the Radiolarian cherts of much more ancient geological periods.

It may be added, finally, that it is quite probable that there are other rock-formations in the dry lands, apart from Radiolarian oozes, or rocks representing the abyssal clays, which are really of deep-water origin. Though the Radiolarian muds and abyssal clays are the most characteristic deep-sea deposits of the present day, it does not in the least follow that corresponding deposits must always have been laid down in the deep sea. We have, for instance, no positive ground for supposing that the abundant presence of manganese is an absolutely essential character of the waters of the deep sea; and we know, for certain, that sharks have not always existed, and that the presence of the teeth of shark-like fishes is assuredly not to be looked for as a constant feature in deep-sea muds. Thus, Neumayr has pointed out that in the Upper Jurassic series of the Alps and Carpathians there exists over large areas a white or light grey limestone associated with hornstones (? Radiolarian cherts), which contains hardly any other fossils than the so-called "Aptychi" of Ammonites; while the shells of the Ammonites themselves are, as a rule, wanting. Associated with these limestones in places are red clays richly charged with *Aptychi*. Neumayr regards the whole series as of deep-water origin, and compares the red clays with *Aptychi* to the modern red clays with *Carcharodon* teeth. He also regards as of deep-water origin a red limestone with Ammonites which occurs in the Trias and Jurassic series of the Alps, and which in places contains small nodules of manganese ("*Erdgeschichte*," p. 364). He suggests, moreover, that the red "Orthoceras limestone" of the Ordovician series of Northern Europe may likewise be of deep-water origin.

GEOLOGICAL STRUCTURE OF OCEANIC ISLANDS.

I have dealt in some detail with the assertion that no deposits analogous to the deep-sea deposits of the present day occur in the present dry lands, because I regard this as embodying the one fundamental argument which can be brought forward in favour of the doctrine of the "permanence of the ocean-basins." The few remaining arguments in favour of the same doctrine I must pass over with very scanty notice. One of the most important of these is based on the assertion that "oceanic" islands, and particularly the smaller ones which rise out of the deeper and larger oceans, are not formed of crystalline or sedimentary rocks, as they would probably be if they were the surviving peaks of a submerged continent, but that they are either volcanic in origin or are formed of coral. This argument would undoubtedly carry considerable weight, if it could be shown to be universally true; but it is far too sweeping, and is not borne out by the actual facts. Of many oceanic islands the geological structure is still unknown; and of those which have been examined by competent geologists, a fair number have been shown to have a core or nucleus of sedimentary or crystalline rocks, and thus to be fragments of larger land-masses now submerged. The archipelago of South Georgia, the Seychelles Islands, New Caledonia, and Barbados are cases in point. Of course, if it is made part of the *definition* of an "oceanic island" that it shall not contain any crystalline or sedimentary rocks, then the argument will hold good; because when you find an island otherwise complying with the necessary conditions, but departing from them in this point, then you simply assert that it is *not* an "oceanic island." It is also to be remembered in this connection, that the fact of an oceanic island being composed of volcanic materials in no way proves that it *can* not be part of an old land; it merely proves that it *may* not be so.

RELATIVE MOVEMENTS OF OCEAN-BASINS AND CONTINENTS.

Another argument in favour of the doctrine of the permanence of the ocean-basins is that the disappearance of an entire continent by sinking would not give rise to the appearance of a new continent in a neighbouring ocean, since the mean height of the existing continents is only 2250 feet, whereas the mean depth of the ocean is 12,000 feet. The basis for this argument is the assumption that "on any large scale, elevation and subsidence must nearly balance one another, and thus, in order that any area of continental magnitude should rise from the ocean-floor . . . some corresponding area must sink to a like amount" (Wallace, *Natural Science*, vol. i., Aug. 1892).

It is quite true, as insisted upon by Lapworth, that the processes which give rise to continents and ocean-basins are the same, in so far that they are parts of a *single* process. Both are primarily the result of the folding of the earth's crust under the tangential stress caused by progressive radial contraction, and the one is complementary to the other. Each continent is the arched *ridge* of a primary earth-fold, while the contiguous ocean is the complementary *trough* of the same—so that the formation of the one implies the formation of the other. But there is nevertheless—as pointed out by Suess (*Natural Science*, vol. ii., 1893)—a marked difference between the types of movement to which continents and ocean-basins respectively owe their existence. The continents are essentially the result of the ridging up of a portion of the earth's crust in a series of parallel folds. On the other hand, the ocean-basins are the result of the settling down ("sagging down" or "effondrement") of larger or smaller areas, more or less as a whole. "The descent of a considerable area, forming a large new depression, demands a certain part of the existing volume of oceanic waters for the filling of the new depth. The consequence is, the sinking of the oceanic surface all over the planet, and the *apparent step-like rising of coast-lines.* Thus is explained the apparently episodic elevation of whole continents, without any disturbance of horizontality, or the least alteration of the net of water-courses spread over the land. It is in this sense alone that a certain balance of 'elevation' and 'subsidence' might be conceded" (Suess, *op. cit., supra*). Without pursuing this argument further, it is sufficient to point out that, owing to the different nature of the movements by which continents and ocean-basins are respectively produced, we cannot assume, with Mr Wallace, that "on any large scale elevation and subsidence must nearly balance one another." If it be admitted that the ridging up of a continent is accompanied by the "sagging down" of a contiguous area, it would seem tolerably certain that the subsidence of a continent would cause the ridging up of a neighbouring ocean-basin; and we have no grounds for assuming that the two processes would exactly balance one another. On the contrary, there are strong grounds for believing that in two contiguous areas undergoing relative displacement, the amount of the folding and ridging up of the one would be much greater than the "sagging down" of the other.

In the difference in the type of movement to which continents and ocean-basins respectively owe their formation, we may, further, find an explanation of the fact that the ocean-floors are comparatively level, whereas the continents have been subjected to much fracturing and folding. This is readily intelligible on the view that the former are the result of the slow descent of larger or smaller parts of the earth's crust as a whole towards the centre, whereas the latter have been mainly produced by crumpling of the crust. Hence this fact cannot be regarded as offering any special support to the doctrine of the " permanence of the ocean-basins."

THE SIGNIFICANCE OF UNCONFORMITIES.

Another argument which has been used in support of the doctrine in question is based upon the asserted " remarkable parallelism and completeness of the series of geological formations in all the best known continents and continental islands, indicating that none of them have risen from the ocean-floor during any portion of known geological history, a conclusion enforced by the absence from any of them of that general deposit of oceanic ooze at some definite horizon, which would be at once the result and proof of any such tremendous episode in their past history" (Wallace, *Natural Science*, vol. i., p. 425, 1894). It appears to me that the first portion of the above-quoted passage involves a proposition conspicuously at variance with geological facts. So far from it being the case that the best known continents and continental islands exhibit a remarkable "completeness" of the series of geological formations, we know of no country in the world where we could find such a complete series. The "geological record" is notoriously imperfect and incomplete. Everywhere we are confronted, at one horizon or another, with gaps in the series, marked by the existence of an unconformity. Some unconformities are quite local, but others are more or less general, and each indicates a period in which a pre-existing ocean-floor was elevated to form dry land, and in which no marine sediments were laid down in that particular region. With regard to the second portion of the passage above referred to, it is enough to point out that the occurrence of a "*general* deposit of oceanic ooze at some definite horizon" in our existing dry lands is a thing which, from the nature of the case, can never be looked for, and that the absence of such a deposit therefore proves nothing. I have endeavoured to show that we *have* oceanic deposits in the dry lands, and that, if admitted, is all that is necessary.

CONCLUSION.

I feel that I owe you an apology for having taken you over ground so well-worn and so familiar. Upon the whole, I am convinced that the geological evidence at present in our hands is sufficient to negative the doctrine of "the permanence of the ocean-basins" as a general theory, and I am confident that in the progress of time this evidence will be largely augmented. As it is, I think we are fully warranted in believing that portions of what are now masses of dry land have at one time constituted parts of the floor of a deep ocean, and have been covered by water of from 1000 to 3000 fathoms in depth. We have also much evidence to show that areas now occupied by broad and deep expanses of ocean have been once in the condition of dry land. The evidence in favour of this latter proposition is largely based upon considerations drawn from the geographical distribution of animals and plants, and I have purposely refrained from entering into this branch of the subject. Not only would it have greatly lengthened this address—already unduly prolonged—but the bearings of the distribution of living beings upon the doctrine here in question have been very fully, and most ably, discussed by Dr W. T. Blanford in the Anniversary Address to the Geological Society of London for the year 1890.

There is, however, one broad consideration based on the ascertained facts of Palæontology, to which I must allude for a moment. One of the great stumbling-blocks to evolutionists has always been the presence of great gaps in the palæontological record, and the sudden appearance of large groups of animals or plants without any traces, or but slight traces, of pre-existent forms of a similar type. The *one* rational explanation of this difficulty is to be found in the supposition that the dry lands and ocean-basins have been capable of changing places at different periods of geological history. What, for example, are the two greatest biological phenomena which characterise the close of the Mesozoic and the commencement of the Kainozoic period? One of these is the apparently sudden appearance of an extensive Dicotyledonous flora in the Upper Cretaceous, and the other is the equally unheralded apparition of the numerous, large, and highly differentiated Eocene mammals in succession to the small and generalised quadrupeds of the Mesozoic epoch. These enormous biological changes did not take place simultaneously, or exactly at the same point of geological time; and we are still without any reasonable explanation of them, other than that proposed nearly a quarter of a century ago by Professor Huxley (*Anniv. Add. Geol. Soc. Lond.*, 1870), namely, that in such cases the early developmental stages of these apparently suddenly appearing groups had been passed in some lost continent now buried beneath the ocean. In the case of the Eocene mammals, Professor Huxley suggested the North Pacific as a probable region for such a lost continent. In the case of the Cretaceous Dicotyledons, it seems not improbable that a great antarctic continent may, as suggested by Blanford, have served as an ancestral home. As supporting this view, we not only have the strong evidence which has been brought forward by Dr H. O. Forbes as to the former existence of a great antarctic continent (vol. iii. of *Supplementary Papers of the Royal Geographical Society*, 1893), but we also have the combined opinion of Professors Haddon, Sollas, and Cole, that "as our knowledge grows, we the more distinctly see in Australia and its islands the ruins of a great southern continent, fractured and submerged, possibly during the great Alpine-Himalayan revolutions, and now in process of resurgence, as the vast folds of the earth's crust roll slowly inward upon the central continental mass" (*Trans. Roy. Irish Acad.*, vol. xxx., part xi.).

In conclusion, I have only to thank you once more, gentlemen, for the honour which you conferred upon me in electing me to the position of your President, a position which I now hand over to my successor. I wish also to take this opportunity of expressing my grateful sense of the friendly indulgence which I have received at your hands, and of the assistance which has been freely given to me by the officers of the Society during my term of office.

I. *Note on the Solubility of Gypsum in Solutions of Sodium Chloride.* By T. CUTHBERT DAY, F.C.S.

(Read 19th December 1894.)

It has been long known that water containing sodium chloride is capable of taking up a considerable quantity of gypsum ($SO_4Ca.2OH_2$) into solution, probably owing to a certain amount of double decomposition taking place between the two salts.

The question is one of considerable importance from a geological point of view, and a knowledge of the degree of action of solutions of sodium chloride of various strengths would aid our conception of the power of this agent in removing gypsum as it occurs in geological formations to which it has access.

I have consulted the following authorities on the subject, but the information I have been able to obtain is rather meagre:—

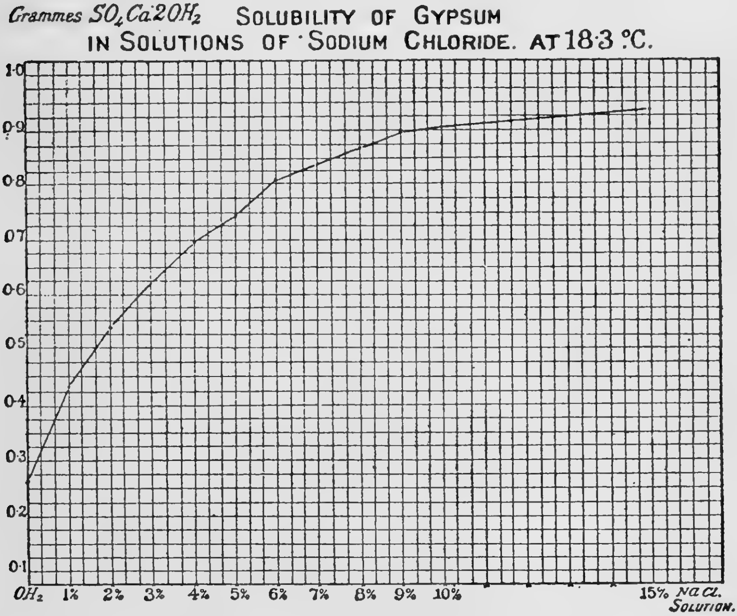
Thorpe's "Applied Chemistry," vol. i., states that "Gypsum is very slightly soluble in water, the solubility is increased by the presence of the chlorides of ammonium and sodium, hence its presence in salt springs."

Roscoe and Schorlemmer, vol. iii.: "1000 parts of water dissolve at 0° C. 2·05, at 35° C. 2·54, and at 100° C. less than 2 parts of gypsum. In presence of common salt gypsum is more readily soluble. According to Anton, 1000 parts of a saturated solution of common salt dissolve 8·2 parts of gypsum."

Watt's "Dictionary of Chemistry," vol. v., old edition:

"According to Lassaigne, 1 part of gypsum dissolves in 332 parts water at any temperature, but according to Poggiale the solubility is greatest at 35° C., 1 part of the salt dissolving, at that temperature, in 393 parts of water, at 0° C. in 488 parts, and at 100° C. in 460 parts. The solubility is increased by the presence of common salt, hence the occurrence of gypsum in salt springs."

I thought it would be of interest to supplement the above information by a few careful experiments on the solubility of gypsum in solutions of common salt of various strengths, and I now have the pleasure of laying the results before you.



The results are given in grammes of calcium sulphate ($SO_4Ca.2OH_2$) taken up by digesting with solutions of sodium chloride in distilled water of strengths varying from 1 per cent. to 10 and 15 per cent.

The method of experiment was as follows:—150 c.c. of a solution of common salt of the required strength was prepared at 15°·5 C. Two grammes of artificially prepared pure gypsum, of the composition $SO_4Ca.2OH_2$, was weighed out into a flask, and the solution of common salt poured on to it. The whole was digested for four days at a constant temperature of 18°·3 C., with occasional stirring. The solution was then filtered through a dry filter, and 100 c.c. taken at 15°·5 C. for estimation of the lime in solution. The determination was effected in the usual way by precipitation with ammonium oxalate, and the precipitate, after drying, was ignited in a platinum crucible over the blow-pipe till it ceased to lose weight, and was weighed as pure lime, CaO. The weight of lime so obtained was calculated back to calcium sulphate, $SO_4Ca.2OH_2$. The following table summarises the results obtained, which have been confirmed by duplicate experiments. I also append a curve, which shows more clearly than the figures the progressive increase in the solubility of gypsum as the solution of common salt is strengthened:—

Solubility of Gypsum ($SO_4Ca.2OH_2$) *in Solutions of Common Salt* (NaCl).

Strength of NaCl Solution.	Grammes of $SO_4Ca.2OH_2$ in 100 c.c. Solution.
1 per cent.	·4380
2 „ „	·5403
3 „ „	·6244
4 „ „	·6960
5 „ „	·7464
6 „ „	·8081
7 „ „	·8360
8 „ „	·8711
9 „ „	·8944
10 „ „	·9079
15 „ „	·9310
Pure water,	·2616

It will be observed that a solution of common salt of about the same strength as sea-water, *i.e.*, 3 per cent., increases the solubility of gypsum nearly threefold, and that above 8 per cent. the increase in the solubility is only trifling.

II. *River Temperature.* Part II. *The Temperature*[1] *of the Nile compared with that of other great Rivers.* By H. B. Guppy, M.B., F.R.S.E.

(Read 16th January 1895.)

From the considerable number of disconnected observations on the temperature of the Nile, which have been already published, it might be inferred that we ought to be well acquainted with the thermal behaviour of this famous river. Such, however, is not the case; and in fact, as far as I am aware, few if any persons have endeavoured to put the data into form. In this paper I have attempted this task, not without misgiving, as the subject is one of much complexity. A previous study of other great rivers, at length led me to hope that, by the free employment of the comparative method, I might be able to distinguish the peculiar features in the temperature of the great river of Egypt. Fortunately in this end I have been much assisted by the large number of observations to be found in the Journal of Robert Hay, which exists in manuscript in the British Museum.[2]

The first reference to the temperature of the Nile that has come under my notice is to be found in the "Pharsalia" (x. 275), when Lucan is alluding to the visit of the emissaries of Alexander to Egypt. "Nilum videre calentem," he observes, yet we are in doubt whether to attribute the epithet to poetic fancy or to the exigencies of the metre. The Nile, however, is not a warm river. In truth, when we reflect on its numerous opportunities of acquiring a high temperature, this river is remarkable for its coolness.

Amongst the earliest investigators of its temperature was M. Coutelle, a French savant, one of the many distinguished men of science who accompanied Napoleon in his Egyptian expedition between 1799 and 1801. His observations were confined to a few weeks in the summer at Philæ; but they are only incidentally mentioned in his meteorological tables given

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[1] The Fahrenheit scale is used throughout this paper.

[2] I intend to deposit in the library of the Royal Physical Society, Edinburgh, a copy of these meteorological observations as far as they are concerned with the river temperature.

in the "Description de l'Égypte." Between 1826 and 1833 Mr Robert Hay, an artist and an Egyptologist, possessed of a good fortune and abundant energy, made a large number of meteorological observations during his long sojourns on the Nile between Cairo and Abu Simbel. Those relating to the river were confined to the period between May 1830 and February 1832, and included two summers and one winter. In the first summer they were taken regularly at sunrise or at 6 A.M., and at sunset, about the best hours he could have selected for the purpose; and on this account alone they are valuable for determining the amount of the daily fluctuations. During the rest of the time they were taken at sunrise. The corresponding air observations, mostly made on the river, were recorded with astonishing perseverance five or six times a day, usually at sunrise or at 6 A.M., at noon, in the afternoon twice between 1 and 4 o'clock, at sunset, and late at night between 10 and 12. These observations are in his manuscript journal in the British Museum, and, with the exception of the entries on a few pages, they are all in pencil. Hay was at times the companion of Wilkinson, then engaged in his Egyptian researches; of Hoskins, the author of "Travels in Ethiopia"; of Linant de Bellefonds, the accomplished French engineer; and of other travellers of repute. I have found no trace of the publication of this journal, and in the most recent Egyptian bibliography of Prince Ibrahim Hilmy, it is referred to as in manuscript. The accompanying diary is apparently full of interesting matter, though more destitute of adventure than the published narrative of Belzoni, who doubtless owed many of his experiences to his poverty.

In April and December 1836 Russegger made a few observations at Terraneh and Cairo; but his most important inquiry was carried out in January 1836, when he took a series of temperatures between Cairo and Assouan. The results are given in his "Reisen in Europa, Asien, and Afrika." Somewhere about 1840 Captain Newbold made a series of over two hundred thermometric observations on the Nile water between Cairo and Thebes in June and July. They are very summarily discussed in a paper contributed by him to volume cxxxv. of the *Philosophical Transactions,* and volume xl. of the *Edinburgh New Philosophical Journal.* Notwithstanding this, the means there given form a valuable check to Hay's summer observations at Beni Hassan. Professor Chaix in December 1846, and in January and February 1847, devoted some of his attention to the river's temperature between Terraneh and Philæ; and his results were subsequently included in a paper in volume xix. of the *Journal of the Royal Geographical Society.* Dr Schnepp in January 1860, during his voyage to and fro between Cairo and Philæ, made some valuable observations, which are to be found in his book "Du Climat de l'Égypte." Between December 1878 and February 1879, Mr H. Villiers Stuart, in a voyage from Cairo to Abu Simbel and back, made a valuable set of sunrise observations on the temperature of this river, which are given in his "Nile Gleanings." His unbroken series of temperatures, both of the air (maximum and minimum) and of the water, made during his ascent from Cairo to Abu Simbel, is unique of its kind; and his January observations above the First Cataract are my check on the winter observations of Hay in that region. Then follow some interesting investigations of Dr Marcet in March 1885 between Siout and Edfou, the results of which will be found in volume xi. of the *Quarterly Journal of the Royal Meteorological Society.*[1]

With these materials at my disposal, I have been able to construct the thermal regime of the Nile in a manner sufficiently accurate for the purpose of a preliminary investigation. Profiting by a suggestion of Dr Ule in one of his papers on the temperature of the Saale, I have to a great extent avoided the disturbing influence arising from seasonal variation in different years, by making but slight use of the actual water temperatures in comparing different periods, and by mainly relying on an element largely independent of such variations, namely, the difference between the air and water temperatures. After a careful consideration of the

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[1] The air observations were in most cases made on the river. The means deduced from them correspond closely, as will be subsequently shown, with recent meteorological evidence; but for reasons given at the close of this paper, I don't think that the daily means are much affected by the river.

data at my disposal, a number of conclusions have been formed; and, for the more convenient treatment of the subject, I will here state them in the form of propositions, which on the facts before me I will then endeavour to sustain.

1. *During its course below the Second Cataract the Nile is in summer markedly cooler than the air.* This is capable of demonstration in several ways. The most obvious method lies in the comparison of the mean temperatures, such as will be found in Table I. below presented, which I have prepared from the observations of Robert Hay. Whether in the means of the individual months, or in the general mean, this striking feature of the Nile is there consistently illustrated, and we learn from its columns that in summer the Nile between the two lowest of the cataracts is on the average nearly twelve degrees cooler than the air, and about half way between the First Cataract and Cairo more than seven degrees cooler than the air.

TABLE I.

The Nile in Summer (prepared from Hay's observations).

Month.	1830.					1831.				
	Locality.	Lat. N.	Air.	Water.	W. diff.	Locality.	Lat. N.	Air.	Water.	W. diff.
May, .	Beni Hassan,	27° 53′	81·0	74·0	−7·0	Abu Simbel,	22° 20′	88·5	75 5	−13 0
June, .	,, ,,	27° 53′	84·0	75·6	−8·4	,, ,,	22° 20′	90·0	78·0	−12·0
July, .	Tel, . . .	27° 37′	86·3	78·4	−7·9	,, ,,	22° 20′	92·1	78·8	−13·3
August,	Manfalut, .	27° 23′	85 9	79 7	−6·2	,, ,,	22° 20′	91·2	82·6	−8·6
		Mean	84·3	76·9	−7·4		Mean	90·4	78·7	−11·7

Although the indications in this table are sufficiently clear, it might with justice be asked whether the data afforded by other observers similarly demonstrate the great coolness of the river in summer in comparison with the air. It will be enough for the present to refer to the observations of the river temperature. Captain Newbold found the mean temperature of the Nile for July (1840 ?) between Cairo and Thebes to be 79°·5. This is near the mean for July, namely 78°·4, obtained from Hay's observations in the vicinity of Tel, about half way between these two localities. As regards the temperature of the Nile in July between Cairo and Thebes, these two observers may be therefore considered as in accord with each other. This is a matter of some importance, since meteorologists are already acquainted with the average conditions of the air temperature in this region, and the point to be established is the average temperature of the Nile. In support of the estimates for the river afforded by the observations of Mr Hay above the First Cataract, we look for the agreement of the observations of M. Coutelle. This meteorologist remarks that during his sojourn on the Isle of Philæ (latitude 24°), the temperature of the Nile in the afternoon was 83°·7. Corrected for the daily range, this estimate falls to about 82°·7. Unfortunately no date is mentioned, but we are informed that at the same time the air in the shade was constantly 107°·4–109°·6, thermometric conditions characteristic of July or August, and indicative of a mean daily temperature of not under 90°. Taken as they stand, these observations give general support to those of Mr Hay at Abu Simbel.

Another mode of demonstrating the summer coolness of the Nile in relation to the air is to be found in the comparison of the observations made at or about sunrise, a method that is free from some of the difficulties connected with the estimation of the daily means. Given the difference between the air and water temperatures at sunrise, and postulating the relatively large daily rise of the air temperature, and the correspondingly limited daily rise of the water temperature, we can, by the aid of these two daily observations only, approximately determine the relation in the day's mean between the air and water temperatures. For example, I will assume that a certain river during the month of June has on the average about the same temperature as the air at sunrise. We have no further data of our own; but we learn from the meteorologist that the average daily rise of the air temperature for this region in June is about twenty degrees, and we are informed by those who have specially studied the temperature of rivers, that the average daily rise of the water temperature could not under these circumstances be more than two or three degrees. Here it is at once evident that the river, as indicated in the day's means, must be some eight or nine degrees cooler than the air. My example, however, is not an imaginary one, it is that of the Nile in June at Beni Hassan as given in Table I.; and in the columns of the same table, it will be observed that the difference of the air and water means, estimated from about six daily observations for the air and two for the water, is 8°·4. All the elements for determining approximately the relative positions of the air and water temperatures by means of the sunrise observations will be found in Table XV. To enlarge on the subject here would be to open up the complicated matter of the daily range, which can only be very cursorily treated in this paper.

The relative coolness of the river to the air in summer being proved alike by the comparison of the daily means and of the sunrise observations, I pass on to consider yet a third plan, by which this characteristic feature of the river can be established. In this method I make use of the isothermal charts, placed at our disposal through the labours of Dove, Mohn, Buchan, and others. Laying aside for a time the air observations, and relying only on those of the river, I appeal to the meteorologist. The chart for July, as constructed by Buchan, will answer the purpose. According to Hay's observations at Abu Simbel, in latitude 22° 20′, during July 1831, the mean temperature of the Nile for that month was 78°·8, and of the air 92°·1. Now the isotherm of 95° for July is drawn across the Nile in about latitude 23°. From this it follows that I have not exaggerated the relative coolness of this river, with respect to the air, in a locality that possesses the highest mean monthly temperature on the globe. Within the borders of the tropics, the Nile is, in July, about thirteen degrees cooler than the air, as indicated by the observations of Hay, and about sixteen degrees as implied by the isothermal chart. Descending the river to the locality between Tel and Beni Hassan, latitude 27° 37′–27° 53′, we learn from the data supplied by Hay, that the mean temperature of the Nile for July 1830 was 78°·4, and of the air 86°·3. The Nile is crossed by the isotherm of 85° for July in about latitude 28° 30′, and allowing for the small difference in the latitude, the air mean deduced from Hay's observations practically corresponds with the isotherm. Whether indicated, therefore, by the isothermal line or by the accompanying air observations, the Nile during July, in the vicinity of Beni Hassan and Tel, is about eight degrees cooler than the air. Farther down still, opposite Cairo, in latitude 30° 3′, we may, following Newbold, place the mean temperature of the Nile in July at 79°. Judging from the position of Cairo, between the isothermal lines of 80° and 85°, the mean temperature of the air for July in this locality is about 83°. The mean temperature accepted for July at Cairo is, however, 85°; but whichever estimate is most correct, we shall not be far wrong in assuming that the Nile at Cairo in July is from four to six degrees cooler than the air. The isotherm of 80° for July crosses the mouths of the river in latitude 31° 30′. The water temperature there would probably be much the same as at Cairo, so that at the mouths the water would only be a degree cooler than the air, or perhaps there would be no difference at all.

These various considerations have led me to the second proposition :—

2. *The coolness of the Nile in summer, in comparison with the air, diminishes as the river flows north.* This feature in the thermal economy of this river has been already indicated in several ways. It is clearly brought out in Table I., whether we take the individual months or the means for the two summers. We there see that whilst for this season the Nile at Abu Simbel, in latitude 22° 20′, was on the average 11°·7 cooler than the air, this difference was reduced to 7°·4 about five degrees of latitude farther north. It is also exemplified in Table XV., and there receives independent support from the comparison of the sunrise observations. Tested by the isothermal lines, it is placed beyond reasonable doubt; and it has been above shown in the case of July by the evidence of the isotherms, as well as by that of the air observations of Hay, that the difference of from thirteen to sixteen degrees at Abu Simbel, in latitude 22° 20′, is reduced to eight degrees at Tel, in latitude 27° 37′, to some five degrees at Cairo, in latitude 30° 3′, and nearly disappears altogether at the mouths.

The following Table for July will serve to summarise the results for this month, and will also introduce the third conclusion.

TABLE II.

General Results for the Nile in July.

Locality.	Lat. N.	Air.		Water.	Relative coolness of the Nile.
		Isotherm.	Observation.		
Abu Simbel, .	22° 20′	95·0	92·1	78·8	Thirteen to sixteen degrees.
Tel, . .	27° 37′	86·5	86·3	78·4	About eight degrees.
Cairo, . .	30° 3′	83·0	85·0	79·0	Four to six degrees.
At the mouths,	31° 30′	80·0	...	79·0	One degree or less.

3. *The diminution in the summer coolness of the river in relation to the air, as the Nile descends from the Second Cataract to the Mediterranean, is almost entirely due to the fall in the air temperature.* The air and water temperatures do not in fact change together, the former altering considerably, and the latter to a much less extent. This feature is brought out in Table I., where we note that the reduction in the relative summer coolness of the river from 11°·7 in latitude 22° 20′ to 7°·4 in a locality about five degrees of latitude farther north, is due principally to the drop of the air temperature, the air cooling more than six degrees, and the river barely two degrees. We are of course here comparing seasons of different years, and it is probable that some portion of the slight cooling here exhibited by the Nile is due to seasonal variation higher up the river. We know from the isothermal lines that this drop in the air temperature is characteristic of this region, but we have no such guide for the Nile. Therefore, in order to obtain a less obstructed view of the matter, I have devoted Table II. to the results for a single month, namely July.

In its columns we can follow the Nile in its course northward during July from the Second Cataract to the Mediterranean. During our imaginary descent we traverse more than nine degrees of latitude, and the temperature of the air drops from 95° to 80°. We look to the river for some response to these great changes in the atmospheric conditions, but we get no reply. Its temperature has varied only one or two degrees between Abu Simbel and Damietta, and we are brought face to face with an enigma that might have been offered by the Sphinx.

4. *The Nile, in summer, is therefore cooler than the air in nearly the whole of its course.* This follows from the fact that its relative coolness, which is very small at the mouth, perhaps not one degree, increases as we ascend the river to the Second Cataract, down which it flows, during the months of May, June, and July, at a temperature between twelve and sixteen degrees cooler than the air.

5. *The Nile, between the First and Second Cataract, is in the middle of winter still cooler than the air; but the difference between the air and water temperatures is much less than in summer, and disappears altogether as the river proceeds north, so that between Assouan and Minieh the water is nearly two degrees warmer than the air, an excess that is further increased at Cairo.* This conclusion is based on the general results of a number of observations made in January by Hay, Russegger, Chaix, Schnepp, and Villiers Stuart, which will be found in Table III. In Table IV. I have subjected these observations to a more detailed analysis, in order to determine the locality of the crossing of the air and water temperatures; and it will be noticed that the locality varies somewhat, a result that might have been expected from observations made in different years. Thus, from the data obtained by Schnepp in 1860, it may be inferred that the crossing occurred between Assouan and Thebes; and from those of Hay in 1832, and Russegger in 1837, we should be justified in placing its locality in the vicinity of Thebes; whilst those of Chaix, in 1847, indicate its having taken place above the First Cataract. According to the observations of Villiers Stuart in the latter part of December and the early part of January 1878-79, the temperatures crossed in the neighbourhood of Kalabshi. The locality of the crossing of the air and river temperatures would, therefore, appear from these observations to vary in January between 23° 30′ and 25° 30′ N. lat. From year to year the climatic

conditions in this region would naturally vary a little. Chaix, Schnepp, and Russegger, for instance, found the air in January to be warmer between Assouan and Thebes than between Thebes and Cairo. Villiers Stuart, on the other hand, found the air cooler above Thebes than below it.

The observations of Mr Villiers Stuart are not only valuable from the indications they afford, but also as an example of how much may be done with little trouble. It will be noticed in the analysis I have made of his observations in Table V., that during the first part of his ascent the air and water temperatures did not vary much; whilst farther up the river they both dropped considerably, the water temperature falling the most. On looking at his daily register, it appears that between Cairo and Esneh the river temperature at sunrise was always 66°, and that between Esneh and Korosko it fell steadily to 58°, and there remained, during the remainder of his ascent for the next four days, until Abu Simbel was reached. This was accompanied by a fall of the air temperature much less in extent, namely, from 65° to 60°, the two temperatures having crossed in the interval.

The altered relation of the air and water temperatures in winter will be also clearly indicated by the comparison of the sunrise observations given in Table XV. Unfortunately, the isothermal chart of Buchan for January does not lend itself to our aid here, there being some discrepancy between the data employed and the course given to the isotherm of 60° in the vicinity of Cairo. The mean temperature for January at Cairo between 1868 and 1881 was 54°·2, and I will take this as my datum for the next conclusion.

TABLE III.

Table of General Results for January in the Nile.

Locality.	Lat N. approximate.	Air.	Water.	W. diff.
Between the First and Second Cataracts, ...	22°–24°	64·3	61·6	−2·7
Between Assouan and Minieh,	24°–28°	58·7	60·6	+1·9
Cairo, ...	30°	54·2	60·0	+5·8

Note.—The Cairo results are only approximate.

TABLE IV.

Analysis of Various Observations to Illustrate the Crossing of the Air and Water Temperatures in Winter in the Lower Nile.

Locality.		January.					Dec.–Jan.	Feb.
		Chaix.	Schnepp	Russegger.	Hay.	Mean.	Stuart.	Stuart.
Cairo to Thebes.	Air,	55·0	56·1	54·5	......	55·2	65·7	63·4
	Water,	59·9	60·0	57·9	......	59·3	66·5	64·6
	W.diff.	+4·9	+3·9	+3·4	......	+4·1	+0·8	+1·2
Thebes to Assouan,	Air,	57·4	61·5	65·3	61·6	61·5	62·7	......
	Water,	60·3	61·9	63·5	60·6	61·6	65·0	......
	W.diff.	+2·9	+0·4	−1·8	−1·0	+0·1	+2·3	......
				Philæ to Kardaseh,	Air, 66·1	Kalabshi to Abu Simbel.	Air, 60·6	
					Water, 62·1		Water, 59·4	
					W.diff. −4·0		W.diff. −1·2	

TABLE V.

Analysis of the Observations made by Mr Villiers Stuart during his Ascent of the Nile from Cairo to Abu Simbel, December 6, 1878, *to January* 10, 1879.

Month.	Locality.	Air Means.			Water Mean.	Difference of the Water Mean from the Air Mean.	Mean excess of the Water Temp. at Sunrise.
		Min.	Max.	Mean.			
Dec. 6–13	Cairo to Beni Hassan, .	57·8	74·6	66·2	66·5	+0·3	8·2
,, 14–22	Beni Hassan to Keneh, .	56·4	74·0	65·2	66·5	+1·3	9·6
,, 23–31	Keneh to Kardaseh, .	53·8	71·1	62·4	64·6	+2·2	10·3
Jan. 1–10	Kalabshi to Abu Simbel,	54·3	67·0	60·6	59·4	−1·2	4·7

Note.—The air mean is the mean of the minimum and maximum observations. The water mean is the mean of the sunrise observations, plus half a degree to allow for the daily range, as indicated by the data of Hay, Marcet, and others. The last column is intended to serve as a check. Knowing the daily air range, and the difference between the air and water at sunrise, we can at once roughly determine the relative position of the air and water means.

6. *The approximation and subsequent crossing of the air and river temperatures in mid-winter below the First Cataract is due mainly to the fall of the air temperature.* During the descent of the Nile in January from Abu Simbel to Cairo, between the 22nd and 30th parallels of north latitude, the temperature of the air drops at least ten degrees, 64° to 54°, whilst that of the water only varies one or two degrees, 60° to 62°. This is shown in the columns of Table III.; and we now perceive that in winter, as in summer, when we follow the Nile from the Second Cataract to Cairo, the air and water temperatures do not change together, and that in both seasons, whilst the air cools considerably, the water varies but little in its temperature.

7. It follows from all that has been previously remarked, as well as from the data for the spring and autumn to be found in Tables XII. and XIII., that between the First and Second Cataracts the Nile is cooler than the air all through the year, the difference being as much as thirteen degrees or more in the middle of summer, as in July, and reduced to as little as two or three degrees in the middle of winter, as in January. Lower down the river, between Assouan and Minieh, the relative coolness in summer with respect to the air is less marked, but is still eight degrees in June and July; whilst in mid-winter, as in January, the river becomes nearly two degrees warmer than the air. At Cairo, or in its vicinity, the summer coolness, though again diminished, is still five or six degrees in July; while in January the Nile is some five or six degrees warmer than the air. With this general conclusion attention is directed to the diagram of the curves of the air and water temperatures for the Nile.

8. *Most of the striking features in the thermal economy of the Nile below the Second Cataract are also brought out in the comparison of the annual mean temperatures of the air and water given in Table VI.* Whilst between the Second and First Cataract (22°–24° lat.) the river is more than seven degrees cooler than the air, between Assouan and Minieh (24°–28° lat.) the difference is less than three degrees, and at Cairo (30° lat.) the river and the air possess about the same temperature. Between the Second Cataract and Cairo the

variation of the river temperature is less than two degrees, whilst the air temperature falls about nine degrees between these two localities. On referring to Buchan's isothermal chart of the mean annual temperature of the globe, it will be observed that the same conclusions could be formed by employing the isothermal lines. The isotherm of 80° crosses the Nile between the First and Second Cataract in about latitude 23° 30′, a region for which the air observations I have used give a yearly mean of 80°·2. That of 75° is drawn across the Nile in about latitude 27°, between Assouan and Minieh, a region for which the air mean deduced from my data comes out as 74°·5.

TABLE VI.

Comparison of Mean Annual Temperatures of the Nile.

Locality.	Lat.	Isotherm.	Air.	Water.	W. diff.
Between Second and First Cataracts,	22°–24°	Lat. of isotherm of 80° = 23° 30′	80·2	72·9	−7·3
Between Assouan and Minieh,	24°–28°	,, ,, 75° = 27°	74·5	71·6	−2·9
Cairo,	30°	,, ,, 70° = 31°	71·2	71·0	−0·2

Note.—The mean annual temperature of the air at Cairo, in accordance with which Buchan has drawn his isotherm of 70°, is 71·2; and from the little variation displayed in the monthly means of the Nile in January and July in the lower course of the river (Tables II. and III.), the year's mean for the river at Cairo may be placed at 71°.

9. *During the four seasons of the year there is no great contrast in temperature between the water of the Nile and the surface-waters of the Mediterranean.* In the accompanying table I have endeavoured to illustrate this. The data for the Mediterranean are taken from the Admiralty Chart of Surface-Temperatures, published in 1885 as one of the sheets of the Wind and Current Charts of the Atlantic, Indian, and Pacific Oceans. In framing the temperatures for the Nile, I have been not only guided by the scattered data given in Table XII*a*.; but as it is evident that the Nile on the average varies but little in its lower course, I have had

regard to the general behaviour of the river between Cairo and Thebes. In February and August, as is shown in Table VII., the temperature of the Nile at its mouths is near that of the surface of the Mediterranean. In May the Nile would be about five degrees warmer, and in November about five degrees cooler. As far as the temperature is concerned, there appears, therefore, to be but little bar to the migration of animals between the river and the sea.

TABLE VII.

Comparison of the Temperature of the Nile at its Mouths with that of the Surface-Water of the Mediterranean.

Locality.	February.	May.	August	November.
Mouths of the Nile, .	62	72	79	66
Mediterranean, . .	62	67	78	71
Nile difference, . .	0	+5	+1	−5

10. *The Nile possesses a thermal regime peculiarly its own, and strikingly different from those of other great rivers, such as the Amazon, the Congo, and the Mississippi.*[1] A comparison of the Nile with other great rivers of the globe will not only give prominence to the distinctive features of its thermal regime, but will also indicate the road we must follow to arrive at some explanation. But it will be at first necessary to consider how small rivers differ from large rivers in these matters. It has been abundantly proved, and especially by Forster in his "Memoir on the Rivers of Central Europe," that rivers of ordinary size in these latitudes, when freed from the controlling influences of their sources in mountain

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[1] It is, however, probable that the Yangtse and the Brahmaputra, when more fully investigated, will be found to resemble the Nile in some points. According to the data supplied by Captain Blakiston, the Upper Yangtse is nearly four degrees cooler than the air; and I have shown in the first part of this paper that the Brahmaputra issues from the Himalayas at a temperature which is in September quite thirteen degrees cooler than the air.

regions or in lakes, possess a temperature which, as represented by the curves of the monthly means, is usually warmer than the air all through the year. This is true of such rivers as the Thames, the Seine, and the Marne, which are from three to five degrees warmer than the air in summer, and from one to three in winter. Rivers of this size, possessing no great bulk of water, soon attain a stable temperature, depending mainly on the climatic conditions of the district traversed. Change of latitude can but slightly affect the mutual relation of the air and water temperatures in a river that, by reason of its small size, so soon responds to changes in the surrounding atmospheric conditions. The great rivers of the earth, such as the Amazon, the Congo, the Mississippi, and the Nile, have, on the other hand, no consistent thermal behaviour, except such as depends on similarity in the direction of their flow; and in their case the difference of flowing with the latitude and with the longitude, or between a course from high to low and low to high latitudes, is strikingly illustrated. As I hope sometime to deal at length with each of these large rivers, I will here treat briefly of each of them, and in the first place I will take the Amazon.

During his descent of the Amazon from the junction of the Huallaga to the mouth of the Madeira, between September 1851 and February 1852, Lieutenant Herndon made a number of observations on the air and water temperatures, which are given in the narrative of his travels. During the whole descent of some 1400 miles, amounting in fact to about two-thirds of the river's navigable course, the water temperature only varied between 79° and 83°, or four degrees. The results, however, are not worked up by the author in his book; and after some labour I have prepared the following table, from which we learn that the water was always a few degrees warmer than the air, the mean excess being a little over three degrees. This is close to the estimate obtained by Maury from the same observations. In an introductory note to Lieutenant Marr's report on the Mississippi at Memphis, he remarks as follows:—"The Amazon, according to Lieutenant Herndon's descent in 1852, has a mean temperature about 2°·5 F. warmer than the air. This river runs east, consequently throughout its course the climate is nearly the same."

TABLE VIII.

Temperature of the Amazon (prepared from Lieutenant Herndon's observations).

Month.	Locality.	Air at 9 A.M.	Water.	Water Excess.
Sept. 1851.	From the Huallaga to the Ucayali, . . .	78·5	80·5	2·0
Nov. ,,	From the Ucayali to Tabatinga, . . .	77·5	81·5	4·0
Dec. ,,	Between Tabatinga and the Purus, . . .	79·2	81·5	2·3
Jan. 1852.	From the Purus to the Rio Negro, . . .	78·5	82·0	3·5
Feb. ,,	From the Rio Negro to the Madeira, . . .	77·8	82 0	4·2
		78·3	81·5	3·2

I now turn to another great tropical river that ought, in a similar manner, to reflect the influence of running with the latitude, though here it flows west. This is the Congo. Dr A. von Danckelman, whilst engaged in making meteorological observations at Vivi between the summers of 1882 and 1883, took from one to three temperatures of the river each month, all of which are considerably higher than the air means for their respective months. The results as employed by me are here appended; and although the river observations are very limited, their possible deviation from the mean of each month is small, since the extreme variation of all the water temperatures taken in the twelve months was barely eight degrees. We perceive, on referring to the chart of the curves, that the Congo, in its relation to the air temperature, behaves very similarly to the Amazon, and maintains a higher temperature than the air throughout the year. Both rivers illustrate in the same manner the effect of flowing with the latitude.

TABLE IX.[1]

Temperature of the Congo at Vivi (prepared from the observations of Dr A. Von Danckelman).

Date.	Air.	Water	W. Excess.	Date.	Air.	Water	W. Excess.
June 1882,	73·2	81·1	7·9	January 1883,	78·4	82·8	4·4
July ,,	69·3	78·8	9·5	February ,,	79·0	82·2	3·2
August ,,	70·5	76·3	5·8	March ,,	79·2	83·7	4·5
September ,,	75·2	77·7	2·5	April ,,	78·6	84·0	5·4
October ,,	77·4	82·0	4·6	May ,,	78·3	83·7	5·4
November ,,	78·6	83·4	4·8	August ,,	...	80·2	...
December ,,	77·9	81·7	3·8				

From the Congo I pass to the Mississippi, which will be regarded here mainly from the contrast it presents to the Nile. A glance at the chart of the curves will be sufficient to show how remarkably the type of its thermal regime diverges from that of a river like the Congo, and, I may here add, from that of the Amazon. On account of the chilling influence of the waters from the colder and more elevated regions of the north, the temperature of the Mississippi at New Orleans is lower than that of the air during eight months of the twelve; and it is only in the latter part of the summer and in the first part of the autumn (August to November in 1851, and July to October in 1852) that the river gains the ascendancy. At Memphis, five degrees farther north, the river temperature exceeds that of the air between June and November; and it is only during about five months, from January to May, that the cool waters from more northern latitudes give to the Mississippi a temperature lower than that of the air.

In the curves of the Nile we find no analogy to those of

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[1] In his ascent from the mouth of the Congo to a little above the Yellala Falls, during July and August 1816, Captain Tuckey found that the temperature of the river varied between 75° and 78°. The mean temperature of the river at noon in the neighbourhood of Boma during July 20-31 was 76°·1, and 76°·7 in the vicinity of Vivi and the Yellala Falls during August 1-20.

In the middle of September 1863 the temperature of the river about Vivi and the Yellala Falls varied, according to Captain Burton, between 75° and 79°.

either the Congo or the Mississippi. Here we notice that between the First and Second Cataracts the river is cooler than the air all through the year, the difference being great in summer and small in winter. Lower down, between Assouan and Minieh, the Nile is cooler than the air during two-thirds of the year, but in the winter period, from December to March, it becomes warmer than the air.

11. When specially contrasted with the Mississippi at New Orleans, the Lower Nile differs from it in the following points:—

(*a*) *In the relation of the curves of the air and water temperatures, as just described, and as illustrated in the table of curves.* They not only differ in this respect conspicuously from each other, but both depart widely from the prevailing type presented by a river under the control of the climatic conditions of the regions traversed. Such a river, whether it be the Congo or the Thames, is warmer than the air all through the year.

(*b*) *Whilst, as shown in Table X., the Nile, judged by its monthly mean temperatures, has a range of temperature much less than that of the air, the range for the Mississippi is considerably greater than for the air.* On looking more closely into this matter, it will be observed that the Mississippi extends its range beyond the limits of the air in winter, whilst the Nile contracts its range considerably within that of the air in summer; and that the Mississippi behaves like other rivers only in the warmer part of the year, whilst the Nile resembles other rivers only in winter. I refer of course to the water temperature rising above the air in those seasons in the case of most rivers.

(*c*) *The Nile is true to the climatic conditions of its latitude only in winter, and the Mississippi only in summer. The influence of the higher courses is displayed, in fact, in contrary seasons, the Nile being under their control in summer and the Mississippi in winter.*

(*d*) *According to the annual mean temperatures (see Table X.), the Nile is some seven or eight degrees warmer than the Mississippi at New Orleans.*

(*e*) As indicated also in the mean temperatures for the year, the coolness of the Nile with respect to the air is characteristic only of its higher courses, and gradually lessens as we descend the river, until it disappears at Cairo. The coolness of the Mississippi is most developed near its mouths, as at New Orleans, and disappears as we ascend the river and arrive at Memphis.

(*f*) *The Nile during any part of its course below the Second Cataract does not acquire the summer temperature of the Mississippi.* This contrast is well brought out in Table X.

TABLE X.

Comparison of the Annual Mean Temperatures and of the Ranges of the Monthly Mean Temperatures of the Nile and the Mississippi.

Locality.	Lat. N.	Year's Mean.			Range of Monthly Means.					
					Air.			Water.		
		Air.	Water.	W. diff.	Min.	Max.	Range.	Min.	Max.	Range.
Mississippi at New Orleans in 1851,	30°	67·6	63·9	− 3·7	45·8	82·8	37·0	40·8	83·4	42·6
Mississippi at New Orleans in 1852,	30°	69·8	64·3	− 5·5	52·2	81·8	29·6	42·5	85·0	42·5
Mississippi at New Orleans, mean, .	30°	68·7	64·1	− 4·6	49·0	82·3	33·3	41·6	84·2	42·6
Mississippi at Memphis in 1850, .	35° 9′	60·4	60·9	+ 0·5	42·1	81·1	39·0	39·3	84·7	45·4
Nile at Cairo, . .	30° 3′	71·2	71·0	− 0·2	54·2	85·0	30·8	60·0	79·5	19·5
Nile between Minieh and Assouan, .	28°6′-24°6′	74·5	71·6	− 2·9	58·7	86·3	27·6	60·6	79·7	19·1
Nile between First and Second Cataracts, ...	24°–22°	80·2	72·9	− 7·3	64·3	92·1	27·8	61·6	82·6	21·0

Note.—Captain Humphreys and Lieutenant Abbot are my authorities for the Mississippi at New Orleans, and Lieutenant Marr for the same river at Memphis. The highest monthly mean for the river at New Orleans in 1846 was, according to Professor Riddell, 83°·7; whilst Dr Drake places the lowest in 1843, off the same city, at 41°. Dr Dowler placed the extreme range of the temperature of the river at New Orleans, in the course of the year, at from scarcely 40° to nearly 86°.

(*g*) *Whilst, as before shown, the difference in temperature between the Nile and the surface of the Mediterranean can never be great, it is far otherwise in the case of the Mississippi and the Gulf of Mexico.* Observations made by Dr Drake in

1843, indicate that in February and March the river-water flows through the Passes into the Gulf at the temperature it possesses opposite New Orleans. On 24th February, the temperature of the river-water in the South-West Pass was 42°·5, which is about the mean temperature for February of the river at New Orleans; the Gulf-water, a few miles out, was 56°·5, or fourteen degrees warmer. On 1st March the river temperature in the North-East Pass, off Balize, was 42°·5, which was also the temperature of the river four days later at Fort Jackson, thirty miles above. Assuming that the river does not change much in temperature between New Orleans and the Gulf, I have arranged the following table:—

TABLE XI.

Comparison of the Temperature of the Mississippi at its Mouths with that of the Surface-Water of the Gulf of Mexico.

Locality.	February.	May.	August.	November.
Mouths of the Mississippi, .	43·0	66·5	84·0	60·5
Gulf of Mexico, . . .	70·0	78·0	83·5	72·0
Mississippi difference, .	−27·0	−11·5	+0·5	−11·5

The data in this table relating to the Gulf of Mexico refer to the northern third of the Gulf, and have been taken from the same Admiralty chart of surface-temperatures that was employed in comparing the Mediterranean and the Nile. We here notice that the waters of the Mississippi are very much colder than the surface-waters of the Gulf in winter, considerably colder in the spring and autumn, and about the same temperature in summer. As far as temperature is concerned, during the greater part of the year there could be but little interchange between the faunas of the Mississippi and the Gulf of Mexico; and from the circumstance of such an interchange being confined to the summer, it may be inferred that the migration from one region to another cannot be on an extensive scale. The Mississippi during recent geological times has thus presented a great contrast to the Nile; the similarity in thermal conditions will have always assisted migration between the Nile and the Mediterranean; the very reverse has been the case as regards the Mississippi and the Gulf of Mexico.

12. *The Nile exhibits an unusually large daily range of temperature.* This matter can be only touched on here; but I may remark that very valuable materials for its study have been afforded to me by Mr Hay's extensive series of sunrise and sunset observations, the results of which will be found in Table XV. It will be there seen that in summer, between Beni Hassan and Siout, the daily rise in summer is on the average from two to three degrees. In winter, according to the observations of Dr Schnepp in January, between Girgeh and Assouan, it is reduced to 1°·1; and in the spring, in about the same locality, it is shown by Dr Marcet in March to be 1°·6. When we turn to other large rivers, we find that as a rule they display but slight change in the day and night. According to Dr Dowler, in the Mississippi at New Orleans there is scarcely any variation in temperature during the whole twenty-four hours, and he shows, in a few observations made in June, that it did not then exceed half a degree. The Niger below the confluence, according to the observations of Dr Baikie, has an average daily rise in August of about one degree; and the Senegal, in August also, has, as indicated in the observations of Captain Borius, a similar range. From the data obtained by Mr Wallace, the Rio Negro, the large tributary of the Amazon, exhibited an average daily rise in September of 1°·3. The Brahmaputra at Sadiyá possesses, according to Dr Griffith, an average daily rise in September of 1°·5. Probably enough, the unusually large diurnal oscillations of the Nile's temperature are to some extent connected with those agencies that produce the great daily range of the temperature of the air. But it is very remarkable that, like the Brahmaputra (see Part I., p. 305), the Nile, when far below the temperature of the air in summer, exhibits the usual daily rise and nocturnal fall, although it is colder than the air during the whole twenty-four hours. This matter will be dealt with in a subsequent paper.

13. *The Nile attains its highest temperature in August, and its lowest in January, usually in the latter part of those*

months. The highest reading obtained by Hay at Manfalut below the First Cataract, in 1830, was 82°; the highest at Abu Simbel, in 1831, was 84°. Coutelle observed temperatures of 83°·7 at Philæ. The lowest temperatures recorded by Hay, Schnepp, Russegger, and Chaix, during January, between Assouan and Minieh, varied from 54° to 58°·5; and between the First and Second Cataracts, Hay in this month obtained a minimum reading of 60°, and Villiers Stuart one of 58°.

14. *The river, no doubt, has an important influence on the temperature of the air over it during some hours of the day.* In Part I., p. 207, I have shown that the Brahmaputra, when it possesses a temperature lower than the air both day and night, affects the air considerably at sunset, and but slightly in the heat of the day, lowering also the daily mean. The effect in summer would be to diminish the relative coolness of the Nile as regards the air, so that if I have erred at all it has been in understating the difference between the air and water temperatures. I do not think, however, that observations of the air made on a house-boat, that retains at night the heat of the day, would much affect in summer the daily air mean, and my air data are mostly of this description. The whole matter is in need of an investigator.

Suggestions for observing the temperature of the Nile. The method that involves least trouble merely consists in taking observations of the air and water at sunrise, an hour well suited to the habits of life on the Nile. For this purpose the same bath-thermometer can be advantageously employed. The air observation should be made first, and care should be taken to thoroughly empty the pocket after the water temperature has been observed. If more attention can be devoted to the inquiry, then maximum and minimum air readings should be taken, or, in the absence of self-recording instruments, observations of the air should be made with a common thermometer at sunrise, and in the afternoon at two o'clock in winter, and between three and four o'clock in summer, the corresponding river observations being taken at sunrise and sunset. In the case of the river, the thermometer of the bath pattern should be lowered to a depth of two or three feet, and must be kept there not less than three minutes.

Special points should be also investigated, such as the change of water temperature when the river begins to rise. Captain Newbold records that the temperature of the Nile between Cairo and Thebes was increased from 79° to 80°·5 "at the commencement of the inundation in June by the freshes from Abyssinia." The relation of the temperature of the river to the velocity of the current should be attended to; and it might be expected that the difference in the river temperature between two localities, such as Cairo and Assouan, would be less when the river runs swiftly than when it is sluggish. The difference between the air temperature on the river and on the land, some distance from the banks, requires to be worked out for the various seasons; and two or three days each month might be devoted to this object, the observations being taken at sunrise, in the afternoon, at sunset, and at midnight. The influence of the northerly winds, or Etesian breezes, in lowering the river temperature should be recorded. Dr Marcet noticed a considerable effect thus produced in March. It would be also worth while inquiring into the variation of the Nile's temperature with depth. For this purpose Messrs Negretti and Zambra, of London (Holborn Circus), supply a useful instrument on the Sixe pattern for about a guinea, and a reference thermometer (certified at Kew) for checking its readings for about fifteen shillings.

TABLE XII*a*.

A few Observations on the Temperature of the Nile at Cairo and in its Vicinity.

January 2–4, 1837, .	Between Cairo and Benisouef,	Russegger, .	Nile mean temp. 60·7.
,, 10, 1847, .	At Benisouef, ...	Chaix, . . .	,, ,, ,, 59·9.
,, 31, 1847, .	At Benisouef, ...	Chaix, . . .	,, ,, ,, 59·4.
February 17–20, 1879,	Between Cairo and Benisouef,	Villiers Stuart,	,, ,, ,, 65·0.
April 12–13, 1836, .	At Terraneh, ...	Russegger, .	,, ,, ,, 70·2.
July, August, }	At Cairo, ...	....[1]	,, ,, ,, 79·0.
December 6–8, 1878,	Between Cairo and Benisouef,	Villiers Stuart,	,, ,, ,, 66·0.
,, 13–14, 1836,	At Cairo, ...	Russegger, .	,, ,, ,, 60·6.
,, 28–29, 1846,	Between Wardan and Terraneh,	Chaix, . . .	,, ,, ,, 60·4.
,, 30, 1859, .	At Benisouef, ...	Schnepp, . .	,, ,, ,, 60·0.

[1] Computed from the observations of Newbold between Cairo and Thebes, and of Hay at Beni Hassan.

TABLE XII.

Materials for the Nile employed in the construction of Table XIII.

Month.	Locality.	Lat. N.	Mean Temp.			Observer.
			Air.	Water	W. diff.	
January 21-31, 1832, .	Assouan to Thebes, . . .	24° 6′-25° 38′	61·6	60·6	-1·0	Hay.
,, 5-25, 1837, .	Assouan to Minieh, . . .	24° 6′-28° 6′	59·2	60·4	+1·2	Russegger.
,, 6-31, 1847, .	Assouan to Benisouef, . .	24° 6′-29° 9′	56·4	60·1	+3·7	Chaix.
,, 3-21, 1860, .	Assouan to Minieh, . . .	24° 6′-28° 6′	57·7	61·2	+3 5	Schnepp.
,, 1-20, 1832, .	Kardaseh to Philæ, . . .	23° 43′-24°	66·1	62·1	-4·0	Hay.
,, 1-10, 1879, .	Abu Simbel to Kalabshi, .	22° 20′-23° 29′	60·6	59·4	-1·2	Villiers Stuart.
February 1-6, 1832, .	Thebes, ...	25° 38′	61·8	59·3	-2·5	Hay.
,, 2-12, 1847, .	Thebes to Minieh, . . .	25° 38′-28° 6′	59·0	61·7	+2·7	Chaix.
,, 1-16, 1879, .	Thebes to Beni Hassan, .	25° 38′-27° 53′	63·1	64·0	+0·9	Villiers Stuart.
,, 26-27, 1885, .	Soohag, ...	26° 29′	..	64·6	..	Marcet.
,, 1-28, 1831, .	Philæ, ...	24°	68·6	..	..	Hay.
March 1-19, 1885, . .	Edfou to Siout, ...	25°-27° 10′	67·2	68·0	+0·8	Marcet.
,, 1-31, 1831, . .	Philæ, ...	24°	74·9	..	..	Hay.
April 12-13, 1836, . .	Terraneh, ...	30° 26′	..	70·2	..	Russegger.
,, ...	Cairo, ...	30° 3′	71·4	..	..	(Buchan.)
,, 13-30, 1831, . .	Abu Simbel, ...	22° 20′	85·5	75·2	-10·3	Hay.
May 11-31, 1830,[1] . .	Beni Hassan to Benisouef,	27° 53′-29° 9′	81·9	74·7	-7·2	Hay.
,, 1-31, 1831, . .	Abu Simbel, ...	22° 20′	88·5	75·5	-13·0	Hay.
June 1-30, 1830, . . .	Beni Hassan, ...	27° 53′	84·0	75·6	-8·4	Hay.
,, 1-30, 1831, . . .	Abu Simbel, ...	22° 20′	90·0	78·0	-12·0	Hay.
July 1-31, 1830, . . .	Tel to Beni Hassan, . .	27° 37′-27° 53′	86·3	78·4	-7·9	Hay.
,, 1-31, 1840, . . .	Thebes to Cairo, . . .	25° 38′-30°	..	79·5	..	Newbold.
,, 1-31, 1831, . . .	Abu Simbel, ...	22° 20′	92·1	78·8	-13·3	Hay.
August 1-31, 1830, . .	Manfalut to Tel, ...	27° 23′-27° 37′	85·9	79·7	-6·2	Hay.
,, 1-31, 1831, . .	Abu Simbel to Amada, .	22° 20′-22° 45′	91·2	82·6	-8·6	Hay.
,, (*circâ*), 1800, .	Philæ, ...	24°	..	82·8	..	Coutelle.
September 1-30, 1830, .	Siout to Manfalut, . . .	27° 10′-27° 23′	82·7	79·0	-3·7	Hay.
,, 1-30, 1831, .	Sabooa, ...	22° 45′	89·0	..	..	Hay.
,, 1-2, 1831, .	Sabooa, ...	22° 45′	..	81·2	..	Hay.
October 1-31, 1830, .	Koorneh to Siout, . . .	25° 41′-27° 10′	79·6	76·7	-2·9	Hay.
,, 18-31, 1831,[2] .	Gerf Hossayn, ...	23° 18′	76·6	75·0	-1·6	Hay.
November 1-30, 1830,[3]	Edfou to Koorneh, . . .	25°-25° 41′	69·3	68·5	-0·8	Hay.
,, 1-30, 1831, .	Gerf Hossayn to Kalabshi,	23° 18′-23° 29′	73·4	67·8	-5·6	Hay.
December 1-3, 1830, .	Assouan, ...	24° 6′	..	63·5	..	Hay.
,, 12-29, 1878, .	Assouan to Beni Hassan, .	24° 6′-27° 53′	64·9	66·0	+1·1	Villiers Stuart.
,, 1-31, 1831, .	Kalabshi to Tafa, . . .	23° 29′-23° 38′	65·9	63·0	-2·9	Hay.

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[1] The air mean for the whole of May 1830, between Beni Hassan and Boolak (latitude 30° 4′), is 80·6, and the estimated water mean 73·4.

[2] The means for the whole month of October 1831, between Dakkeh (latitude 23° 12′) and Gerf Hossayn, are 80·4 for the air and 77·4 for the water, the last computed in part.

[3] The water mean has been estimated by curves, there being only observations for eight days during the month. The air observations were continuous.

TABLE XIII.

Mean Monthly Temperatures of the Nile, obtained from the materials given in Table XII., and employed in the Table of the Curves on page 58.

Month.	Between Assouan and Minieh.			Between First and Second Cataract.		
	Air.	Water.	Water diff.	Air.	Water.	Water diff.
January, .	58·7	60·6	+1·9	64·3	61·6	−2·7
February, .	62·0	62·4	+0·4	68 6	(65·0)	−3·6
March, . .	67·6	68·3	+0·7	74·9	(70·5)	−4·4
April, . .	73·0	70·5	−2·5	84·0	74·0	−10·0
May, . . .	81·0	74·0	−7·0	88·5	75·5	−13·0
June, . .	84·0	75·6	−8·4	90·0	78·0	−12·0
July, . . .	86·3	78·4	−7·9	92·1	78·8	−13·3
August, . .	85·9	79·7	−6·2	91·2	82·6	−8·6
September, .	82·7	79·0	−3·7	89·0	(80·0)	−9·0
October, . .	79·6	76·7	−2·9	80·4	77·4	−3·0
November, .	69·3	68·5	−0·8	73·4	67·8	−5·6
December, .	63·9	65·0	+1·1	65·9	63·0	−2·9
	74·5	71·6	−2·9	80·2	72·9	−7·3

TABLE XIV.

Mississippi.

Month.	New Orleans.								Memphis.			
	Capt. Humphreys and Lieut. Abbot.						Prof. Riddell.		Lieut. Marr.			
	1851.		1852.		1853.		1846.		1850.		1851.	
	Air.	Water	Air.	Water	Air.	Water	Air.	Water	Air.	Water	Air.	Water
January, .	...	...	45·8	40·8	52·2	45·0	...	...	...	...	44·3	39·3
February,	(62·5)	(44·5)	58·5	42·5	(56·5)	(43·5)	...	...	...	...	47·2	42·0
March, .	68·2	50·7	64·8	50·7	...	...	...	...	53·2	47·8	...	...
April, . .	68·0	62·0	65·8	56·5	...	...	...	...	53·3	51·5	...	...
May, . .	76·8	68·4	75·2	64·8	...	...	...	(73·0)	66·6	65·6	...	...
June, . .	79·0	78·7	79·5	76·0	...	...	...	76·4	75·0	76·7	...	...
July, . .	82·8	80·0	80·7	82·0	...	...	...	81·9	79·0	83·9	...	...
August, .	81·2	83·4	81·8	85·0	...	...	...	(83·7)	81·1	84·7	...	...
September,	77·0	81·7	79·0	82·3	...	...	...	...	73·2	75·1	...	...
October, .	67·7	73·5	74·5	76·2	...	...	...	...	59·7	65·1	...	...
November,	58·0	59·4	63·4	61·4	...	...	...	...	50·5	51·4	...	...
December,	52·3	46·7	62·7	48·5	...	...	...	...	42·1	42·2	...	...

Note.—The means for February 1851 refer only to the last two weeks, and those for February 1853 to the first two weeks only. According to Dr Drake, the mean for the river at New Orleans, in February 1843, was 41°. The water mean for May 1846 applies to the last ten days, and that for August to the first two weeks.

TABLE OF CURVES.

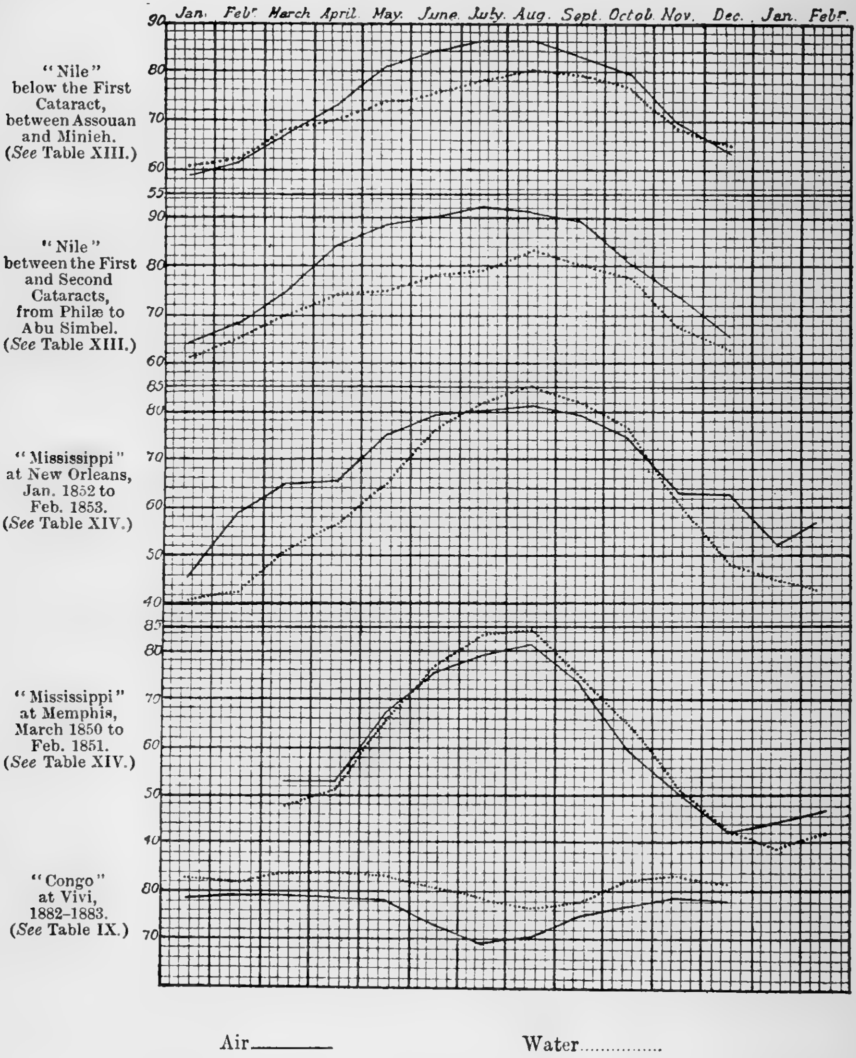

TABLE XV.

[*Intended to Illustrate the Relation between the Daily Range and "Sunrise Difference" of the Air and Water Temperatures for the Nile. The Difference of the Water Temperature at Sunrise is given in the column "S. diff." Table XIII. must be consulted for the Monthly Means of each complete month, since this Table is only intended for the purpose stated.*]

Month.	Year.	Lat., approx.	Mean.				Air.			Water.			Year.	Lat., approx.	Mean.				Air.			Water.		
			Air.	Water	W.diff.	S. diff.	Mean Min.	Mean Max.	Range	Mean Min.	Mean Max.	Range			Air.	Water	W.diff.	S. diff.	Mean Min.	Mean Max.	Range	Mean Min.	Mean Max.	Range
January,	1860	26°	57·7	61·2	+3·5	..	47	70	23	60·5	61·6	1·1	1832	24° 30′	64·5	61·6	−2·9	+8·1	53·0	75·0	22·0	61·1	..	..
February,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March,	1885	26°	67·2	68·0	+0·8	+14·9	52·5	82·3	29·8	67·4	69·0	1·6	..	..	..	..	..	..	..	..	..	..	..	..
April,	..	..	..	..	..	..	..	..	..	..	..	..	1831	22°	85·5	75·2	−10·3	−1·3	75·5	96·9	21·4	74·2	..	..
May,	1830	28°	81·9	74·7	−7·2	+1·3	72·7	93·1	20·4	74·0	75·8	1·8	,,	22°	88·5	75·5	−13·0	−4·1	78·3	99·8	21·5	74·2	..	..
June,	,,	28°	84·0	75·6	−8·4	−0·4	74·8	95·7	20·9	74·4	76·8	2·4	,,	22°	90·0	78·0	−12·0	−2·2	78·8	102·3	23·5	76·6	..	..
July,	,,	28°	86·3	78·4	−7·9	−0·8	77·6	98·0	20·4	76·8	80·1	3·3	,,	22°	92·1	78·8	−13·3	−3·0	80·3	105·0	24·7	77·3	..	..
August,	,,	27° 30′	85·9	79·7	−6·2	+1·4	77·4	95·9	18·5	78·8	80·6	1·8	,,	22°	91·2	82·6	−8·6	+1·7	79·9	102·3	22·4	81·6	..	..
September,	,,	27°	82·7	79·0	−3·7	+2·9	74·8	91·9	17·1	77·7	80·3	2·6	,,	..	..	..	..	..	..	..	..	..	..	..
October,	,,	26° 30′	80·0	78·3	−1·7	+5·5	71·1	88·6	17·5	76·6	79·4	2·8	,,	23°	76·6	75·0	−1·6	+10·7	..	..	..	..	..	..
November,	..	..	..	..	..	..	..	..	..	..	..	..	,,	23°	73·4	67·8	−5·6	+4·5	62·8	82·9	20·1	67·3	..	..
December,	1878	27°	64·9	66·0	+1·1	+9·4	56·0	73·2	17·2	65·4	..	..	,,	23° 30′	65·9	63·0	−2·9	+7·4	55·2	74·8	19·6	62·6	..	..

Mean Temperature of the Air at Cairo, 1868-81 (Buchan).

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
54·2	56·4	62·4	71·4	78·7	83·8	85·0	84·4	79·4	73·5	66·2	58·7	71·2

List of Authors referred to in this Paper.

(See also the List at end of Part I.)

Abbot, Lieut. See under Humphreys.

Baikie, Dr, On the *Niger* Temperature, in Manuscript Journal in British Museum.

Blakiston, Capt. T. W., Five Months on the *Yang-tsze*, 1862.

Borius, Dr A., On the *Senegal* Temperature, *Ann. de Soc. Mét. de France*, tome xxv., p. 130.

Buchan, Mr, On the Isothermal Lines, vol. ii., *Phys. and Chem. Challenger Reports.*

Burton, Capt., On the *Congo* Temperature, *Gorilla Land*, 1876, p. 292.

Chaix, Prof., On the *Nile* Temperature, *Jour. Roy. Geog. Soc.*, vol. xix., p. 148.

Coutelle, M., On the *Nile* Temperature, *Descript. de l'Égypte*, Hist. Nat., tome ii., p. 334.

Danckelman, Dr A. von, On the *Congo* Temperature, *Mém. sur les Obs. Met. à Vivi*, Berlin, 1884.

Dowler, Dr, On the *Mississippi* Temperature, "Researches in Meteorology," *New Orleans Med. and Surg. Jour.*, January 1848.

Drake, Dr, On the *Mississippi* Temperature, *Interior Valley of North America*, 1850, p. 67.

Forster, Dr, Die Temp. fliess. Gewässer Mitteleuropas, *Geograph. Abhandl.*, Band v., Heft 4, Wien, 1894.

Griffith, Dr. See under Guppy.

Guppy, Dr, River Temperature, *Proc. Roy. Phys. Soc. Edin.*, vol. xii., part 2, p. 286.

Hay, Mr, On the *Nile* Temperature, in Manuscript in British Museum Add. MS. 29858 (vol. xlvii., Robert Hay, Egyptian Collections).

Herndon, Lieut., On the *Amazon* Temperature, *Valley of the Amazon*, part i., 1854.

Humphreys, Capt., }
Abbot, Lieut., } Physics and Hydraulics of the *Mississippi*, 1861.

Marcet, Dr, On the *Nile* Temperature, *Quart. Jour. Roy. Met. Soc.*, vol. xi., p. 284.

Marr, Lieut., On the *Mississippi* Temperature, *Astron. Obs. Nat. Observatory*, Washington, 1853, vol. iii., Appendix B.

Maury, Lieut., On the *Amazon* Temperature. See under Marr.

Newbold, Capt., On the *Nile* Temperature, *Philos. Trans.*, vol. cxxxv.; and *Edin. New Philos. Jour.*, vol. xl.

Riddell, Prof., On the *Mississippi* Temperature, *De Bow's Commercial Review*, vol. ii., p. 435, New Orleans, 1846; also in Drake's work above named.

Russegger, J., On the *Nile* Temperature, *Reisen in Europa*, etc., 1841-49, Band i., pp. 213, 215.

SAREL, Col., On the *Yang-tsze* Temperature, *Jour. Roy. Geog. Soc.*, vol. xxxii.

SCHNEPP, Dr, On the *Nile* Temperature, *Du Climat de l'Égypte*, 1862.

STUART, Mr VILLIERS, On the *Nile* Temperature, *Nile Gleanings*, 1879.

TUCKEY, Capt., On the *Congo* Temperature, *Narrative Expedition Congó*, 1818, p. 355.

WALLACE, Mr, On the *Rio Negro* Temperature, *Jour. Roy. Geog. Soc.*, vol. xxiii., p. 212.

III. *Obituary Notice of the late George Leslie, M.D., F.R.S.E.*

By R. H. TRAQUAIR, M.D., LL.D., F.R.S.

(Read 19th December 1894.)

George Leslie was born at Turriff, Aberdeenshire, in the year 1850. Having spent some time as assistant to a chemist and druggist in Dundee, he repaired to Edinburgh about the year 1876, and commenced the study of medicine at the University.

Having a decided inclination towards the subject of natural history, he became assistant to the late Professor Sir Wyville Thomson shortly after his return from the "Challenger" Expedition, and for some time he also worked in the Challenger Commission Office as secretary to Sir Wyville. In 1879 he joined the Royal Physical Society, contributing in the same year a paper "On an Abnormal Specimen of *Euplectella aspergillum*" to its *Proceedings*. This was followed in 1881 by the well-known "Catalogue of the Invertebrate Fauna of the Firth of Forth," which he prepared in conjunction with his college friend, Mr W. A. Herdman, now Professor of Biology in the University College, Liverpool.

At that time it seemed uncertain as to whether Mr Leslie would ultimately devote himself to practical medicine as his profession, or allow himself to be tempted to turn aside into that most uncertain path to eminence or even bare livelihood which is trodden by those who, unsupported by private fortune, choose to devote themselves to pure science. Certainly he was not wanting either in ability, or in the bent of mind, necessary for the development of a thorough good zoologist. But prudential considerations prevailed, and in August 1881 he graduated with honours M.B. and C.M., and presently repaired to Larbert, where he became assistant physician to the county lunatic asylum there. After remaining two years in this institution, an opportunity for establishing himself in the neighbouring town of Falkirk occurred through the death of the late Dr Hamilton, whose practice he acquired. From now onwards began his laborious and successful career as a general practitioner, during which he found time to write several interesting papers on medical subjects, which he published in the *Edinburgh Medical Journal.* In August 1892 he took the degree of Doctor of Medicine, receiving commendation for his thesis "On the Physical Relations of Idiocy and Imbecility." Though he had abandoned zoology as his business in life, he did not cease during these busy years to take the deepest interest in the subject, and remained a sympathetic member of the Royal Physical Society to the last. More especially was he interested in the ornithology of the district in which he practised, and in fact had in view the preparation of a paper on the birds of the upper part of the Forth area, had he lived to carry it out.

In March 1893 he had the sad misfortune to lose by death his devoted wife, daughter of his predecessor, Dr Hamilton, and sister of the present eminent Professor of Pathology in the University of Aberdeen. He was not long in following her, for in the beginning of January of the present year (1894) he died, at the early age of forty-three.

Personally Dr Leslie was endowed with a full measure of that integrity and faithfulness of character which is so eminently characteristic of the Lowland Scottish nature, but he was also possessed of a peculiar charm of manner not quite so common among our countrymen, which gained for him speedy popularity among all with whom he came in contact. Herein he was also aided by the great breadth of his sympathies, for he was not only a man of scientific bent and abilities, but displayed and cultivated a strong taste for the somewhat different field of poetry and literature. Some people may think those two channels of human thought incompatible—George Leslie, whose loss the Royal Physical Society deplores, was an example to the contrary.

IV. *Rockall.* By J. A. HARVIE-BROWN, F.R.S.E., F.Z.S.

(Read 20th March 1895.)

Mr T. E. Buckley and myself included in our treatment of the Outer Hebrides[1] an account of this island or oceanic rock, taking the opportunity of telling its history so far as it was then known to us.

At that time we overlooked the relation of Surgeon Alexander Fisher, R.N.,[2] and we have gratefully to acknowledge the kindness of Mr Miller Christy in directing our attention to it. Now we desire to supply the omission.

Surgeon Fisher says:—"Monday, 24th [of May 1819].—We had a distant view to-day of that remarkable insulated rock called Rockall. It looked, at the distance we were from it (viz., between four and five leagues), exactly like a ship under sail: it was reported, indeed, by the person who first saw it to be a strange vessel. Its resemblance, not only in form, but also its colour, tended to make the deception more complete, for it appeared to be perfectly white, a hue most probably produced by the excrement of birds. Our distance from it, indeed, was too great to enable us to speak with certainty on this head; but, from the number of birds we saw in its neighbourhood and its insular situation, we may fairly conclude that it is well inhabited by the feathered race, for here they are perfectly secure from the attacks of their greatest enemy—man.

"If we estimated our distance from it at all correctly, its situation, as determined by His Majesty's ship 'Endymion,' is very accurately laid down—at least inasmuch as it agrees with the mean of the results of the sights taken for our chronometers.[3] In the course of the afternoon, when at least forty miles from this rock, we found soundings in one hundred and fifty fathoms water, so that it may be regarded as the summit of a very extensive submarine mountain,

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[1] A Vertebrate Fauna of the Outer Hebrides. Edinburgh, 1888.

[2] A Journal of a Voyage of Discovery to the Arctic Regions in Her Majesty's Ships "Heckla" and "Griper" in the Years 1819 and 1820. By A. F. Fourth edition. London. Demy 8vo. 1821.

[3] Lat. 57° 39′ 30″ N. and long. 13° 30′ W.

whose sides — at least the western one — decline very gradually."

Now again, in endeavouring to supplement our previous summary, and bring our information concerning Rockall up to date, we desire it to be understood that we do not claim this far-off fragment of the earth as a part or portion belonging to the faunal area of the Outer Hebrides, because certain facts which have become known to us since the date of our last article upon it, tend to the indication of its geological and faunal relations to the islands of Iceland, or at all events to more recent volcanic action than we have any traces of in the Hebrides; and the soundings show, probably, much more decided rupture or separation from any of our British isles than from more northern land.

Soundings, when more exhaustively overtaken, may, and doubtless will, assist us further in our judgments in this direction; and before long, as we have some reason to hope, such soundings, and a more minute account of the rock and its surroundings, will be attempted, and more definite information obtained regarding its geology, flora (if any), and fauna.

In Basil Hall's account, the geology of the rock has been described as a "dark-coloured granite," and this has been repeated in the corner of Captain Vidal's map, where the stone is spoken of as "coarse granite."

From what has already been published regarding this still somewhat mysterious ocean-rock, we know a few points of its history. We know its position with considerable accuracy; and the Admiralty chart, which is now out of print and scarce, has laid down upon it accurate soundings so far as the survey was mapped. We know that it is surrounded by dangerous reefs, especially those which lie out three-quarters of a mile or thereby towards the N.E. The fishing banks around, as is well known to crews and masters of fishing smacks from Grimsby, Færöe, and Shetland, lie at depths of from 60 to 120 fathoms. We know also that it is a nursery for sea-fowl, and positively that a species of guillemot breeds upon it, besides several other birds, of the identity of some of which, however, we are not so certain.

Of its geology we have only the accounts of Vidal and Captain Hall.

My friend Mr John Cordeaux of Great Côtes, Ulceby, Lincolnshire, who at my request has assisted me in preparing the materials for this paper, and who has good opportunities of interviewing the Grimsby smacksmen and owners, sent me, amongst other items, a small piece of stone which was obtained near Rockall, and concerning which he writes to me as follows:—"With regard to your question as to where I got the rock and from whom? It was given to me by a man who had been line-fishing off Rockall for cod. I had several pieces, with a branching coral attached, brought up entangled on the cod-lines. I cannot remember the man's name now, but believe that it was one by name Frederick Barr, formerly of this parish, and drowned at sea some few years ago. There was a good deal of the coral and rock brought to Grimsby about the same time. The little bit I sent to you was the only piece I could find, although I had several pieces on the chimney-piece when at Eaton."

You will, from the above notes, observe that this piece of rock was not obtained *in situ* from Rockall, but from the floor of the ocean in its vicinity. Nevertheless I considered it worthy of a specialist's examination.

It was therefore forwarded to Professor Heddle, with a request to report upon its character, which he has done as follows:—"I have cut a slice out of Rockall rock, and now return the rest. I cannot finish the section here, so have sent it to London to be finished, and on receipt of it will report." He goes on to say—"If this comes from there, it is none of the rocks mentioned before, but (unless *possibly*, but *not probably*, a hornblende band of old gneiss) a *volcanic* rock. This would make Rockall a plugged volcanic throat, which its form makes very probable."

After a later and more exhaustive examination, Professor Heddle writes:—"It is an olivine-dolerite of an unusually close-grained or dense character. It has an unusual structure, as containing very little augite. Olivine and labradorite crystals occur porphyritically disposed; and also in what Professor Judd calls glomero-porphyritic clusters; and here both the above minerals are associated in these clusters. There is much saponite in small and loosely arranged flakes. This is not in small druses, but in irregular patches, as if it had replaced augite. Lath-shaped crystals of labradorite penetrate these patches, showing that this mineral had been protero-genetic to the augite. Analcime in somewhat large crystals occurs as an imbedded ingredient."

"Though not for a moment calling in doubt the fact that the piece of rock sectioned came from Rockall, I must express the very strongest doubts as to this being the usual, or main, rock of that extended reef. Such a mass as that would stand above the water in high, cliffy bluffs, with deep water up to the very edge of the precipitous sides. It seems to me much more *probable* that the fragment of rock sent had been a portion of a number of volcanic dykes which had cut the true rock in all directions, and, by their greater hardness, had saved it from utter disintegration. Moreover, the specimen sent was itself of an unsatisfactory character. It did not show properly fractured edges, these being rounded from more or less atmospheric or marine rubbing. It looked like a fragment which had been dislodged out of a rent in a stone."

Early in 1894 some talk was made of erecting a lighthouse upon Rockall, and, in a letter received by me on 28th April 1894, from Mr D. A. Stevenson,—Secretary's office of the Board in Edinburgh,—that idea for the time being appears to have been dismissed, after all possible inquiries had been made. Mr Stevenson wrote: "It is evident that there is not much information forthcoming from those who have actually landed on the rock."

The difficulties of storage, of laying a cable, supplying victuals to workmen excavating for foundations, first for storehouses and workshops, and secondly for the lighthouse itself, distance out in the Atlantic, and the incompleteness of charts and soundings, for the present, at least, render the prospect unlikely.

Until a more careful survey both of the rock itself and its capabilities, and of the surrounding seas, be completed, it is not likely that any steps can be advanced in this direction, however desirable such might be, both for saving life and serving as a meteorological station. A cable would have to be laid, with all proper connections, to the nearest land in Scotland; and to do so safely, a careful series of soundings and samples of the bottom would have to be made and reported upon. Such might be undertaken by private enterprise, or it might be done by the Northern Lighthouse Board, or otherwise by a Government expedition.

Meanwhile I have endeavoured, since the date of the issue of my volume on the Outer Hebrides, to ascertain as much more as possible from fishermen and others who have landed or been in its vicinity.

The materials at my disposal to date are:—

Information obtained by me when in Færöe in the summer of 1894, which I detail further on as nearly as possible in the words of the several narrators, and jotted down immediately on the spot.

Information obtained with the assistance of Mr John Cordeaux of Great Côtes, Lincolnshire, by interviewing various smack-owners and fishermen of Grimsby, which I also propose to give in detail.

Other information received—if still indefinite—seems to agree at all points regarding the numbers and considerable *variety* of the birds which are found upon the rock.

To secure more certain data, when in Færöe in 1894 I made the best arrangements possible to have the rock landed upon, and every obtainable specimen brought home in 1895. I trust my endeavour may meet with success. Both Færöe smacksmen, and Grimsby owners and fishermen, agree as to the large number and considerable variety of birds seen there, on various occasions; and most of these men carry at least two fowling-pieces, and some also a rifle in their ships.

Another point gained—if absolutely correct—is, that the Grimsby men agree that there *is* vegetation and plants of some sort on the rock (J. Cordeaux).

The accounts of the species of birds and descriptions are, however, as yet too vague to make it worth while at present to retail them.

One Grimsby headman adds a crumb of interest. He says, after the usual description of the rock and its appearance, "like a big hay-stack, and covered by bird's dung—in fact, quite white." "There is a ledge round the island, on which it is possible to land and walk, and the high portion rises precipitously from this. There are also great reefs not awash all round, and extending for miles. Grey Seals frequent the rocks. Gulls, Cormorants, Gannets, and *many other sorts* of birds nest there, also Kittiwakes" (*viva voce* to Mr John Cordeaux; in letter to J. A. H.-B. from J. C., 6th November 1894).

Mr G. C. Bennett—in a letter to Mr J. Cordeaux—says, 1st November 1894: "I have just seen a man who landed on Rockall about thirty-nine years ago (say 1856 or thereby). He was then a sailor on board Colonel Gascoigne's yacht 'Myra.' He says that the yacht lay-to at some distance off the rock; the yacht party went off in boats, and landed on part of the rock *which slopes down to the water's edge.*[1] After shooting a quantity of Cormorants, Kittiwakes, and Sea-Gulls, they returned. At ordinary times the seas wash over the rock, and it is only after very fine weather a landing can be effected."

Of a different nature altogether was a very clever but insincere article printed in *Chambers's Journal,* which related an entirely supposititious personal visit to the rock by a person who had never been there, and which was allowed to appear—as indeed it was supposed to be—as a genuine record. The article, indeed, was simply a *resumé* of Basil Hall's relation, and of what had previously been written—placed under the first personal pronoun—but, fortunately, in the few concluding lines the cloven hoof was detected, in the statement that the Little Auk was found to be nesting upon it. This promptly led to the detection of the fraud. We would not dwell upon this hoax at such length, were it not that years afterwards we find—so late as the 1st November 1894—a correspondent from Lloyds' Agency (!) in a private letter, expressing himself thus, in reply to inquiries: "*About the best description of the rock I have ever perused appeared in a*

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[1] Italics are mine.—H.-B.

periodical—'CHAMBERS'S JOURNAL,' *a monthly publication published at Edinburgh, . . . was from the pen of a yachtsman, who, along with a companion, landed on the rock, having been conveyed there by a steam-yacht. It gave a most graphic description,*" etc.

This only shows how hard it is to "kill a lie," for it had been to all purpose killed—or maimed considerably—before, in *The Annals of Scottish Natural History* immediately after its issue.

I am still of the opinion, however, without desiring to be ultra-critical, that the mis-statements ought to have received editorial reproof promptly, and that it is *not even yet too late to "scotch" them.*

I have never seen the very good Admiralty chart (No. 2870, 1861)—now unobtainable—and which gives views of the rock and other information.

At the Geological Museum, London, inquiries have been made as to the geology of the rock, and they know absolutely nothing about it (Miller Christy in letter, January 31, 1895).

Now, as regards any slight information which I procured in Færöe—July 1894—I give it as received.

Herr H. C. Müller, who kindly assisted me in procuring some of the notes from smack-owners and others, placed in my hands the following note and a translation.

Captain Johannes Hansen of Thorshavn was on Rockall in 1887. He says: "The rock is 70 feet high, steep on the northward side, sloping to the contrary side 50 feet, with ledges (shelves). He went up on the east side, but could not get down again unless by the assistance of a rope. The birds he saw and took—as they were very tame—were members of *Uria bruennichii*, *Alca torda*, *Fulmar*, and *Great Shearwater*. The *Puffinus major* had their eggs deposited in holes in the rock. No vegetation. The rock was white over with guano. The rock was solid. He does not think that the sea ever washed over it. The depth of the sea where he landed was 60 fathoms." The above was taken down in Danish, and translated by Herr H. C. Müller for my benefit.

Afterwards Mr Jens Olsen—Herr Müller's son-in-law—the principal storekeeper and fishcurer in Thorshavn, who knows all the Færöe captains who go to Rockall, added, "Two crews from two vessels landed on this occasion;" and there remained some slight discrepancy as to whether the *Uria breunnichii bred or not.* (See conclusion of our chapter on Rockall in the volume on the Outer Hebrides, page xciii, and the last sentence: "The egg, which was forwarded to Buckley for identification, is that of a Guillemot." To this sentence, by Mr Buckley's goodness, I have since been able to add, "and is now in the collection at Dunipace." I have often looked at this egg, and compared it with those of Common Guillemots and with Breunnichs Guillemots. It certainly seems to agree more closely with the latter, but it is premature perhaps to lay such a leading point. Above written at date of February 25, 1895.—H.-B.)

Mr Olsen has promised to get the captains interested to bring home, *if they ever land*, specimens of every egg and bird on Rockall, and also specimens of the rock itself, to be broken off with a hammer.

Upon my return journey to Scotland, I had taken on board, on his consenting to work his passage and replace a dismissed member of the crew, one Mr Andresen, a Færöese, and owner of three smacks, viz., the old yacht "Dauntless" of Cowes—a very fine old ship,—the "Flower of Essex," and a third. Mr Andresen desired to go to Scotland to see about a steam-alteration or adjustment of the "Dauntless," to suit goods and passengers and inter-coastal traffic amongst the Færöe Isles, and, if possible, obtain a contract of the mails.

At intervals of time during our home-voyage, and as suddenly and casually as I deemed right, I interviewed him, beginning thus, for instance as regards Rockall: First question, suddenly,—"Have you been at Rockall?" "Yes, several times." Second question—"Have you landed?" "No; but I have been with a crew, some of whom did, last year:" then, "Last year, a brother in partnership in our boat was at Rockall fishing." Third question—"How near were you to the rock?" "About half a mile. One can very seldom land, and then only always with great difficulty in east winds or calms; hopeless with westerly wind. Usually only with the help of ropes tied round each man.

Ropes may be necessary at any time." Mr Andresen also supplied the following further information, which was written down immediately afterwards by me.

In 1887 the crews of the "Dolphin" (or "Delphin"?) and "Gauntlet" landed. The crew of the former once—and "brought off a boat-load of eggs." The crew of the "Gauntlet," three weeks later, did the same. All the eggs were used for food.

Mr Andresen added, "The species of birds I could not make out with any certainty except 'Mollies'—*dark grey Mollies*—but," he said decidedly, and more than once, "there is *one* kind of bird there not found in the Færöerne." He went on to relate, "The fishermen catch many birds on lines—using them for food (?) and bait; also in traps set upon boards and baited, and floated on the water—such as 'Mollies.' The fishermen also usually carry two guns in each boat, and some a rifle, but the latter only for fun (*i.e.*, sport)." Mr Andresen never saw any seals there. Mr Andresen believes that the seas break right over the rock in winter, and even in spring up to the end of April. His boat or boats were there after the 1st of May.

There is a shoal W.N.W. of the rock half a mile, and another outside that at 30 fathoms depth.

Amongst a number of boats with sails set, Mr Andresen describes it as almost impossible to distinguish the rock from the boats at a distance; and Mr Andresen added, to the best of his belief, "There are no surrounding shoals or reefs except the above-mentioned."

I make no comments upon Mr Andresen's narrative—only to say that it bore every appearance of a reliable personal inspection so far, and of his reliable knowledge, from fellow-smacksmen, owners, and fishermen in Færöe. He has promised every further help and assistance in his power, should his vessels go out again to the bank fisheries of Rockall in 1895.

Later, during another conversation I had with Mr Andresen, as we crossed from Great Dimon of the Færöes towards the Orkneys, he mentioned the names of several Grimsby owners and curers whose vessels make a practice of visiting the

Rockall seas, which craft likewise go from Grimsby to Iceland. These names have since been supplied to Mr John Cordeaux, who has been so kindly assisting in gathering up the strands of this Rockall query "up to date," and they are entered in my journals, for further use as opportunities may occur.

So far as I have been able to ascertain, few, if any, of the Peterhead or Fraserburgh smacks ever go out to Rockall.

In conclusion, I desire to say, if these notes—tentative and incomplete—serve any useful purpose, in time for the summer of 1895, apart from my own endeavours in the same direction, I will feel that they have not been altogether penned in vain.

V. *Note on Muscle Fibre, Electric Disc, and Motor Plate.*

By G. Carrington Purvis, B.Sc., M.D.

(Read 16th January 1895.)

Some time ago, while examining the isolated striped muscle fibres of the Skate, I was much struck with certain appearances which these fibres presented, and which seemed to me to afford a clue as to the *primitive or original position* of the motor plate with respect to the muscle fibre itself.

It is now well known that the electric organ of fishes is developed from muscle, and that each muscle fibre gives rise to one electric disc, cup, or plate in that organ; also that the connective tissue between muscle fibres gives rise to the fibrous septa and gelatinous tissue which separate the discs from one another; and further, that the immense number of nerve branches entering the anterior face of the disc or concavity of the cup (in the cup-shaped variety of electric organ) in the Skate group are equivalent to the nerve ending in muscle, and which is commonly known as the motor plate.

It happens, however, that whilst the nerve destined to supply the future electric disc, cup, or plate, always enters the club-shaped muscle fibre at one extremity, the nerve which supplies a muscle fibre (destined to remain as a muscle fibre) always enters the muscle laterally—in other words, at right angles to the direction in which it enters the disc, cup, or plate.

It was therefore with no little surprise that I observed, on carefully examining the isolated muscle fibres of an adult skate (probably *R. batis,* but unfortunately I did not make a note of the species at the time), that one extremity was slightly larger than the other, and that this larger end was, further, *hollowed out or excavated* to a slight extent. It is to this hollowing out that I especially wish to call attention. What does it indicate? Is it a mere accidental condition, or does it point to a time when the muscle fibre, like the electric disc or cup, received its nerve supply at its anterior end?

To me this latter alternative seems to be the right explanation, viz., that the concavity at the end of the striped muscle fibre does indicate the primitive position of the motor plate.

To account, therefore, for the present position of the motor plate, we have two alternative explanations, viz., (1) that the original anterior motor plate, or its equivalent (nerves to disc), has disappeared, and that the lateral or true motor plate of muscle fibre is a secondary formation; or (2) that the motor plate is really the original one (or its equivalent), which has gradually (in the course of ages) shifted its position till it now comes to occupy one side of the muscle fibre, somewhere about the middle of its length.

It would appear that a motor plate situated about the centre of the fibre is more advantageously situated for purposes of quick contraction of the fibre than one situated at its extremity. Be this as it may, it is certain that all motor plates are situated about the centre of their respective fibres.

One can imagine that, given all muscle fibres provided with nerve supplies at one of their extremities, and that under certain conditions, of which we are still wholly ignorant, some of the fibres developed into electric discs, which collectively constitute the electric organ, whilst others collectively went to form various groups of muscles,[1]

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[1] It is to be regretted that no terms have been coined, so far as I am aware, to distinguish between fibres which remain as muscle fibres and those which transform themselves later on into electric discs, cups, or plates. Such terms would be very convenient.

and that in the latter a shifting of the nerve supply took place, it is also quite certain that no fish could possibly have all, or even the larger part, of its muscles transformed into electric organs, for the animal would at least be required to feed itself, and so move its jaws, and have some power of locomotion. These movements would of necessity insure some of its fibres remaining permanently as muscles.

We have thus, in the development-history of the electric organ—(1) an indifferent stage, *i.e.*, a stage in which the fibres of future muscle and future electric organ are exactly alike; this stage, however, is of short duration, for it is (2) very quickly followed by one extremity of the fibres becoming club- or mace-shaped in those fibres which are destined to form the electric organ. This club-shaped condition may be permanent, as in *R. radiata*, or (3) may advance further and become either cup-shaped, as in *Raia circularis* and *R. fullonica*, or (4) may become flattened out to form the complicated discs of *R. batis* and *R. clavata*, or (5) may be still further modified to form the simple hexagonal plates of the Torpedo or Electric Ray.

It is a noteworthy fact that electric organs occur only in the fish group, and are practically confined to two subdivisions of this group, viz., Elasmobranchs and Teleosteans; also that in these fishes they do not occupy the same position in all genera, for whilst in the Skate section they occupy the tail region, in the closely related Torpedo they are in the head region—one organ on each side of the jaw, between the dorsal and ventral surfaces. This of course seems to show that the electric organs of the Skate and Torpedo have not been inherited from a common ancestor. Probably the electric organ of the Skate has been later in forming, as, according to Professor Ewart, it is still on its way to further development; and yet, if my theory be a correct one, the electric organ must have commenced developing before the motor plate—or rather its equivalent (the various nerve branchings)—had shifted its position to the centre of the muscle fibre, or at all events before the motor plate had lost its connection with the anterior extremity of the muscle fibre. It is almost certain that the motor plate of muscle fibre, and the nerve endings in the anterior or "electric layer" of the disc, are one and the same thing. If such be really the case, though the point requires a little further investigation, then the difference in position of the nerve endings in electric disc and muscle fibre proper requires some explanation, and this I have attempted to offer in this brief paper.

VI. *Results of Meteorological Observations taken at Edinburgh during* 1894. By R. C. MOSSMAN, F.R.S.E., F.R.Met.Soc.

(Read 20th February 1895.)

During the past year observations have been made at the usual hours of 9 A.M. and 9 P.M., and the results transmitted weekly and monthly to the Meteorological Office, London, and to the Registrar-General for Scotland, the latter being sent through the Scottish Meteorological Society. The instruments in use are practically the same as those described in previous reports. A Fortin standard barometer has, however, been substituted for the Kew marine barometer formerly employed; while one of Richard's self-registering rain gauges (improved balance pattern) has been added, at considerable expense, to the stock of instruments. The ordinary bi-daily observations are eye-readings, but automatic methods of registration yield continuous traces of the fluctuations in pressure, temperature, humidity, rain, and sunshine. The cylinders from which these records are obtained revolve once a week. With the exception of sunshine values, no attempt has been made to tabulate hourly readings from these records, but they are of considerable value for purposes of interpolation and as a check on the eye-readings. The rainband observations continue to be made, as in former years, at 9 A.M., noon, 3 P.M., and 6 P.M., the latter observation being dispensed with in the winter owing to the lack of sunlight at that hour. The rainband is not observed during the author's absence from home, as this work cannot conveniently be handed over to an assistant, as is done with in other cases.

The reduction of the meteorological observations taken at Edinburgh since 1764 continues to make satisfactory progress, but it is estimated that another year will elapse before the long averages of all the climatic elements will be available. It has therefore been deemed unadvisable to make any alteration in the averages at present in use until all are completed.

REMARKS ON THE METEOROLOGY OF 1894.

January.—During the first week intense frost was experienced, the minimum temperature on the 6th being 13°·9 in the shade, while on the ground a reading of 9°·0 was recorded. The maximum temperature for the 12 hours ending 9 P.M. of the 6th was only 17°·8, the lowest day value for at least 40 years, the nearest approach to this low shade maximum being readings of 19°·8 on December 24 and 19°·0 on December 25, 1860. Frequent snow showers accompanied the easterly winds during the first seven days of the month, during which time only half an hour's sunshine was registered, after which westerly winds prevailed till the close of the month, with a good deal of sunshine. Snow showers were again experienced during the last week. A slight thunderstorm occurred at 11.10 P.M. on the 30th.

February.—The weather of February was very changeable. The rainfall was unprecedentedly heavy, falling as it did on 21 days to the amount of 6·81 inches. Severe gales were of frequent occurrence, and were usually followed by a brief spell of cold weather, with snow showers. A very rapid fall of the barometer commenced at 5 A.M. on Sunday the 11th, with heavy rain; and at 2 A.M. on Monday the 12th the low reading of 28·319[1] inches at 32° and sea-level was registered. An unusually rapid rise then set in, and in the one hour from 4 to 5 A.M. pressure rose 0·307 inch, as recorded by Richard's barograph, controlled by readings with the standard mercurial barometer. Consequent on a change of wind from E.S.E. to S.W., Richard's thermograph registered a rise of

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[1] All readings of the barometer quoted in the text are corrected to 32°, and reduced to mean sea-level.

temperature from 37°·5 to 48°·0, or 10°·5 in the seven minutes ending 1.10 P.M. on the 11th. Heavy rain fell on the 17th, to the amount of 1·47 inch. Thunderstorms were recorded on the 24th and 25th, while an aurora was seen on the 28th. In different parts of Edinburgh observations of rainfall have been made for 130 years. The wettest previous February was 1848, with 5·21 inches, or 1·60 inch less than was recorded during February 1894.

March.—The earlier part of the month was very unsettled, with heavy westerly gales, accompanied by rain, snow, or sleet. After the 14th a spell of very fine weather was experienced, no rain being noted, whilst sunshine was abundant and temperature high, readings of over 60° being registered on the 23rd, 29th, and 30th. The mean temperature (44°·1) was the highest since 1882, while the bright sunshine recorded (171 hours) was the greatest registered in this month in a record extending back to 1878. The nearest approach to this large amount was 146 hours in 1878, the smallest being 40 hours for March 1888. Thunder was heard on the 11th.

April.—During the first half of the month easterly winds prevailed, only 36 hours' sunshine being registered up to the 18th, after which sunshine was abundant. No gales were experienced, the only barometric depression of any depth being on the 24th, when the barometer fell a little below 29·5 inches. Frost was absent, the temperature in the shade never falling below 34°·3, the highest absolute minimum observed since 1867, when 36°·0 was recorded. The mean temperature (47°·6) was but a third of a degree lower than in the unusually warm April of 1893, with which month it compares very favourably in other respects.

May.—Unusually cold weather prevailed throughout May, nocturnal frosts giving a severe check to plant life. The mean temperature was 47°·1, being thus half a degree below that of April, a circumstance that has taken place on nine occasions since 1764, the last occurring in 1874. The maximum temperature recorded was only 64°·1, the lowest in May since 1885, when the temperature did not exceed 62°. Bright sunshine amounted to 170 hours, the only dull period being from the 13th to the 19th. Snow fell on the 19th and 20th. An aurora was observed on the 7th, the beams being of a whitish colour.

June.—The first three weeks of June were characterised by a temperature under the average, with dull weather; but the last week was sunny and warm, the maximum temperature recorded on the 26th being 74°·1. Winds were rather variable, being chiefly from the east during the first half, but from the westward during the second half of the month. The rainfall was about half an inch above the average, nearly all falling on four wet days. Thus on the 4th and 5th there fell 1·21 inch in 16 hours, while on the 10th and 11th 1 inch was registered. Thunderstorms occurred on the 1st and 10th. A fine display of illuminated night clouds was seen on the evening of the 24th.

July.—The month opened with warm weather, the maximum temperature on the 1st being 73°·6, and on the 6th 77°·5. Exceedingly unsettled weather prevailed, thunderstorms being frequent. No warm weather occurred after the first week, although there were many days that felt exceedingly close, owing to the abundance of water-vapour. Rainfall was slightly below the average, in spite of torrential showers on the 2nd, 6th, 15th, 20th, and 21st, when thunderstorms were experienced. The weather during the last week was very foggy, especially in the mornings, the afternoons being on the whole sunny. This is well shown from the records of sunshine from the 25th to the 31st, during which period the sun shone in the aggregate on only 3½ hours before noon, but on 22 hours during the afternoon.

August.—Cool and wet weather were the leading features of the meteorology of this month. Not a single warm day was recorded, the absolute maximum of 68° registered on the 8th being the lowest since 1865, when the same low maximum was observed. Westerly winds blew during the first three weeks, and were sometimes rather strong in force. Dull weather predominated. Thunderstorms occurred on the 9th and 17th.

September.—Very dry weather was experienced throughout, no rain whatever falling from the 6th to the 20th inclusive, while the downfall for the month was under half an inch, the smallest for September since 1860, when 0·34 inch fell. Barometric pressure was unusually high and steady, and as pressure was greater in the north than in the south of our islands, the prevailing winds were easterly, which explains the small amount of sunshine registered, viz., 91 hours. The mean barometric pressure (30·22 inches) was the highest observed in September during at least the last 55 years.

October.—During the first three weeks the prevailing type of weather was anti-cyclonic, but as N.E. and E. winds predominated, temperature was low and sunshine scanty, the total for the month being only 64 hours. The wind never attained the force of a gale, the mean velocity being barely four miles per hour. A deep depression passed over the north of Scotland on the 24th and 25th, the barometer at midnight falling to 28·661 inches. During the last fortnight there was only one dry day, over 2 inches of rain falling in this period. The first frost of the season was registered on the grass on the 3rd, and in the shade on the 23rd.

November. — Unusually mild weather was experienced throughout, the mean temperature being 5° above the average, and the highest since 1881. Since 1764 only two milder Novembers have occurred, viz., those of 1818 and 1881, with mean temperatures of 47°·1 and 46°·3 respectively. Westerly winds blew well nigh persistently throughout, not a single observation of a N., N.E., or E. wind being recorded, whilst W. and S.W. blew on 22 days. Sunshine was abundant, and the greatest since 1879. Rainfall was only half the average, nearly all of which fell during the first fortnight. The unusual phenomenon of rain falling from a cloudless sky was observed on the 16th, at 11 P.M.

December.—The month was noteworthy for two exceptionally severe storms, each involving the loss of many lives both on land and sea. That of the 21st to 22nd was, if anything, the more remarkable of the two, the barometer falling to the low level of 28·12 inches at 6.30 A.M. of the 22nd, on which day the increase of pressure from 8 A.M. to 2 P.M. amounted to 1·02 inch, or 0·17 inch per hour. The following were the readings made at 9 A.M. and 9 P.M. on the three days covered by the two great storms of the month:—

Barometer at 32° and Sea-Level.

	9 A.M.	9 P.M.
December 21, . .	29·852 inches.	29·281 inches.
,, 22, . .	28·382 ,,	29·779 ,,
,, 23, . .	29·941 ,,	29·930 ,,
December 27, . .	30·577 inches.	30·624 inches.
,, 28, . .	30·018 ,,	29·284 ,,
,, 29, . .	28·939 ,,	29·249 ,,

The month was very dull, only 17 hours' sunshine being registered. Temperature was 3° above the average, while the rainfall was slightly below the mean.

NOTEWORTHY PHENOMENA IN THE METEOROLOGY OF 1894.

Highest barometric reading 30·759 inches, on January 3rd, at 9 P.M.

Lowest barometric reading 28·121 inches, on December 22nd, at 6 A.M.

Highest temperature in shade 77°·5, on July 6th, at 1 P.M.

Lowest temperature in shade 13°·9, on January 6th, at 8.30 A.M.

Greatest range of temperature 31°·4, on March 29th.

Least range of temperature 2°·7, on July 25th.

Highest temperature in sun's rays (black bulb thermometer in *vacuo*) 130°·4, on July 6th.

Greatest excess of sun maximum over shade maximum 63°·3, on May 29th.

Lowest temperature on grass 9°·0, on January 6th.

Greatest difference between minimum on grass and in shade 9°·1, on November 2nd.

Sunniest day June 21st, with 15 hours 6 minutes bright sunshine, being 87 per cent. of the total possible.

Stormiest day February 5th, average velocity of wind 25 miles per hour.

Greatest daily rainfall 1·47 inch, on February 16th.

	Barometer at 32° and Sea-Level.					Temperature in Shade 4 Feet above Grass.									
	Mean.	Diff. from Average, 1854-93.	Highest.	Lowest.	Monthly Range.	Mean.	Diff. from Average, 1764-1893	Highest.	Lowest.	Monthly Range.	Mean of Maxim	Mean of Minim.	Mean Daily Range.	Greatest Daily Range.	Mean Daily Variability.
	Inches.	Inches.	Inches.	Inches.	Inches.	°	°	°	°	°	°	°	°	°	°
January, .	29·650	− ·148	30·759	28·938	1·831	38·0	+1·3	51·7	13·9	37·8	42·8	33·3	9·5	18·5	4·4
February, .	29·755	− ·126	30·466	28·316	2·150	40·4	+2·0	54·5	26·1	28·4	45·7	35·1	10·6	17·7	3·6
March, .	29·821	− ·033	30·509	28·789	1·720	44·1	+3·9	64·3	30·1	34·2	51·3	36·9	14·4	31·4	2·4
April, . .	29·878	− ·038	30·423	29·291	1·132	47·6	+2·8	63·8	34·3	29·5	54·6	40·7	13·9	23·4	2·7
May, . .	29·941	− ·001	30·519	29·466	1·055	47·1	−2·9	64·1	32·0	32·1	54·2	40·0	14·2	26·2	2·4
June, . .	29·971	+ ·025	30·477	29·561	0·916	54·7	+0·7	74·1	38·7	35·4	62·0	47·4	14·6	22·9	2·2
July, . .	29·832	− ·055	30·342	29·188	1·154	59·0	+0·3	77·5	46·5	31·0	65·7	52·2	13·7	21·4	2·1
August, .	29·826	− ·040	30·323	29·074	1·249	56·9	−0·9	68·1	44·4	23·7	63·7	50·1	13·6	19·8	2·0
September,	30·220	+ ·349	30·578	29·851	0·727	52·2	−1·4	65·9	37·2	28·7	58·3	46·0	12·3	21·0	1·9
October, .	29·926	+ ·104	30·497	28·646	1·853	46·4	−0·8	64·4	28·1	36·3	52·6	40·1	12·5	21·2	3·1
November,	29·786	− ·064	30·528	28·802	1·726	46·0	+4·9	60·3	30·4	29·9	50·6	41·3	9·3	13·8	3·3
December,	29·854	+ ·041	30·642	28·121	2·521	40·9	+2·8	56·2	27·6	28·6	45·6	36·2	9·4	19·2	3·2
Year, . .	29·872	+ ·002	30·759	28·121	2·638	47·8	+0·9	77·5	13·9	63·6	53·9	41·6	12·3	31·4	2·8

	Rainfall.				Cloud 0–10.			Solar Radiation. Black Bulb in *Vacuo*.			
	Total.	Diff. from Average 1868-93.	No. of days ·01 in. or more fell.	Maxim. Fall in 24 hours.	9 A.M.	9 P.M.	Mean.	Maxim. in Sun.	Mean.	Average excess over Shade Maxim.	Greatest excess over Shade Maxim.
	Inches.	Inches.		Inches.				°	°	°	°
January, . . .	2·47	+0·04	20	0·45	6·6	4·7	5·6	76·0	55·6	12·8	36·6
February, . .	6·81	+4·84	21	1·47	7·1	5·3	6·2	90·8	68·4	22·7	45·7
March, . . .	1·71	−0·26	13	0·37	4·8	3·4	4·1	107·1	89·0	37·7	48·9
April, . . .	1·75	−0·31	15	0·44	7·5	5·9	6·7	117·2	93·7	39·1	56·8
May, . . .	3·20	+1·11	22	0·56	7·9	6·2	7·0	124·1	101·3	47·1	63·3
June, . . .	2·65	+0·55	14	0·81	7·9	6·5	7·2	124·3	108·5	46·5	58·5
July, . . .	2·83	−0·53	19	0·62	8·9	8·0	8·4	130·4	114·7	49·0	61·8
August, . . .	3·83	+0·35	17	1·24	7·7	7·0	7·4	128·5	113·7	49·9	62·7
September, . .	0·48	−2·44	11	0·12	6·8	6·3	6·6	115·0	95·1	43·1	53·7
October, . . .	2·79	+0·39	18	0·45	6·9	5·6	6·2	105·4	82·6	30·0	50·4
November, . .	1·43	−1·21	15	0·45	5·8	4·3	5·0	103·5	77·6	27·0	48·9
December, . .	2·25	−0·23	18	0·76	7·3	5·6	6·4	75·2	54·5	18·9	23·8
Year, . . .	32·20	+2·31	203	1·47	7·1	5·7	6·4	130·4	87·9	34·0	63·3

	Terrestrial Radiation.				Horizontal Air Movement.			
	Minim. on Grass.	Mean.	Average Diff. from Shade Minim.	Greatest Diff. from Shade Minim.	Total.	Mean Hourly Velocity.	Maxim. in 24 hours.	Mean Wind Force, 0–12.
	°	°	°	°	Miles.	Miles.	Miles.	
January,	9·0	29·1	−4·2	−7·6	6,953	9·3	551	1·47
February,	23·9	31·7	−3·4	−6·0	7,564	7·6	585	1·35
March,	26·2	32·5	−4·4	−8·3	4,618	6·2	570	0·82
April,	30·3	37·2	−3·5	−8·0	2,598	3·6	196	0·72
May,	27·5	36·9	−3·1	−6·5	4,187	5·6	240	1·00
June,	33·0	44·9	−2·9	−6·0	3,049	4·2	215	0·81
July,	41·5	50·5	−1·7	−6·8	3,331	4·4	224	0·86
August,	39·4	47·2	−2·9	−8·9	4,217	5·7	275	0·96
September,	33·0	41·4	−4·6	−8·3	2,015	2·8	255	0·51
October,	23·1	36·1	−4·1	−7·7	2,887	3·9	252	0·71
November,	24·3	36·1	−5·2	−9·1	5,427	7·5	366	1·24
December,	23·5	32·7	−3·5	−8·3	5,570	7·5	495	1·62
Year,	9·0	38·0	−3·6	−9·1	52,416	6·0	585	1·00

	Relative Humidity. Saturation = 100.					Tension of Vapour.			Weight of Vapour in Cubic Foot of Air.	Rainband 0–6.		
	9 A.M.	9 P.M.	Mean.	Max.	Min.	9 A.M.	9 P.M.	Mean.		Mean.	Max.	Min.
	°/₀	°/₀	°/₀	°/₀	°/₀	Inch.	Inch.	Inch.	Grains.			
January, . .	79·5	81·0	80·2	99	49	·188	·190	·189	2·11	1·03	2·0	0·5
February, . .	83·9	82·2	83·0	100	34	·203	·208	·206	2·37	1·11	2·0	0·5
March, . . .	84·1	78·6	81·4	98	32	·224	·216	·220	2·52	1·02	2·0	0·5
April, . . .	78·9	83·0	81·0	96	37	·263	·250	·257	2·99	0·98	1·5	0·5
May, ...	73·8	81·4	77·6	96	38	·244	·242	·243	2·78	1·17	3·0	0·5
June, ...	73·5	85·3	79·4	98	44	·339	·336	·338	3·79	1·24	2·5	0·5
July, ...	79·6	85·9	82·8	100	42	·394	·391	·392	4·21	1·20	3·0	0·0
August, . . .	77·6	84·8	81·2	96	52	·361	·356	·358	4·00	1·15	2·5	0·0
September, . .	79·9	85·3	82·6	98	40	·311	·318	·314	3·51	1·10	1·5	0·5
October, . . .	83·7	87·3	85·5	100	39	·273	·269	·271	3·10	1·38	3·5	0·5
November, . .	83·5	83·0	83·2	100	51	·262	·253	·257	2·94	1·20	2·0	0·5
December, . .	84·9	84·4	84·6	100	55	·224	·214	·219	2·51	1·32	3·0	0·5
Year, ...	80·2	83·5	81·8	100	32	·274	·270	·272	3·07	1·16	3·5	0·0

	Hourly Values of Bright Sunshine for Hour ending Greenwich Time.																	Per Cent. of possible Duration.	Greatest in One Day.	Greatest Percentage of possible in One Day.	Days with None.
	A.M.								P.M.								Total.				
	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8					
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs	%	Hrs.	%	
January, .	...	...	...	...	...	0·42	7·10	8·56	9·32	7·91	5·93	0·90	...	...	...	...	40·1	17	4·4	55	15
February, .	...	...	...	...	0·60	5·03	8·74	7·98	8·47	8·03	6·69	5·47	2·47	...	...	...	53·4	20	7·6	73	9
March, .	...	...	0·08	4·86	16·33	18·60	20·52	20·44	17·75	18·00	18·74	19·93	13·47	2·13	...	...	170·9	47	10·4	81	2
April, . .	...	0·28	3·32	6·91	9·42	7·98	9·50	10·91	9·77	10·48	10·77	11·27	10·25	9·39	1·15	0·03	111·4	26	10·5	71	6
May, . .	0·86	9·58	12·33	10·53	9·47	10·86	11·07	11·78	15·27	14·41	12·22	13·13	13·33	13·00	11·98	2·17	170·0	33	14·5	87	6
June, . .	3·63	6·55	8·07	9·81	10·50	8·08	7·02	10·58	10·81	9·98	11·08	11·02	10·11	9·36	9·98	5·94	142·6	27	15·1	86	7
July, . .	1·67	4·23	6·00	8·47	8·05	8·10	7·90	10·11	9·25	12·23	10·86	11·28	10·55	10·45	9·48	3·42	132·0	25	11·4	66	3
August, .	0·37	2·08	4·85	6·32	10·28	11·81	10·64	10·61	14·19	13·41	13·61	11·93	9·78	8·74	4·78	0·23	133·6	29	10·5	72	1
September,	...	...	0·23	2·11	7·78	9·28	10·67	9·67	9·75	9·78	8·44	11·37	7·52	4·02	0·41	...	91·0	24	10·3	78	6
October, .	...	...	...	...	2·03	7·91	7·56	8·55	11·36	12·72	8·42	4·83	0·83	...	...	...	64·3	20	6·3	59	6
November,	...	...	...	...	...	7·80	14·93	15·52	13·86	10·80	9·27	0·55	...	...	...	...	74·7	30	6·1	72	7
December,	...	...	...	...	...	...	1·30	2·93	6·55	4·67	1·78	...	...	...	...	...	17·2	8	4·2	61	15
Year, . .	6·53	22·72	34·88	49·01	74·46	95·87	116·95	127·64	136·35	132·42	117·81	101·68	78·31	57·09	37·78	11·79	1201·2	27	15·1	87	83
	528·06 hrs.								673·23 hrs.												

	Wind from Observations made at 9 A.M. and 9 P.M. Number of Days it blew from certain directions.									Number of Times the following Phenomena were observed.													
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.	Solar Halos.	Lunar Halos.	Rainbows.	Thunder-storms.	Lightning.	Aurora.	Snow.	Hail.	Frost in Shade.	Frost on Grass.	Mist.	Mist on Arthur's Seat.	Gales.
January,	1	1	3	1	3	7	12	1	2	3	6	0	1	0	0	11	6	13	21	0	0	4
February,	0	0	1	2	1	6	16	1	1	4	2	1	2	1	1	3	3	7	15	0	2	7
March,	1	3	2	1	2	5	13	1	3	3	1	0	1	0	2	1	1	3	16	3	5	3
April,	1	3	8	9	1	3	2	0	3	2	1	1	1	0	0	0	1	0	2	3	7	0
May,	5	3	6	1	2	2	8	4	0	4	0	1	1	0	1	2	7	1	6	1	4	0
June,	2	3	8	2	1	2	9	3	0	3	0	1	2	0	0	0	1	0	0	1	8	0
July,	1	3	8	0	1	2	14	1	1	4	0	1	5	0	1	0	2	0	0	6	12	0
August,	0	0	5	1	0	3	18	4	0	0	0	0	2	0	0	0	0	0	0	0	3	0
September,	3	2	14	1	0	1	4	3	2	0	0	0	0	0	0	0	0	0	0	1	4	0
October,	3	2	6	5	2	0	9	2	2	1	2	0	0	0	0	0	1	3	9	0	4	0
November,	0	0	0	1	3	10	12	2	2	0	0	0	0	0	1	0	0	1	9	1	1	1
December,	1	0	2	2	1	4	15	4	2	1	3	0	0	0	0	1	0	9	16	3	4	4
Year,	18	20	63	26	17	45	132	26	18	25	15	5	15	1	6	18	22	37	94	19	54	19

VII. *On the Occurrence of* Sphenopteris communis, *Lesqx., in Britain.* By R. Kidston, F.R.S.E., F.G.S. [Plate I.]

(Read 20th March 1895.)

For some years I have had in my possession specimens of a sphenopteroid fern from the Yorkshire Coal Field, which, from its fragmentary condition, I was unable to satisfactorily determine; but about two years ago I received from Dr Hind, Stoke-upon-Trent, more perfect specimens of the same species, from the Potteries Coal Field, Staffordshire, from which I was enabled to identify my fern as the *Sphenopteris communis*, Lesqx.

There is often considerable difficulty in identifying Carboniferous ferns, and I think this is specially felt in connection with the sphenopteroid members of that class when dealing with figures and descriptions unassisted by authentic specimens; and it was only through the study of examples of *Sphenopteris communis*, Lesqx., from Washington County, Arkansas, kindly sent me by Mr R. D. Lacoe, Pittston (to whom I have to express my indebtedness in this, as on many other occasions, for similar help), that I recognised that the Staffordshire and Yorkshire specimens belonged to that species.

Before describing the fern, it is desirable to make a few remarks on the horizon from which the American specimens were derived.

In the "Coal Flora of Pennsylvania," by the late Mr Leo Lesquereux, vol. ii., p. 667, 1880, he gives, in chapter v., a "Geographical Distribution of the Plants of the United States Coal-Measures." This chapter is preceded by a "Table of Vertical Distribution," and in the introductory remarks to the table he gives a synopsis of the various horizons.[1]

It is not my intention to analyse this table, but only to refer to some of the divisions which refer to the geological position of the American specimens of the plant under discussion.

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[1] *Loc. cit.*, p. 636.

The two principal divisions given by Lesquereux are :—

I. Pre-Carboniferous.
II. Coal-Measures proper.

These are further divided as follows :—

I. Pre-Carboniferous.
  1. Devonian.
  2. Pocono Sandstone.
  3. Sub-Conglomerate.
  4. Inter-Conglomerate.

II. Coal-Measures proper.
  1. Anthracite Fields.
  2. Bituminous Fields.

In vol. iii. of the same work,[1] at page 883, a table brought up to date of publication is given, showing the distribution of the plants described in the three volumes on the United States Coal Flora. This is prefixed by "A List of the Species of Fossil Plants found at each Locality."[2]

Turning to the plants recorded from the Sub-Conglomerate of Arkansas,[3] from "various coal-beds of the same horizon," we find included the *Sphenopteris communis*, Lesqx. Associated with it are species, some of which in Britain, and, I believe, in Europe generally, are characteristic of, and restricted to, the Lower Carboniferous, and along with these a greater number of species which in Europe are characteristic of Upper Carboniferous Rocks, and to the Lower and Middle Coal-Measures of that division.

Such an admixture of species is so contrary to what Carboniferous Palæobotany has taught us in Europe, that one cannot help suspecting that beds of very different ages, and which belong to more than one series, have been classed together under the term of Sub-Carboniferous, and it appears to me that some of the rocks included by Lesquereux under this name belong to his "*Coal-Measures proper.*"

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[1] Published in 1884.

[2] *Loc. cit.*, vol. iii., p. 849.

[3] *Loc. cit.*, p. 854.

The Staffordshire specimens of *Sphenopteris communis* came from the Lower Coal-Measures, and the Yorkshire examples belonging to the same species originate from the Middle Coal-Measures, and were collected by Mr W. Hemingway.

SPHENOPTERIS COMMUNIS, Lesqx.

[Plate I.]

1884. *Sphenopteris communis*, Lesqx., Coal Flora, vol. iii., p. 762, pl. civ., figs. 1, 1*a*.

Description.—Frond tripinnate or decompound; primary (?) pinnæ oblong lanceolate, close together; secondary pinnæ linear, lanceolate, touching or slightly overlapping, and containing 9 to 12 tertiary pinnæ. Tertiary pinnæ oblong, with rounded apices, and bearing oblong or rounded convex pinnules more or less united to each other, or separated almost to the rachis on which they are decurrent. Veins distinct, bifurcating, somewhat distant, and running to the margin of the pinnule, which is slightly crenulate. Pinnules with roughened surface, probably caused by the presence of short, rigid, adpressed hairs. Rachis broad. Fructification indistinctly preserved on the Staffordshire specimens.

Remarks.—The upper surface of the pinnules have a dull appearance, which, when examined under the lens, seems as if caused by the presence of numerous close, rigid, short, adpressed hairs. The pinnules have very much the villose appearance which is seen on many species of *Pecopteris* belonging to the Cyatheites group (Fig. 5).

This character is not mentioned in the description given by Lesquereux, but is clearly seen on the specimens of *Sphenopteris communis* received from Mr Lacoe. The nervation is slightly flexuous and indented, and it is this character which produces the crenulate margins of the pinnules. The pinnules form a decurrent margin on the rachis, but the rachis of the primary pinnæ on all my specimens is embedded in the matrix, so I am unable to ascertain whether it was winged or naked, though I am inclined to think it was not winged, as I cannot discover this character on the corresponding pinnæ of my American specimens. On the fruiting specimens, which, however, are not very distinctly preserved, the rachis does not show any wing so far as I have been able to observe, but it is very broad.

Fig. 4 gives an enlarged figure of a fruiting-pinna, and though badly preserved, it shows the general arrangement of the sporangia, from which one might be led to believe that the fern was *Calymmatothecous.* From the imperfect condition of the specimen, one cannot, however, risk any conclusive opinion on this point, for some of the pinnæ seem to indicate a gradual reduction of the limb, which seems to have entirely disappeared from those pinnules which bear the sporangia; but even in these cases the apparent disappearance of the limb may be due to imperfect preservation.

My thanks are due to Dr Hind and to Mr W. Hemingway for the specimens which form the subject of this communication.

Horizon.—Lower Coal-Measures. From bed below the *Moss Coal.*

Locality.—Lane End, Fenton, Staffordshire (Potteries Coal Field) (Dr Hind).

Horizon.—Middle Coal-Measures. Shale over *Barnsley Thick Coal.*

Locality.—Monckton Main Colliery, near Barnsley, Yorkshire (W. Hemingway).

EXPLANATION OF PLATE.

Fig. 1. *Sphenopteris communis,* Lesqx. ; nat. size (Reg. No. 2081).

Figs. 2 and 3. Tertiary pinnæ enlarged 4½ times to show pinnule cutting and nervation.

Fig. 4. Fruiting-pinna ; enlarged 4 times (Reg. No. 2083).

Fig. 5. Surface of barren pinnule showing short adpressed hairs ; enlarged.[1]

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[1] The figured specimens are in the author's collection.

VIII. Diomedea melanophrys *in the Færöe Islands.* By KNUD ANDERSEN, Esq. Communicated by W. EAGLE CLARKE, F.L.S., as requested. [Plates II., III.]

(Read 17th April 1895.)

[The following paper was forwarded to Mr Harvie-Brown, by the author, accompanied by the stipulation, if it came to be communicated and printed, that it must be printed *in extenso;* and was, with that understanding, offered to the Society.]

In the month of May 1894, Mr P. F. Petersen of Nalsoe, Færöe Islands, sent me an account of an Albatross, shot on Myggenaes Holm, which had been living there together with the Gannets for more than thirty years. Up to the time of writing, Mr Petersen had obtained no further information, especially with regard to the remarkable length of time during which it had been observed. In the beginning of July I received the skin of the bird. It proved to be a *Diomedea melanophrys*, Boie, fully adult, in very fine plumage. When I got it, it was perfectly fresh, and beautifully prepared by Mr Petersen. At the same time, I was informed that the removed body had not been preserved.

Immediately on receiving the bird, I sent to Mr Petersen a schedule containing a list of questions, intending to procure the fullest intelligence possible as to the life of the bird, but especially the reasons for asserting that it had lived on Myggenaes Holm during such a length of time. The answers reached me in the beginning of November, accompanied by a letter from Mr Petersen, stating that he had sent my questions to Myggenaes, where they had been answered by Mr S. J. Joensen, a resident of that island.

The schedule was filled in as follows:[1]—

"1. When was the Albatross shot?—It was shot on the 11th of May.

"2. Where was it shot?—It was shot on Myggenaes Holm itself, sitting among the Gannets.

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[1] Nos. 3 and 4 are answered by Mr Petersen of Nalsoe, the rest by Mr S. J. Joensen of Myggenaes.

"3. Is it a male or a female?—A female.

"4. In the latter case, had it then fully-developed ovaries?—When opening the bird, I found the ovaries almost fully developed.

"5. Has only one person, or have several, observed the bird during the period of thirty years?—Many persons have observed the bird during a period of thirty-four years.

"6. Did it remain on, or near, Myggenaes during all these years, or did it, perhaps, roam among the islands?—For aught I know, it has lived only on or near Myggenaes Holm during all this time.

"7. Did it stay at Myggenaes all the year round, or did it leave at certain seasons, returning again regularly at other times?—It stayed at Myggenaes only from spring to autumn, coming and leaving regularly with the Gannets.

"8. Is it ascertained if there was only the one specimen?—It is supposed that there was but one bird of the kind, as only one has been seen at the same time.

"9. This being the case, and supposing the bird to be a female, is it known whether it has been nesting or breeding?—Nobody has seen it nesting or breeding, but it cannot be stated with any degree of certainty, as it always has lived among the Gannets, who are generally let alone from the beginning of the breeding season until the young are fledged.

"10. Is it known what its food consisted of?—No, it is absolutely unknown.

"11. Did it show any inclination to follow vessels or boats?—It showed no inclination to follow small boats; whether it ever followed vessels is unknown.

"12. Was it usually silent, or has any one ever heard its cry? In the latter case, can the sound of it be expressed by letters or in any other way?—It was silent, when observed; its cry has never been heard.

"13. Am I to understand that it both lived with the Gannets and was seen flying with them, or did it also seek the company of other birds? In this case, of which? Or did it, perhaps, seem to prefer being alone?—It lived with the Gannets, and flew together with them.

"14. Was it ever seen swimming or diving?—No.

"15. Has any attempt been made to shoot it before now? —No.

"16. Was it very shy, or was it possible to approach it? —It was not more shy than the Gannets.

"17. Was it known during all these years to be an Albatross? Or was it only discovered lately?—It has not been known as an Albatross until it was shot.

"18. Is any one sure of the time when the bird was first seen in the Færöe Islands; or why is it stated to be just or about thirty years, neither more nor less?—It may be stated on good authority that it was seen on Myggenaes Holm for the first time in April or May 1860; this year, 1894, being thus thirty-four years since it first was observed.

"19. Is it known whether the colour of its plumage had changed during this period? For instance, whether the colour was darker many years ago?—The colour has been the same during its stay here.

"20. Is it possible to tell more about the bird than has been inquired about here?"

There was no reply to the last question.

Mr Petersen enclosed the following letter, received from Mr Joensen together with the above-named answers:—

"MYGGENAES, *Oct.* 13*th* 1894.

"Having received some questions about the Albatross of Myggenaes, I write the following. . . . Herewith I enclose the answers to the questions, that you may learn what I know about it.

"I have also seen another letter[1] containing questions referring to the Albatross. The letter was not addressed to me, but the questions were similar to yours. The writer, however, wanted the names of persons who had seen this bird during its long stay here, as also the name of the man who shot it. It was shot by Johannes Frederik Joensen, and seen by Samuel Joensen, Jacob Jensen, Jacob Jacobsen, Hejne Jorgensen, Joen Joensen, jun., Joen Abrahamsen, Poul

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[1] The above-mentioned letter was sent by Mr Bergh, H.B.M. Vice-Consul at Thorshavn, to the Rev. Johansen, Vaagoe, who forwarded it to Myggenaes; *cf.* p. 94.

Abrahamsen, Jacob Isaksen, Daniel Joensen, and others, who have observed it constantly during a period of thirty-four years.

"Furthermore, I wish to tell you that in September 1891 a curious young Gannet was caught; it was of a lighter grey than the young Gannets, and had a bill like that of the Albatross—its wings resembled those of the Gannets. The men who saw it were surprised, and they believed it to be the young of that bird.

"It was not known to be an Albatross until it was shot. The old folk called it the 'Sulkonge' [Gannet King].

"SAMUEL JOHANNES JOENSEN."

These two reports give most reliable information. I have had no hesitation in giving Mr Joensen's answers and his letter in full, as both form and contents show how impartial his words are, and how exact and conscientious he has been in writing down what he knew, neither more nor less.

Long before I received above replies to my questions, Mr L. Bergh, H.B.M. Vice-Consul at Thorshavn, promised me his valuable assistance in investigating the subject. In the following, Mr Bergh reports the results of his investigations:—

"THORSHAVN, *Oct. 22nd* 1894.

"Your letter of the 13th ult. is to hand, and I shall be happy to give you the information I have succeeded in obtaining up till now.

"I was so fortunate as to meet a very reliable man from Myggenaes, by name of Jacob Isaksen, Kongsbonde, on the island, fifty years of age. He declared that he was perfectly certain that the Albatross had been at Myggenaes during thirty years at least, as he was about twenty when he first saw it and heard people speaking of it. Since that time he has seen it every year. It migrated with the Gannets regularly every autumn, returning with them in the spring.

"More than this one specimen has never been seen.

"It has never been seen nesting or breeding.

"It lived among the Gannets on the rock, but whenever it approached they always moved away to make room for it, and, according to his statement, it seemed to be among them only on sufferance; friendly relations did not appear to exist.

"He has never seen it flying across the island, but often over the sea, though never diving.

"People did not like shooting it, but often tried to catch it alive, although they never succeeded. When anyone came to the bird's rock at night, it was always awake, and very shy when approached, while the Gannets remained sleeping in their nests and were easily caught.

"A young man of Sorvaag, Vaagoe, Hans Pauli Hansen by name, now married on the island of Myggenaes, observed it last summer sitting on a projecting rock. He aimed at it, without really intending to shoot it, but, though the distance was considerable, he hit it, and it fell down dead.

"He had no further particulars to give as to its life and habits.

"There is no doubt about the bird having lived at Myggenaes during a period of at least thirty years. I also distinctly remember having heard of the 'Sulekonge,' as it was usually called, shortly after coming to Thorshavn School, more than twenty-seven years ago.

"As the Myggenaes people but rarely visit Thorshavn, and hardly ever during the winter, I have written to the minister at Vaagoe, if possible to investigate the subject further. As he, however, does not visit Myggenaes until next summer, he has sent your questions to a reliable man on the island, but it is very uncertain when I shall receive the answers to them.

"For the present I send you above particulars: when I learn more about the subject, I shall write you again.

"LOUIS BERGH."

As will be noticed, this account agrees with that of Mr Joensen, except in one point of no great importance—the name of the man who shot the bird is different.

But even this little difference was removed quicker than might have been expected. In December I obtained, through Mr Bergh, the report of the investigations made by the

Rev. Mr Johansen of Vaagoe. They are written by a man at Myggenaes, Mr Joen Abrahamsen, one of those who for years have watched the Albatross, and run as follows:—

"1. It is a fact that it was observed for the first time in 1860 by a party consisting of twelve or fourteen men, who came to Myggenaes Holm in the spring in search of Gannets. Since then it has been seen every year, especially by those who have been there to catch Gannets. That the period of its stay there is not stated at random may be proved by the fact that Kongsbonde Jacob Jensen saw it for the first time in 1860, when hunting Gannets, a year after his confirmation.

"2. No attempt has been made to shoot the bird during the period of its stay here, but attempts have been made to catch it at night, as the Gannets are caught; but as it has not been found among them at night, this has always been a failure. However, it was again seen with the Gannets in the morning. It was once caught with the hands alone. Men also attempted to catch it with the 'Flejestang,'[1] and nearly succeeded. The most important reason why no attempt had been made to kill it, was, that it always stayed with the Gannets, who, as well known, change the colour of their plumage several years during their growth from young to adult. In colour it therefore greatly resembled one sort of Gannet, its wings and bill only being different. For this reason most people took it for a strange Gannet: Albatrosses they had never heard of."

[3. The report of the spring and autumn migration repeated.

4. Only one Albatross has been seen.]

"5. Whether it has ever been nesting or breeding cannot be stated with any degree of certainty; it is supposed not to have done so, because nobody has seen it do so; people, however, do not like to disturb the Gannets from the time they are breeding until the young birds are about fledged.

"6. Many people have seen it, among others Jacob Jensen, Kongsbonde; Jacob Jacobsen, sen., Odelsmand; Joen Joensen, Joen Abrahamsen, Jacob Isaksen, Samuel J. Joensen. It

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[1] The well-known implement used in the Færöes to catch sea-birds with—a very long stick, furnished with a peculiarly-shaped net.

was shot by Johannes Frederik Joensen. These men are all from Myggenaes." [The last-named man is undoubtedly the right one. Mr Bergh has afterwards obtained confirmatory evidence from another source.]

"7. As to its mode of life, especially its food, nothing is known. It has lived by turns in different parts of the islet: during the first years it resorted mostly to the northern part, where the Gannets are found in the greatest number, but lately it has been seen more frequently in the western part, which is not so much occupied by the Gannets. And here it was shot from a boat under the rock, when sitting among the Gannets' nests."

SPECIFIC CHARACTERS.

Diomedea melanophrys belongs to a small section of Albatrosses (*Thalassarche*, Rchb.), that may be distinguished as follows:—the bill is considerably compressed; the culminicorn meets behind the rhinothecæ with the latericorn; the latter is broader at the base than in the middle. Only four species of this group have hitherto been described: *D. melanophrys*, *D. immutabilis*, *D. irrorata*, and *D. gilliana* (whose right to be included in this group is, perhaps, doubtful). When determining the species of the Færöe bird, the last two species may be left out entirely.

It has been questioned, however, by Mr J. A. Harvie-Brown (*The Zoologist*, September 1894, pp. 337, 338), whether the Myggenaes Albatross could be a *D. melanophrys* or a *D. immutabilis*. Consequently it will be necessary to examine a little closer into this question, and first of all to establish the points of difference between these two species.

D. immutabilis,[1] that breeds in the island of Laysan in the Pacific Ocean, has just been established as a species in 1893 by the Hon. W. Rothschild. In the very short original description (*Bull. Brit. Orn. Club*, No. ix., June 1st, 1893; in *Ibis*, 1893, p. 448), the following points are of importance

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[1] I have not seen any specimen of this species. It is figured in Mr Rothschild's Avifauna of Laysan, but this work has not been accessible to me.

as distinguishing characters:—(1) in *D. immutabilis* the first plumage of the young resembles that of the adult, in *D. melanophrys* the two plumages are different; (2) in *D. immutabilis* the bill is "grey, darker at base, tip blackish-brown, base of under mandible pale yellow." The bill of the adult *D. melanophrys* is yellow, the tip of the upper mandible only being often slightly darker.[1] All other points in Mr Rothschild's description of *D. immutabilis*, both with regard to colour and measurements, appear to me to apply just as well to *D. melanophrys*. It is evident that the two species are very closely allied; if they really are "species" is—at all events in this connection—of comparatively subordinate importance; the main thing is, that the two forms are separable. The first of the above-mentioned marks of distinction, important as it is in itself, is, of course, not applicable at the determination of the species of the Færöe bird; but with regard to the second, the latter bird corresponds exactly with *D. melanophrys*. This point must then be decisive, and, according to my opinion, it excludes all doubt as to the species of the Myggenaes Albatross.

The colouring of the Færöe *D. melanophrys* is as follows:— ♀ ad. (May 11): Head, neck, wings, upper tail coverts, and entire under surface, white. A well marked, dark transocular fascia, in front, over, and behind the eyes; this streak extends, in front of the eyes, to a greyish-black patch, slightly marked in front and below, where it gradually shades into white; over the eyes the streak is black, behind them blue-grey, by and by shading into the white colour of the head. Back, greyish-black, paler in front, washed with bluish-grey, and here gradually shading into the white colour of the neck. Quills and wing coverts black; shafts

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[1] It is possible that a third mark of distinction might be alleged, viz., Mr Rothschild writes of *D. immutabilis* (*loc. cit.*): "space in front of the eye sooty black," but does not mention that this spot continues in a streak over and behind the eyes. It is not quite clear to me if from this may be inferred, that this stripe is constantly wanting in the Laysan Albatross. *D. melanophrys* has, as is well known, a dark eyebrow stripe, that often extends to a spot in front of the eyes; sometimes—but not in the Færöe bird—this marking is entirely wanting.

of quills whitish in the middle, tipped with black; the transition between these two colours formed by yellowish-white and brownish-yellow; under wing coverts mixed blackish and white. Tail greyish-black, paler, almost white at base; shafts of tail feathers pure white. Bill yellow, the tip slightly darker; the soft skin bordering the extreme base of the bill makes a very narrow dark line all around. Feet (in a dried state) yellowish-brown, interdigital membrane yellowish-white, claws yellow. The measurements are as follows:—

Bill, from frontal feathers; curve of culmen,	140·5	mm.
,, ,, ,, chord of culmen,	118·5	,,
,, from anterior border of rhinothecæ to tip of upper mandible; chord,	88	,,
,, lower mandible: from feathers on side to tip,	98	,,
,, width at anterior border of rhinothecæ,	20	,,
,, ,, middle,	13·5	,,
,, height at anterior border of rhinothecæ,	36·5	,,
,, ,, middle,	27	,,
Wing,	529	,,
Tail,	207	,,
Tarsus,	79	,,
Inner toe, without claw,	88	,,
Middle toe, ,, ,,	108	,,
Outer toe, ,, ,,	108·5	,,

The young in first plumage have the head and neck ash-grey, the bill blue-black. They are grey in down; bill brownish-black, tip paler; feet yellowish-white.

GEOGRAPHICAL DISTRIBUTION.

The observations as to the occurrence of the Albatrosses are scattered in many different places, but have never been collected into a general view of the distribution of the species. Only Professor Alph. Milne-Edwards (36)[1] has given some hints in this direction. Very often it is quite impossible, on the foundation of the scattered records, to draw the line between *habitual* distribution and *casual* occurrence. When, in the following, I have attempted to give an outline of the

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[1] This and similar figures refer to the "References," pp. 112-114.

geographical distribution of the present species,[1] it is—and can only be—a simple compilation of the present observations; even under the most favourable circumstances it will only be of value as a primary sketch, on which others, having access to richer and especially to more reliable materials, may build further. More detailed information may be found in the "References," pp. 112-114.

Atlantic Ocean.—On the eastern coast of South America, Sperling (22) observed it not farther north than lat. 24° S.; the "Novara" Expedition (v. Pelzeln, 13), however, met with it a few miles farther north, in lat. 23° 9′ S., about off Rio Janeiro (two specimens shot August 4, 1857); this latitude is, as far as hitherto known, the northern boundary for its distribution in these regions. Farther south, on the eastern coast, only few observations are found (Kittlitz, 5). Near the Falkland Islands it is often seen. Along the south-western coast of Africa it has been met with, almost exactly as far north as on the opposite side of the Atlantic: Andersson (25) has seen it not unfrequently in Walwich Bay (lat. 23° S.); farther south it is very common, but most numerous, certainly, at the southern extremity of Africa—Table Bay, Cape of Good Hope, False Bay, Cape Hanglip, and Cape Agulhas are localities often named. On the open Atlantic, Tschudi (4) saw it on his voyages not farther north than lat. 39° S., and not farther south than lat. 50°-51° S. The Zoological Museum of Copenhagen possesses, however, the skeleton of a specimen from lat. 37° 20′ S., long 7° 20′ W. (nearly east of Tristan da Cunha); and the "Novara" Expedition (v. Pelzeln, 13), records a specimen shot in lat. 36° 22′ S., 5° 29′ E. (between Tristan da Cunha and the southern extremity of Africa, September 20, 1857). Probably Hutton (16) has seen it still farther north, about lat. 34° S. (April 5), but the exact place is not stated. Thus, according to the hitherto recorded observations, the northern and

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[1] It is hardly necessary to observe, that, as far as the Albatrosses are concerned, I do not confine the meaning of the term "geographical distribution" only to comprise the breeding-places of the species, but understand it as synonymous with their usual range of distribution, both in and *outside* of the breeding season.

southern boundaries for the distribution of this species in the open Atlantic, are about lat. 34°-36° and 51° S. Gould (3) gives it in round numbers as 35° and 55° S. It seems, however, commonly to occur in greater numbers only between lat. 40° and 50° S. The northern range of *D. melanophrys* in the open Atlantic may thus, from the hitherto known observations, be fixed as off the southern extremity of Africa (lat. 35° S.), while, on the coasts of the ocean, it extends under lat. 23° S. Towards the south this Albatross has been seen, both in the open sea and along the coast, about as far as off the southern extremity of America.

Indian Ocean.—Off the southern part of the east coast of Africa *D. melanophrys* is very common. Sperling (22) records its northern range as lat. 26° S. It is included in the lists of the birds of Madagascar (Milne-Edwards and Grandidier, 34; Sibbree, 48). On the ocean itself, Layard (9) saw it north of Prince Edward and Crozet Islands (about lat. 41° S., long 46° E.). It has been observed several times in the vicinity of St Paul and Amsterdam (Schlegel, 11). The Zoological Museum of Copenhagen owns the skeletons of two specimens from lat. 38° S., long. 74° 20′ E., and of a third from lat. 38° 14′ S., long. 71° E. (*i.e.*, west of the above-named islands). Around Kerguelen Land it does not appear to be common; at all events it was not seen by the English, German, and American Expeditions to this place, undertaken to observe the transit of Venus in 1874-75 (Eaton, ap. Sharpe, 33); whereas the "Challenger" Expedition brought home two specimens from Christmas Harbour, on the northern side of the island (about lat. 49° S., January 1874; Salvin, 31; Sclater 37); south of Heard Island it was not seen (lat. 53° 10′ S.; Murray, ap. Sclater, 37). I do not know of any observations recorded from the open sea north of lat. 38° S. and south of lat. 53° S. Gould (2) mentions it among the birds of Western Australia, without giving any exact locality; Layard (10) saw it now and then off the southern coast of Australia, between Cape Leeuwin and Adelaide; Gould (3) found it nowhere more common than on the south coast of Tasmania.

Pacific Ocean.—On the eastern coast of Australia *D.*

melanophrys has been met with as far north as lat. 24° S., at Gladstone, Port Curtis, Queensland, though only on one occasion (Ramsay, 30). Between the Australian Continent and New Zealand it is very common (Layard, 9). It was first introduced into the avifauna of New Zealand by Finsch (15) in 1867, Finsch (27) and Buller (46) both considering it as one of the most common species of Albatross in the waters around New Zealand. It is, moreover, observed in nearly all groups of islands to the east and south (Kermadec, Chatham, Bounty, Antipodes, Auckland, and, farthest south, Campbell Islands, about 53° S.). Its range extends surely far north of these islands. Layard (29) includes it in the Fiji Island avifauna, but only because a specimen is said to have been met with at Kadavu (lat. 19° S.); farther north it has not been observed. From the wide stretch of water between New Zealand and South America, observations as to the occurrence of this bird are almost wanting. On the coast of Chili it is recorded from Talcahuano Bay (lat. $35\frac{1}{2}$° S.; Salvin, 39) and from Valparaiso (33° S., August 13, 1879; Sharpe, 35); the latter point seems to be the most northern locality where it has been observed on this coast; farther north, at Callao Bay, Peru (lat. 12° S.), occurs a closely allied species, *D. irrorata* (Salvin, *Proc. Zool. Soc.*, 1883, p. 430). Towards the south it ranges beyond the southern extremity of America, as it has been seen by Buller (50) near the island of Diego Ramirez (lat. 56° S.; March 16), by Tschudi (4) even in lat. 57° 20′ S., the most southern locality where the species has ever been observed.

D. melanophrys is said to have been met with twice far north of its usual range. The first case is mentioned by Bean (38): a specimen was seen, October 31, 1880, about 1060 miles west of Cape Mendocino, California, in lat. 40° 30′ N., long. 142° 23′ W. For this reason the species has been included in the lists of the North American avifauna. It is not quite certain, I think, that the bird observed by Bean was a *D. melanophrys* and not a *D. immutabilis*.[1]

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[1] *D. immutabilis* has its breeding-places in the island of Laysan in the Pacific (about lat. 26° N.; Rothschild, Proc. Zool. Soc., 1893, p. 505); moreover, it has been met with at Miyakeshima, Japan (about 34° N.; Rothschild, Ibis,

Regarding the second case, an account is written by Mr J. A. Harvie-Brown (*The Zoologist*, September 1894, pp. 337, 338). A specimen was killed, June 15, 1878, in lat. 80° 11′ N., long 4° E., *i.e.*, north-west of Spitzbergen; it was presented by Captain David Gray, of the steam whaler "Eclipse," to the Arbuthnot Museum, Peterhead. Mr Harvie-Brown informs me that this bird has not been compared with specimens of *D. immutabilis.*[1]

BREEDING-PLACES.

The first breeding-place known of this species was the Falkland Islands. Gould (6) gives, in 1859, a description of the eggs from this place, being in doubt, however, whether they belonged to *D. melanophrys* or to *Phoebetria fuliginosa.* Captain Abbott (8), who collected the eggs described by Gould, gives a further account of the matter a few years later, and it appears, from his reports, that the breeding-places he found were situated on some islets adjacent to (probably south of) East Falkland. Professor A. Newton (19) afterwards described the eggs of *D. melanophrys* from these islands; also the "Challenger" Expedition (Sclater, 32) brought home eggs from the same place.[2]

When Professor Alph. Milne-Edwards (36) names Tierra del Fuego among the breeding-places of this species, it is founded on a misunderstanding of Captain Abbott's report (*Ibis*, 1861,

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1894, p. 548). Judging only from the latitude (40½° N.) where Bean observed his Albatross, the chances would be greater for a *D. immutabilis.* In his description of the bird, Bean says: "The bill is light; a dark streak runs from the bill behind the eye;" to which of the two species these words apply best I shall not decide. If Bean's Albatross was a *D. melanophrys*, it is the only instance of its occurring in the Pacific north of the Equator.

[1] Mr Harvie-Brown has kindly sent me photos of this bird. As far as the colour of the bill can be guessed from photos, the Peterhead Albatross seems to me to be a true *D. melanophrys.*

[2] It is probable that Snow (Two Years' Cruise off Tierra del Fuego, 1857, vol. i., p. 140; vol. ii., p. 366) had already found this species breeding in West Falkland (Keppel Island). He does not, however, call the bird by its systematic name, but gives it the name of "Mollymauk," a name bestowed upon all southern Albatrosses with the exception of *D. exulans* (and *regia*) and *Ph. fuliginosa.* The few words he says about the nest agree with Captain Abbott's description.

p. 165). In this place Captain Abbott writes: "This Albatross is seldom seen in East Falkland, but breeds in large numbers in the adjacent islands." With "adjacent islands" Captain Abbott means surely the islets immediately south of East Falkland, and not the comparatively distant Tierra del Fuego.

Whether it breeds on Tristan da Cunha is very doubtful.[1] Mr Sperling (22), indeed, insists on having obtained eggs of *D. melanophrys* from this place; but he has evidently identified the bird from the eggs. The eggs of this species are, however, not to be distinguished with certainty from those of *D. chlororhyncha* (*cf.* Layard, *Ibis*, 1869, p. 377). Moseley ("Notes by a Naturalist," pp. 129, 130) calls the Mollymauk breeding on the Tristan group (Nightingale Island) *D. culminata*, though the colour of the bill, according to his description, seems rather to indicate *D. chlororhyncha*;[2] while Murray (ap. Sclater, 37) mentions it as *D. chlororhyncha.* The Albatross eggs collected on Nightingale Island and Tristan da Cunha by the "Challenger" Expedition are by Sclater (32) assigned to "*Diomedea sp. inc.*" In reality there is thus no other evidence than Sperling's, which rests on very weak foundation, for supposing that *D. melanophrys* breeds on the Tristan group.

Still smaller reason is there to believe that it breeds on the Prince Edward Islands. Milne-Edwards (36) certainly insists on it, but refers to Hutton only (*Ibis*, 1865, p. 283). Professor Hutton, however, says just the contrary: "It is never seen on the Prince Edward Islands." On Kerguelen Land it has never been found breeding.

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[1] Captain Carmichael (Trans. Linn. Soc., vol. xii., 1817, p. 489) mentions four species of *Diomedea* as breeding there: *spadicea, exulans, chlororhyncha,* and *fuliginosa;* as *spadicea* and *exulans* must be considered as synonymous, there are consequently but three in number. Carmichael's work appeared twenty-one years before Temminck published the description of *D. melanophrys.* When Hutton (12) nevertheless quotes the authority of Carmichael for stating that the latter species breeds on Tristan da Cunha, it is surely because Hutton is inclined to believe that *D. melanophrys, chlororhyncha,* and *culminata* are the same species.

[2] Possibly Moseley considers the *D. culminata* and *chlororhyncha* as synonymous; at all events the latter species is not named a single time in his "Notes" from the "Challenger" Expedition.

It is certain, however, that breeding-places are found on some islands in the vicinity of New Zealand. Mr Dougall (Buller, 46) found it breeding in the Auckland, Campbell, and Antipodes Islands; in the Campbell Islands hundreds of nests were seen, at from about 700 to 1000 feet above sea-level. Mr Potts (26) also mentions it as breeding in the Aucklands; Buller ("Birds of New Zealand," vol. ii., 1888, p. 197) also names the Bounty Islands. Probable breeding-places are the Kermadec Islands (Cheeseman, 47) and the Chatham Islands (Travers, 21, Pitt Island; Buller, 50).

Captain Abbott (8) describes the nest as "raised of mud to nearly a foot high from the ground." Dougall (ap. Buller, 46) says, on the contrary, that it is "built up of moss and earth about four inches above the surface of the ground"; the material of which the nest is made is "so taken from the soil as to leave a trench all round it, and this keeps things dry."

The eggs mentioned by Professor A. Newton (19) were "white, with blotches, a few spots and multitudinous specks of reddish-brown," the markings being especially collected at the larger end; their size was 4·05 × 2·61, and 4 × 2·57 inches. The larger of two eggs measured by Buller was 4·3 × 2·2 inches. The period of incubation is said to be sixty days (Dougall, ap. Buller, 46).

THE ALBATROSS OF MYGGENAES HOLM.

After the detailed reports of Mr Bergh, British Vice-Consul, and of Mr Joensen, it is evident that the Myggenaes Albatross has lived in the Færöe Islands for a period of thirty-four years. As might have been expected, the accounts do not mention how it came there. If this Albatross had only been seen or killed in the northern part of the Atlantic, there would have been nothing very extraordinary in such a fact; it would, in this respect, have had several predecessors: a *D. exulans* was killed at Dieppe about 1830 (Degl., *Orn. Eur.*, ii., p. 357); another near Antwerp, September 1833 (*Isis*, 1835, p. 259); a *D. chlororhyncha* was shot at Stockwith, near Gainsborough on the Trent, November 25, 1836 (*The Analyst,* vi., pp. 160, 161); another bird of the same species, at Vestmanoe, on the southern coast of Iceland, about 1843 (the skeleton in the Museum of Copenhagen); a *D. culminata* was caught on the ice, April 1837, at Fiskumvand, Eker, in Norway (preserved in the Christiania Museum). When we add the above-mentioned *D. melanophrys,* shot north-west of Spitzbergen in June 1878, it will be seen that, in the course of about fifty years, no less than six Albatrosses, of four different species, have occurred in the northern part of the Atlantic.[1] But in all these cases there is no reason to believe anything but that they have been accidental visitors. The case of the Myggenaes Albatross is, however, quite different: it is the only instance of a southern Albatross, not only flying far away from its home, but choosing a new home in a northern latitude, and settling among birds of a quite different species, and which year by year, for more than a generation, migrates and returns to the same spot. It is this that makes the case interesting, and makes it worth while regarding this rock in the far north more closely, to see what conditions of living it may offer to an Albatross.

Myggenaes Holm is the small islet—the most western of the Færöese—situated in the immediate neighbourhood of the western coast of Myggenaes, in lat. 62° 8′ N. In his classic "Forsóg til en Beskrivelse over Færóerne" ("Attempt at a Description of the Færöe Islands," Copenhagen, 1800), Jórgen Landt mentions it as follows (pp. 73, 74):—"Myggenaes Holm is situated to the west of Myggenaes, at a distance of 20 fathoms; it is evident that it has been torn from this island by some revolution of Nature; the islet is nearly a mile in length and 1600 feet wide, and consists of closely joined basaltic rocks; this is seen especially on the southern side; to the west or north-west it is about 30 fathoms high, and around it are several projecting rocks, called 'Drengur.'

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[1] I have only here given the most undoubted dates. In The Zoologist, 1871 and 1876, are found two notes: "Albatross in Derbyshire," and "Yellow-nosed Albatross in Derbyshire"; I do not know whether they record anything new. Van Kempen (Bull. Soc. Zool. France, xiv., 1889, p. 106) mentions a *Phoebetria fuliginosa* from Dunkerque, but satisfactory account of its history is wanting. An Albatross, seen by Mr Harvie-Brown in 1894, remains to be mentioned.

This is the only place in the Færöes where the large aquatic bird, the Gannet (*Pelicanus bassanus*), has its home. From the north-west the island slopes gently to the south, like one side of the roof of a house. . . ." The islet is quite uninhabited, and is only used as pasture for oxen and sheep. The grass which covers its surface, but not the declivities sloping seaward, is uncommonly thick and luxuriant. It is said that the Gannets only live and breed on the north and west side of the islet, and on two adjacent rocks, "Puigarsdrengur" and "Fleátidrengur." It must be granted that the natural surroundings of this rocky islet would appear rather home-like to an Albatross. For nesting in the southern seas, it selects just such rocky islets or single rocks, though often considerably higher than Myggenaes Holm and its "Drengur." The nests, which Mr Dougall found on Campbell Island, were on the slopes of Mount Honey; the breeding-place on Keppel Island in West Falkland, described by Snow, was also situated on a precipitous rock; in short, all the breeding-places known are in similar places.

The Gannets among whom it settled are certainly, in structural characters, highly different from their southern guest, but less in their habits of life. Like the Albatrosses, they are strong and persevering fliers, only resting on level ground in the utmost need; they breed in colonies, on rocky coasts by the open sea, and make nests in the form of a flattened cone, and with a shallow terminal cavity for their only egg. Among northern sea-birds, the Albatross could hardly find any species whose mode of life resembled its own more closely; in so far it is easy to understand that it chose a home among the Gannets. Nor has the aquatic avifauna in the Færöe Islands been quite unknown to the Albatross; several of the northern seabirds—not the species, but the types—are found again in the southern seas, for instance, Gannets, Cormorants, Petrels, Skuas, Gulls.

Nor have the climatic conditions, or the food, been more unfavourable to its stay here, than the natural surroundings. The climate of the Atlantic in lat. 51°-53° S. (Falkland Islands), and of the Pacific in lat. 49°-53° S. (the New

Zealand breeding-places), does not differ essentially from that of the Færöes. But even if the difference had been greater, a seabird that, in the Pacific, has been seen from lat. 19° to 57° S., would easily adapt itself to the changed conditions. The food of the Albatrosses consists of oceanic molluscs, crustacea, and medusæ, and also of dead animals that happen to float on the surface of the water; the former being their essential food. We can hardly suppose the North Atlantic to be poorer in this respect than, for instance, the corresponding part of the Pacific, where Albatrosses abound (*D. albatrus, nigripes*).[1] There is abundant reason to believe that the sea around the Færöe Islands is especially rich in pelagic animal life. Mr Dickson's latest researches[2] have proved that in the summer a wide current passes from the open Atlantic through the channel between the Færöes and the Shetlands, turns around the latter group, and runs along the east coast of Scotland; this current certainly carries along an immense number of these pelagic organisms.

It is worth noticing that *D. melanophrys*, also elsewhere, shows inclination to roam and settle north of its usual home. The above-mentioned closely allied species, *D. irrorata* and *D. immutabilis*, may safely be considered as having sprung from the principal species of *D. melanophrys*, as comparatively new colonies, sent out from the original southern colony, one south of, the other far north of, the Equator, in the Pacific. About the distribution of the first species very little is known; the latter has undoubtedly settled permanently in the northern part of the ocean. Suppose this assertion to be true, and it will be another proof of the capacity of the species to adapt itself to new surroundings and to a new climate, another evidence that the region where it finds sufficient food must extend very far, and only depend slightly on the geographical latitude.

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[1] *Cf.* Ergebnisse der in dem Atlantischen Ocean von Mitte Juli bis Anfang Novbr. 1889 ausgef. Plankton-Expedition; herausgeg. v. V. Hensen, 1892 *sqq*.

[2] Twelfth Annual Report of the Fishery Board for Scotland, being for the year 1893, part iii., Edinburgh, 1894; Report of Physical Investigations carried out on board H.M.S. "Jackal," 1893-94, by H. M. Dickson, pp. 348-359.

All the above-mentioned accounts agree as to the fact that the Albatross at Myggenaes migrated with the Gannets in the autumn (November), returning with them in the spring (February). Scarcely anything has been heard from other places about the migrating of the Albatrosses. It is certain that they leave the colonies after the breeding season, and that the rest of the year is spent over the sea, on the surface of which they probably sleep (*cf.* Hutton, 16); within certain latitudes their roamings even extend around the earth; but if they assume the character of regular migrations, or if they only are guided in any direction, wherever they happen to find an abundance of food, is not quite established. It is said, however, about the species in the Northern Pacific, that they occur in the seas around Kamtchatka and Okhotsh at certain seasons, and return south at the end of a few weeks. This, compared with the habits of the Myggenaes Albatross, might perhaps indicate that the "roamings" are more than accidental.

A very important side of the bird's life has not yet been elucidated. To the question whether the Albatross has ever been seen breeding on Myggenaes Holm, Mr Bergh's informant gives a decided negative answer, while both Mr Joensen and Mr Abrahamsen more cautiously reply: "it cannot be stated with any degree of certainty." It cannot be denied, that it would be very strange, if the bird voluntarily had given up the instinct of breeding for so long a period. And what motive should have taken it back, year after year, to the very same islet, but the instinct which directs all other birds from their winter quarters to the breeding-places? I have not the slightest doubt that the answer is given at the end of Mr Joensen's letter, in his account of the "curious young Gannet." Of course, we can only surmise what this "young Gannet" has been; it has certainly perished long ago; but I think the few words said about it are sufficient to lead us into the right track. Only three possibilities may be conjectured: it has been an abnormal young, a hybrid, or an Albatross. That it was a deformed young Gannet is not very probable. It is expressly stated that it "had a bill like that of the Albatross," therefore probably with nasal tubes and curved upper mandible; but even supposing that Mr Joensen has observed only the last fact, he adds that it also differed in colour from the young Gannets; *both* deviations, *i.e.*, that of bill *and* colour, cannot easily be supposed united in the same abnormity. It is just as unlikely to have been a hybrid between two birds differing as widely as a Gannet and an Albatross, species that are no more closely allied than Penguin and Diver, far more different than cat and dog. Only the third possibility remains: it has been a young Albatross; every item in the short description corresponds; the bird-catchers of Myggenaes have surely been right in supposing it to be "the young of that bird." Its being the single specimen of its species in the island does not speak against it. It is said to migrate every year to the south with the Gannets, *i.e.*, its migration occurred at the same time as that of these birds; but it is not probable that it has accompanied them constantly during the winter season, if only for the reason that its food is different in kind from that of the Gannets. It is more likely that the Albatross, as a more powerful flier, has ranged considerably farther south, far beyond the Equator; and here it would meet with birds of its own species, just at the beginning, or immediately before, the breeding season on the southern hemisphere; here it probably dwelt until its instinct again took it back to Myggenaes Holm. There is even a probability that it, at least once, has been accompanied by a mate: perhaps the Albatross shot at Spitzbergen, a bird in full plumage, consequently capable of breeding, may have accompanied it to the northern latitudes. At all events, it must have passed the Færöe Islands on its way to Spitzbergen. In this connection I shall mention an observation by Mr Harvie-Brown, published in *The Zoologist* (September 1894, pp. 337, 338): off the Orkneys, twenty miles from land, he saw (July 18, 1894) an undoubted Albatross of the same size as the one living in the Færöe Islands, but "distinctly an immature bird"; perhaps a full-grown young of the Albatross of Myggenaes Holm!

But if an Albatross can exist on the Færöe Islands during so many years, and breed there, the question suggests itself:

Why has this family no representatives at all in the northern part of the Atlantic? There are species of it in the Northern Pacific (even sometimes as far north as lat. 64½° N.), and in the southern part of this ocean, as well as in the South Atlantic; only in the northern part of this ocean they are entirely wanting, at all events at present.[1] There are, however, many examples on this kind of inequality of geographical distribution. I shall just note one: Why are *Hypolais icterina* and *Alauda cristata* common breeding birds on this side of the Channel, but only rare and accidental visitors in Great Britain? The cause of this "vagary" in distribution that is found among birds as well as among other vertebrates, in families as in genera and species, is very difficult to find, whether looked upon from a biological or a geological point of view; the time when these zoo-geographical riddles will be solved is surely far off still. As for the Albatrosses, Professor Milne-Edwards (36) thinks to find the cause in the distribution of the pelagic animals, their food. The Myggenaes Albatross has, however, picked up a living for a considerable number of years in the north latitudes of the Atlantic, and would scarcely have returned constantly if it had experienced a want of food; nor does the distribution of the aquatic Mammalia (or of certain fishes, *e.g.*, *Selachus maximus*), that essentially feed on the same organisms, speak for their being found in less abundance there than elsewhere. Perhaps the cause is rather the want of really good breeding-places for the Albatrosses. The northern part of the Atlantic does not abound in high, uninhabited, rocky islets, sufficiently isolated, and situated at such a distance from the Continent, that these birds might select them for their *colonies;* the Myggenaes Albatross has only proved that a single bird can live and breed there, but not that the Færöes are

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[1] Of Lydekker's *Diomedea anglica* (Quart. Journ. Geol. Soc., vol. xlii., 1886, pp. 366, 367, fig. 2; and Cat. Foss. Birds Brit. Mus., 1891, pp. 189, 190, fig. 42) from the Upper Pliocene (Red Crag) at Foxhall, Suffolk, only one tarso-metatarsus with the associated proximal phalangeal of the fourth digit is known. The history of the Myggenaes Albatross shows how careful it is necessary to be in drawing inferences from a single discovery.

adapted to Albatross *colonies.* This is the case with the Northern Pacific, and still more so with the southern seas, where the centre of the distribution of the family is found.

The following "References" give the sum total of what is known about *Diomedea melanophrys,* especially as to its geographical distribution and breeding-places, as far as works on the subject have been accessible to me:—

1. Temminck, *Pl. Col. d'Oiseaux*, livr. 77, pl. 456 (1838).
2. Gould, in Gray, *Jour. Two Exped. Disc. N.W. and W. Austr.*, p. 420 (1841). (W. Australia.)
3. Gould, *Birds of Australia*, pl. 43 (1848). (Atlantic and Pacific, lat. 35°–55° S.)
4. Tschudi, *Jour. f. Orn.*, 1856, pp. 156, 157, 158, 161. (Notes from South Seas.)
5. Kittlitz, *Denkw. ein. Reise n. dem russ. Amerika,* etc., i., pp. 104, 105 (1858). (S.E. America.)
6. Gould, *Proc. Zool. Soc.*, 1859, p. 98. (Eggs from Falklands.)
7. Sclater, *Proc. Zool. Soc.*, 1860, p. 390.
8. Abbott, *Ibis*, 1861, p. 165. (Breeding-place in Falklands.)
9. Layard, *Ibis*, 1862, pp. 97, 98, 99. (Notes from South Seas.)
10. Layard, *Ibis*, 1863, pp. 245, 247, 249. (Notes from South Seas.)
11. Schlegel, *Mus. Pays-Bas,* Procell., pp. 33, 34 (1863). (St Paul and Amsterdam, 42° 40′ S., 12° 4′ W.; Cape.)
12. Hutton, *Ibis*, 1865, pp. 281, 283. (Notes from South Seas.)
13. v. Pelzeln, *Reise d. österr. Freg. Novara,* Vögel, p. 148 (1865).
14. Coues, *Proc. Ac. Nat. Sc. Philad.*, 1866, p. 181.
15. Finsch, *Jour. f. Orn.*, 1867, pp. 338, 347. (New Zealand.)
16. Hutton, *Ibis*, 1867, pp. 185, 191, 192. (Notes from South Seas.)
17. Hutton, *Trans. New Zeal. Inst.*, 1868, vol. i., p. 105. (Great Barrier Island.)
18. Sperling, *Ibis*, 1868, p. 295. (S. Africa.)
19. A. Newton, *Ibis*, 1870, p. 503. (Eggs from Falklands.)
20. Finsch, *Jour. f. Orn.*, 1870, p. 375. (New Zealand; Great Barrier Island.)
21. H. & W. Travers, *Trans. New Zeal. Inst.*, 1872, vol. v., p. 219. (Pitt Island; Chathams.)

22. Sperling, *Ibis*, 1872, pp. 75, 76. ("Tristan da Cunha"; Notes on Distribution.)
23. Hutton, *Ibis*, 1872, p. 248. (Chathams.)
24. Finsch, *Jour. f. Orn.*, 1872, p. 254. (New Zealand.)
25. Andersson, *Birds of Damara Land*, p. 356 (1872).
26. Potts, *Trans. New Zeal. Inst.*, 1873, vol. vi., pp. 139, 152. (Egg from Aucklands.)
27. Finsch, *Jour. f. Orn.*, 1874, pp. 173, 206. (New Zealand; Chathams.)
28. Sharpe, Voyage "Erebus" and "Terror," *Birds*, App. p. 32 (1875). (New Zealand.)
29. Layard, *Ibis*, 1876, p. 393; *Proc. Zool. Soc.*, 1876, p. 506. (Kandavu; Fijis.)
30. Ramsay, *Proc. Zool. Soc.*, 1877, p. 348. (Gladstone; Port Curtiss; Queensland.)
31. Salvin, *Proc. Zool. Soc.*, 1878, p. 740. (Christmas Harbour; Kerguelen.)
32. Sclater, *Proc. Zool. Soc.*, 1879, p. 510. (Eggs from Falklands.)
33. Sharpe, *Phil. Trans. Roy. Soc.*, vol. clxviii., pp. 146, 147 (1879). (Kerguelen.)
34. Milne-Edwards and Grandidier, *Hist. nat. d. ois. de Madagascar*, t. i., pp. 669, 670 (1879).
35. Sharpe, *Proc. Zool. Soc.*, 1881, p. 12. (Valparaiso.)
36. Milne-Edwards, *Ann. Sc. Nat. Zool.*, sér. 6, t. xii., art. 7, pp. 8, 9, carte 2 (1881). (Notes on Geographical Distribution and Breeding-places.)
37. Sclater, *Report on Birds*—"Challenger," p. 148 (1881).
38. Bean, *Proc. Un. St. Nat. Mus.*, 1882, pp. 144, 170, 171, 173. (Lat. 40° 30′ N., long. 142° 23′ W.)
39. Salvin, *Proc. Zool. Soc.*, 1883, p. 430. (Talcahuano Bay; Chili.)
40. Baird, Brewer, Ridgway, *Water-Birds N. Amer.*, vol. ii., p. 357 (1884).
41. Reischek, *Trans. New Zeal. Inst.*, 1884, vol. xvii., p. 191. (Dusky Sound.)
42. Layard, Sharpe, *Birds of South Africa*, pp. 772 (1884).
43. Hamilton, *Trans. New Zeal. Inst.*, 1885, vol. xviii., p. 128. (Hawkes Bay.)
44. Ridgway, *Man. North Amer. Birds*, pp. 51, 52, pl. xiii., fig. 2 (1887).

45. Green, *Ocean Birds*, pp. 13, 15, tab. iii., fig. 7 (1887).
46. Buller, *Birds of New Zealand*, 2nd edition, vol. ii., pp. 198-200, 293 (1888).
47. Cheeseman, *Trans. New Zeal. Inst.*, 1890, vol. xxiii., p. 224. (Kermadecs.)
48. Sibbree, *Ibis*, 1892, p. 273. (Madagascar.)
49. Forbes, *Ibis*, 1893, p. 541. (Chathams.)
50. Buller, *Trans. New Zeal. Inst.*, 1893, vol. xxvi., pp. 186, 187. (Notes from South Seas.)
51. A. Newton, *Dictionary of Birds*, part ii., pp. 530, 531, art. "Mallemuck" (1893).

IX. *A List of* Phalangidea (*Harvestmen*) *and* Chernetidea (*False-Scorpions*) *collected in the Neighbourhood of Edinburgh.* By GEORGE H. CARPENTER, B.Sc., and WILLIAM EVANS, F.R.S.E.

(Read 17th April 1895.)

[*Note by W. Evans.*—The records contained in the following paper are based mainly on specimens obtained by me while collecting material for the list of Edinburgh Spiders prepared by Mr Carpenter and myself, and published by the Royal Physical Society last summer (*Proceedings*, vol. xii., page 527).

In the early stages of that investigation, little or no attention was paid to the two groups of Arachnids now under consideration, and at no time were they so systematically searched for as the Spiders, consequently the number of specimens preserved for examination was relatively much smaller. Since the publication of the Spider paper, however, I have been able to add very considerably to the Phalangid data, which may now be held to be fairly representative. I wish I could say the same of the Chernetidea, the data for which is most inadequate, and makes me doubt the wisdom of including the order in the present paper. Owing, however, to their small size, and habit of concealing themselves in out-of-the-way places, they are never easy to find; and adequately to investigate them would take more time and labour than, in the near future, at any rate, I am likely to be able to devote to the subject.

I would again express my indebtedness to Mr Carpenter (to whom the whole of my specimens have been submitted) for his invaluable co-operation in the production of these papers on Arachnids.]

The Phalangidea and the Chernetidea have received even less attention at the hands of British naturalists than the Araneidea (Spiders), along with which and the Acaridea (Mites) they make up the class Arachnida, so far as it is represented in these islands. They are, no doubt, in a general way less attractive than the true Spiders, both as regards habits and variety of form and coloration, but they have, nevertheless, about them much that is of the deepest interest, and we hope that the present paper, slight as it is, may be the means of directing the attention of Scottish naturalists to them, so that our meagre information regarding their life-histories and distribution may soon be largely augmented.

In his "Monograph of the British Phalangidea, or Harvestmen," published in 1890, the Rev. O. P. Cambridge enumerates twenty-two species, if we neglect *Phalangium minutum*, Meade, and reckon *Oligolophus alpinus* (Herbst.) to be simply a variety of *O. morio* (Fabr.). Fourteen, or as near as may be two-thirds, of this number are now recorded for the Edinburgh district, and no less than seven of them are additions to the Scottish list. Curiously enough, the same fourteen species have been, up to the present, found by us in Ireland, with the exception of *O. palpinalis* (Herbst.), which is replaced in the Irish list by *O. ephippiatus* (Koch).

It will be noticed that the two British species of *Sclerosoma* and the two *Trogulidæ* are absent from our list. Seeing that these groups have their headquarters in the Mediterranean region, and are almost unknown in northern Europe, this is not surprising. Yet the habits and appearance of these Phalangids are so obscure, that it is possible some of them remain to be discovered in the district—the most likely being *Trogulus tricarinatus* (L.), which occurs in Denmark. The other three absentees all belong to the genus *Oligolophus*. *O. cinerascens* (Koch) is a northern and alpine species, which

Mr Cambridge records from Scotland without specifying the exact locality;[1] and *O. ephippiatus* (Koch) has been recorded from Argyll by ourselves. *O. Meadii,* Cambr., is a species apparently confined to the south of England. *O. spinosus* (Bosc.) has been found in the south and midlands of England; and abroad it is also a species of southern distribution occurring in France, South Europe, and North Africa. The general southern range of these last two forms, as well as their tolerably conspicuous appearance, renders it probable that they are not to be found in our district; while *O. cinerascens* and *O. ephippiatus,* though probably present, could hardly have escaped our notice were they at all common.

In his "Monograph on the British Species of Chernetidea, or False-Scorpions," published in 1892, the Rev. O. P. Cambridge enumerates twenty species, most of which he characterises as rare even in the south of England, and no Scottish localities are given, unless "near Berwick-on-Tweed" — whence he has received *Chelifer latreillii,* Leach—refers to one. In Scotland we have only found two species, namely, *Obisium muscorum,* Leach, and *Chthonius rayi,* L. Koch, the former alone having been obtained in the Edinburgh district, where, however, it is tolerably common. Others, no doubt, occur, but we are inclined to think that the number of species which range north of the Tweed is very small. *Chiridium muscorum* (Leach) should be looked for in old books and herbaria;[2] and collectors of our Diptera will do well to bear in mind that another species, *Chernes nodosus* (Schr.), which has been taken as far north as Yorkshire and Carlisle, is usually found adhering to the legs of flies.

The arrangement and nomenclature of the present list are in keeping with the two "Monographs" by Mr Cambridge, mentioned above.

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[1] Since the above was written, Mr Cambridge has kindly informed us that specimens of this species were sent to him from the neighbourhood of Glasgow by Mr H. C. Young, and from the valley of the Tweed by the late Sir W. Elliot.

[2] I am nearly certain I once saw this creature, the tiny "Book-Scorpion," in my herbarium, but not being at the time specially interested in the group, I unfortunately did not think of preserving a specimen.—W. E.

SYSTEMATIC LIST OF SPECIES.

Order PHALANGIDEA.

Family PHALANGIIDÆ.

Liobunum rotundum (Latr.).

This characteristic "Harvestman" is fairly common during summer and autumn among rough herbage in most well-sheltered localities. In our experience, however, it is not nearly so abundant in the district as some other members of the family. It seems to be generally distributed in the British Isles, and is spread over Europe and North Africa, occurring also in the Canaries.

Neighbourhood of Leven, Fife, Aug. 1893, ad. ♀s; Merchiston, Edinburgh, Aug., ad. ♀; among herbage on a bushy roadside leading through Biel to Stenton, East Lothian, Sept. 1894, numerous ad. ♂s and ♀s; also at Presmennan, Tynefield, etc., in same neighbourhood, Aug. and Sept., adults of both sexes not uncommon; underneath stones of a broken-down wall at Morton, Nov., several adults; young common among herbage by Braid Burn in June; Dreghorn, Ormiston, Longniddry, July, a good many, some ♀s ad.

Liobunum blackwallii, Meade.

Apparently a local and by no means abundant species. As yet we have detected it in but one locality: further research, however, will no doubt reveal its presence in a number of other spots. Probably of general distribution in Britain; and recorded from Denmark, Belgium, France, and Germany.

On the banks of Bilston Burn at Seafield, near Rosslyn, 29th June 1893, half a dozen ♀s., some ad.

Phalangium opilio, Linn.

This typical Phalangid is generally distributed, and often abundant among grass and other herbage in fields, commons, waste places, etc., and, like the majority of the family, it attains the adult state during the summer and early autumn months. Not having met with examples in spring or in a hibernating state, we conclude that they all die off on the approach of winter, and that there is but one brood in the year. The species is widely spread over the British Isles and throughout Europe. The name stands in Stewart's "List of Insects found in the Neighbourhood of Edinburgh," published in 1808.

Colinton, Dreghorn, Pentlands, Rosslyn, Newpark, Winton, Borthwick, etc., June and July, ad. ♂s and ♀s and imm. examples common; banks of the Avon above Linlithgow, June, a few imm.; Leven, Falkland, Aberlady, Aug. and Sept., many ♂s and ♀s ad.; Tynefield, Westbarns Links, Biel, etc. (East Lothian), Aug. and Sept., ad. ♂s and ♀s common; Isle of May, Aug., imm. ♀; Merchiston, Aug., ad. ♂; etc.

Very young Phalangids, many of them referrable apparently to this species, were often noticed on the undersides of stones and among grass about the beginning of May.

Phalangium parietinum, De G.

Is common in summer and autumn on walls in the southern suburbs of Edinburgh, and probably also in similar situations elsewhere. During the daytime they are to be found at rest under the copings, from which it would seem they are mainly noctural feeders. Widely distributed in the British Isles; and recorded from Sweden, Denmark, Germany, France, and the Canaries.

Merchiston and other suburbs of Edinburgh, on walls, ad. ♂s and ♀s and imm. examples common in July, Aug., and Sept., ad. ♀s in Nov.; Leven (Fife), Aug.; Largo, Sept., ad. ♀; Comiston, Nov., several.

Phalangium saxatile (C. L. Koch).

Among a number of Phalangids collected in the vicinity of Leven, Fife, during August 1893, there is an adult female of this species. We have recognised it on but one other occasion. Rev. O. P. Cambridge only records it from the south of England. It has occurred once in Ireland (near Dublin), and is found in France, Germany, Italy, and the Canaries.

Near Leven (Fife), Aug., ad. ♀; Kaimes, near Edinburgh, Oct., several ad. ♀s on the undersides of stones.

Platybunus corniger (Herm.).

Though we have collected this species on some half-dozen occasions only, it is probably neither particularly local nor uncommon in the district. When Mr Cambridge published his Monograph on the British Phalangidea, it was one of the few he had received from Scotland. It is widely distributed on the Continent.

Callander, May 1889, one; Blackford Hill, May 1894, ad. ♀; Kirknewton, off bushes, May, ♂ and two ♀s ad. and one young; Dreghorn, off lower branches of trees, July, three ♂s and one ♀, all ad.; Newpark, July, ad. ♂; Longniddry, July, ♂ and ♀ ad., and one very young.

Platybunus triangularis (Herbst.).

This small species seems to be generally distributed and common, more especially in sub-alpine districts, concealing itself under stones, fallen leaves, grass, heather, etc. Our specimens were almost all taken during winter and spring. Mr Cambridge records it from the south of England and from Ireland. On the Continent it is known from France and Germany.

Pentlands, Sept., ♀; Linhouse and Dalmahoy Hill, Nov., a few imm.; Morton, Nov., one ad. and several imm.; Torduff (Pentlands), Dec., several imm.; Greenbank, Dec., ♂ and ♀; Frogston, near Edinburgh, and Bridge of Allan, Dec., several ♀s; Buckstone, Jan., a few; top of Caerketton Hill (Pentlands), Feb., common under stones; Braidburn, Rosslyn, Balerno, Kirknewton, March, a number, some ad.; Braid, Fairmilehead, Corstorphine Hill, Dalmeny, etc., April, many ♂s and ♀s, mostly ad.

Megabunus insignis, Meade.

We find this pretty little Phalangid widely distributed and fairly common in the district. A lichen-covered wall or tree-trunk, with which its greenish-grey markings closely assimilate, is a favourite habitat, though it is also to be found readily enough among heather, grass, and other herbage. Adult in spring and summer. It is recorded by Mr Cambridge from Dorset, Devon, Wales, Yorkshire, and Ireland.

The Continental species, *M. diadema* (Fabr.)—from which *M. insignis* can hardly be separated—seems decidedly rare, being recorded only from Norway, Normandy, and near Bayonne. The only other known species of the genus occurs in the Swiss Alps. The comparative abundance of our British *Megabunus* makes it therefore one of the most interesting and characteristic members of our Arachnid fauna.

Bonaly Glen, Rosslyn, Arthur's Seat, Braids, March, fairly common, both ad. and imm.; Fairmilehead, Corstorphine Hill, Hopetoun, April, many ad. and imm.; Raith (Fife), April, one ad.; Comiston, Callander, May, ads., etc., common; Pentlands above Hillend, under stones, June, many, all ad.; Pentlands, Oct., one young; Newpark, Linhouse, and roadside south of Dalmahoy, Nov., a number imm.; Morton, Torduff, and Bridge of Allan, Dec., several imm. and young; Buckstone, Jan., two young, etc.

Oligolophus morio (Fabr.)

This is one of our commonest and most generally distributed Phalangids, occurring abundantly among all sorts of rough herbage, as well as on furze and other bushes, both in woods and in the open. It seems to be most active after nightfall; and when "sugaring" for moths about the end of summer, we seldom miss seeing numbers crawling on the palings and tree-trunks. The var. *alpinus* (Herbst.) is probably common in the outlying hill-districts.

This is a northern and alpine species on the Continent, and is widely distributed in the British Isles.

Blackford Hill, May, two young; Seafield near Rosslyn, Pentland Hills, Newpark, Aberlady, June, many, mostly imm. and young; near Linlithgow, June, a few imm.; Loch Leven, June, several ad. and imm.; Dreghorn, Boghall, Kirknewton, Borthwick, Ormiston, etc., July, many ♂s and ♀s, mostly imm.; Callander, Aug., a few ♂s, more ♀s; Tynefield, Tyninghame, Presmennan, etc. (East Lothian), Aug. and Sept., a few ad. ♂s and many ♀s, some still imm.; Braid Hills, etc., Aug., ad. ♂s and ♀s common; Dunfermline, Leven, Falkland (Fife), Aug., many ♂s and ♀s; Dalmeny Park, Sept., imm. ♀. Var. *alpinus*—Newpark, July, several ad. ♂s, on heather; Kirknewton, July, ad. ♂; Callander, Aug., ♂; Presmennan (foot of Lammermoors), Aug., ad. ♂; Morton, near Edinburgh, Nov., ad. ♂.

During April and May we find many very young Phalangids, of which a large proportion probably belong to this species, under stones and about the roots of herbage.

Oligolophus agrestis (Meade).

Generally distributed and very common throughout the second half of the year. During summer and early autumn great numbers may be obtained by beating the lower branches of trees, particularly conifers. Another favourite habitat—more especially about the end of autumn—is behind grass or other herbage at the base of a wall. Never having met with this or any other species of the genus in the spring time, though we have looked for them in the identical spots where they were observed hiding at the end of autumn, we conclude they do not survive the winter.

Widely distributed in the British Isles. On the Continent recorded from Denmark, Belgium, and France.

Bilston, end of June, one imm.; Newpark, Rosslyn, Penicuik, July, a good many imm., a few ♀s ad.; Dalmeny, Tyninghame, Biel, Largo, etc., Aug. and Sept., many ♂s and ♀s ad. and imm.; Luffness, Oct., ad. ♀; Comiston, Craigmillar, Bush, Colinton, Linhouse, Kirknewton, Pentlands, Oct. and Nov., many ad. ♂s and ♀s; Blackford Hill, Craiglockhart, Bridge of Allan, Dec., a number of both sexes; etc.

Oligolophus tridens (C. L. Koch).

A widely distributed and fairly common species: adult in the latter part of summer and onwards. As Mr Cambridge remarks, it seems partial to moist places, where it hides among the grass and rushes; but we have also found it on dry ground, on bushes, and even on a wall.

Mr Cambridge records the species from Dorset, the Cheviots, and Ireland. On the Continent it occurs in Sweden, Denmark, Germany, and France.

Seafield near Rosslyn, and Dreghorn, June and July, several young; Merchiston on wall, Aug., ad. ♀ and another imm.; Tyninghame and Biel, Aug. and Sept., ad. ♂s and ♀s and imm. examples common; Gosford, on young conifer, Sept., two ad. ♀s; Raith, Sept., ♀; Luffness, July, ad. ♀ (on links), Oct., a few ♀s ad. and imm. (on marsh); near Colinton, Nov., several ad. ♂s and ♀s; Blackford, Dec., ad. ♂s and ♀s.

Oligolophus palpinalis (Herbst.).

An adult female found among heather by the hill road a mile or so behind Bridge of Allan in the end of December 1893, and recorded in the *Annals of Scottish Natural History* for April 1894 (p. 118), and a male taken at Craiglockhart, 13th December 1892, are, so far as we know, the only examples hitherto obtained in Scotland.

Mr Cambridge records the species only from Dorset and North Wales. On the Continent it occurs in Denmark, Germany, and the mountainous districts of France.

Family **NEMASTOMATIDÆ.**

Nemastoma lugubre (O. F. Müller).

This very distinct species (black, with two rather conspicuous whitish spots) is common all over the district, concealing itself under stones, logs, fallen leaves, etc. We have found it at all seasons of the year; most frequently, however, between autumn and spring. It is generally distributed in Britain, and widely spread on the Continent.

Salisbury Crags, Rosslyn, Woodhouselee, Bonaly Glen, Pettycur, etc., Feb. and March, ♂s and ♀s common; Greenbank, March (1895), several ♂s and ♀s under stones, where they had survived the great frost of the two previous months; Colinton, Dalmeny, etc., April, ♂s and ♀s; near Dalkeith, May, a few; Penicuik and Dreghorn, July, a few ♀s; Braid Hills, Aug., ♀s; Tyninghame, Sept., frequent; Morton, Oct., ♂s and ♀s; Craigmillar, Colinton, Morton, Kirknewton, Linhouse, Nov., ♂s and ♀s common; Blackford Hill, Merchiston, Kaimes, Bridge of Allan, Dec., a number of ♂s and ♀s; etc.

Nemastoma chrysomelas (Hermann).

While probably of general distribution, this—in many respects the most attractive of our Phalangids—is to be found in the same situations as the last, but much less frequently, and in smaller numbers; indeed, in our experience, single examples are the rule. Despite its delicate appearance, it (in common with other small species) occurs chiefly during the winter half of the year. Mr Cambridge records it from both the north and south of England. It occurs in Ireland; and on the Continent in France, Germany, Austria, and Italy.

Mortonhall, Nov., ♀; Linhouse, Nov., ad. ♀; Bridge of Allan, Dec., ♀; Braid, Jan., ♂; Hillend (foot of Pentlands), Feb., three; Rosslyn, March, one; Loganlee (Pentlands), Sept., ♀; etc.

Order CHERNETIDEA.

Family **CHELIFERIDÆ.**

Obisium muscorum, Leach.

This, perhaps the most widely distributed species of the order in the British Isles, is as yet the only one we have detected in the neighbourhood of Edinburgh, where it occurs sparingly, and, in our experience, chiefly under stones lying among moss and heather in hilly places. It seems to occur throughout the year.

Mr Cambridge records the species from several English counties (including Cumberland), and we have taken it in Ireland. On the Continent it has been found in Holland, Denmark, Germany, France, Switzerland, and Austria; also in North Africa.

Hillend, Feb., two specimens; Carnethy (Pentlands), March, a dozen; Ravensnook Moor, near Penicuik, July, two; Braid Hills, Aug., a few; Loganlea (Pentlands), Sept., seven; Aberlady, Sept., four; Pentlands, Nov., one; Bridge of Allan, Dec., three; Granton, one under a stone, 1893 (found by Mr J. Strachan); etc.

Note.—As already mentioned, the only other species of the Chernetidea we have recognised in Scotland is *Chthonius rayi*, L. Koch, of which we have several specimens obtained near Oban in April 1894. Others must occur, but we are inclined to think that a few only of the British species range north of the Tweed. We have, however, paid but slight attention to the group, having only picked up such specimens as have come casually under our notice when searching for spiders during the last two or three years.

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OF THE

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Wednesday, 20th November 1895.—Professor J. STRUTHERS, M.D., LL.D., President, in the Chair.

The retiring Vice-President, Dr WILLIAM RUSSELL, F.R.C.P.E., delivered the following opening address, on "The Light thrown on some Biological Processes by the Investigation of Disease":—

GENTLEMEN,—In thinking over the fact that, at the conclusion of my term of office as one of your vice-presidents, it would be my duty, in accordance with the custom of the Society, to address a few valedictory words to you, I had to realise the fact that for some years past the demands of the purely practical side of my profession as a physician have driven me completely from those investigations which, had I had the opportunity of continuing, might have formed a suitable and satisfactory theme on which to address you on this occasion. As the results of original investigation were awanting, I thought that it might be interesting to you if I could convey to you some of the thoughts which occur to me when I contemplate the advances, which are being made in our knowledge of many disease processes; tell you something of the investigation of these undertaken with the object of saving life or mitigating suffering; and indicate the light which these investigations throw upon biological processes, giving us glimpses of the elaborate and subtle conditions which influence and determine our physical and even our mental constitution.

I cannot do this without going into some questions which are to some of you an oft-told tale, but they cannot be known to all of you; so those who know must bear for the sake of those who know not.

The first discovery to which I shall refer is the best known of many to which reference will have to be made. There is in man and the higher animals a gland in the neck which is known to anatomists and others as the Thyroid Gland. It belongs to the class of glands which are without a duct by which to discharge their special secretion. The function of this gland was unknown until quite recently; not only so, but it was questioned whether it performed any special function or useful purpose whatever in the animal economy. I have, indeed, a recollection that, in my student days, when the argument for design was advanced, and illustrated from the human body, the Thyroid Gland was a stumbling-block, for there was either an idea, or an accepted conviction, that this gland had been left by mistake; that it was one of those organs, stranded on the shores of the stream of evolution, having the same kind of interest as the finding of a Norse galley on the shore of Labrador would have; the one revealing the evolutionary antecedents of man, the other revealing an America known before Columbus. This was the state of ignorance within the last twenty years, and our present knowledge is mainly the outcome of investigations suggested by a series of observations in cases in which the gland had been removed for surgical reasons, and having no connection whatever with a desire to become acquainted with its function. The discovery might in this respect be looked upon as accidental, or, at all events, merely incidental. It is not my purpose to trace the steps by which our knowledge has been attained, so I may at once proceed to the facts which have been correlated, and the light they have thrown upon a hitherto dark region. Some of you are doubtless aware that in certain districts of

Switzerland a type of human being is met with, known as a cretin; their dwarfed stature, misshapen limbs, large belly, thick lips, and protruded tongue, make them the reverse of pleasing objects to look upon. The condition, however, is not confined to Switzerland, for a goodly number of cretins are scattered up and down throughout this country. Not only is the body stunted and unlovely, but the mental faculties are in the most primitive and elementary state, and can hardly be said to be on a level with the higher domesticated animals. A cretin, no matter what its age, gives no more, or even less evidence of mind than an infant a few months old. In fact, it is a human being whose physical and mental growth and development have been arrested and perverted, producing an uncomely body and an idiot brain.

In this connection I must also refer to a disease, known as Myxœdema, which is met with in adult life—a disease characterised by deposition under the skin of a mucoid substance, a disappearance of the hair leading to complete baldness, and a marked alteration in the expression of the face, in the direction of coarseness and loss of expression. Along with these visible physical alterations, there are marked mental phenomena; the individual affected changes from mental vigour to feebleness, from alertness to apathy, until, finally, no mental response beyond the very feeblest can be elicited. Body and mind alike become ponderous and inactive, and the individual sinks as a water-logged vessel forsaken by captain and crew.

These two conditions are allied, although the phenomena presented by them differ. By experiments and observations, which need not be detailed here, it has been proved beyond question that both conditions result from changes in the Thyroid Gland leading to annihilation of its function. This in itself would be a most interesting discovery, but the sequel to it is much more so. It has been found that, if the Thyroid Gland of one of the higher mammals, the one used being the sheep's, be eaten raw, or if an extract of it be given, as striking a physical and mental change is wrought, but in the reverse direction. The ponderous body resumes its antecedent proportions, the bald head grows its hair, the fog is dispelled from the brain, and the mental faculties resume their activities. In the cretin, if a young child, what was little more than a sentient vegetable becomes active and lively, amusing itself as other children, grows in body, develops a mind like other children, and, if I may say so, presents the potentialities of an immortal soul.

In these cases there is no doubt as to cause and effect, and you will agree with me that such a correlation suggests many curious thoughts. The destruction of a gland, thought to be useless, leads to physical conditions which are strikingly apparent, and are allied with mental phenomena startling both in degree and in kind; and all these then removed by regularly swallowing small quantities of the gland from the sheep corresponding to the one destroyed in the human being.

The inference is, of course, unavoidable that this gland elaborates a substance which passes into the blood, is carried to brain and other tissue, and is absolutely essential for the maintenance by these of their normal functions. The steps of this discovery were made by men engaged in the observation and investigation of disease, and pure physiology and biology owe it to medicine. The discovery has thrown a new light on vital processes, for the glands, the functions of which were known, were glands whose secretions in the main were connected very directly with digestive processes, while some others were related to blood-corpuscle formation. The function of the thyroid showed that there were organs whose secretions were essential to the well-being of certain tissues, and that they could, of course, only reach these tissues, and be uniformly distributed to them, by the secretion entering the blood; and this could only be attained in the ductless glands by passing through the lymphatic vessels. The influence of this particular secretion, which is perhaps the most attractive, is the effect its absence has upon the brain—an effect altogether surprising and unexpected, as is also the further fact that this potent substance can be added to the blood by the somewhat coarse method of introducing it artificially into the stomach, and that the stomach secretions fail to take from it its power. To me it is a very curious fact that brain function—that is, mind—should be so dependent upon an organ of this kind, and upon a secretion which is as good, for its special purpose, when taken from a sheep, as when elaborated in the human body.

The discovery has necessarily given a place of much higher importance to the ductless glands than they formerly held. Two other ductless glands may be mentioned—the pituitary body, situated inside the skull, and the supra-renal capsule. I need not dwell on these, as we are not yet fully informed of their functions, but everything points to their functions being of the utmost importance, although wanting in the special features of interest possessed by the thyroid.

A further result of the study of disease in definite organs, and of observations in cases where organs have been removed, is to indicate that, in addition to the special activities and special functions of organs which have been long known, there are side influences, or supplementary functions, which play a very subtle rôle in the animal economy, and have a very marked influence upon brain vigour and mental activity, in addition to more palpable physical effects. The inference being that, from some of these, substances are absorbed which act as invigorators of brain and nerve tissue, while others are necessary for the prevention of morbid brain action. From these facts, the blood-composition has been shown to possess an infinitely more complex character than had hitherto been fully realised; and the function of important organs and tissues shown to be influenced, and their activity determined, by other organs which had no direct or apparent connection with them.

From the foregoing facts you can readily understand that quite a new line of investigation has been opened, and that the tissue of organs, or extracts of them, have come to be regarded as possibly possessing unknown potentialities, which might be utilised for various medicinal purposes. It is fortunately a line of investigation which can be soon exhausted, and the limits of its applicability will soon be determined; and if it were permissible to prophesy, I should say that it is quite unsafe to make a general deduction from one instance, however marked it may be, and that it is unlikely we shall find results at all corresponding to those obtained with thyroid. Still, the possibilities have an alluring effect upon the imagination, and in connection with the use of animal extracts it may not be uninteresting to refer to some of its historical associations. In ancient Egypt human brains were prescribed for eye diseases. In the Talmud, a dog's liver is permitted for the bite of a mad dog. In China, at the present time, a decoction of scorpions is used in fever, rat's flesh is eaten as a hair restorer, and leprosy is supposed to be curable by drinking the blood of a healthy infant. Amongst cannibals, you will remember that eating the heart of a warrior is believed to give courage. These might be multiplied indefinitely, but they are sufficient to show that in unenlightened time there was a belief in the remedial efficacy of the organs or tissues of human or animal bodies.

I next desire to lay before you facts which have been discovered in the investigation of diseases due to bacteria, and at the same time to refer to light which has in this way been thrown upon biological processes. On this subject I have to ask your patience, for it is necessary to enter into considerable detail.

It has long been known that the blood taken from a person suffering from certain infective diseases could communicate the disease when introduced into the body of another person; but there was no attempt to distinguish which of the elements in the blood was the carrier of the infection. It had, for instance, been shown in the case of the calf that the transfusion of blood, or of lymph taken from an animal at a certain stage of vaccine eruption, conferred immunity on another animal. This was looked upon as an indication of the virulence of the blood, and as a proof that the blood contained the special morbific agent. The blood-serum was looked upon as occupying quite a secondary place, and as performing an almost purely physical or passive function—as, in fact, an inert vehicle.

This idea, which was the predominant one, has gradually had to give way, as a result of investigations into disease processes.

Perhaps the first new power which blood-serum was found to possess was the destructive action which it sometimes exercised on certain micro-organisms, and which has become known as its bactericide power. It was found that the serum of certain animals opposed the development of certain micro-organisms, and even destroyed them, so that no culture of them could be obtained from a mixture of the serum and the microbe. Some of the instances in which this bactericide property was present in the serum occurred in animals which were refractory to the action of certain microbes and the disease which they produced. At first it was thought that this bactericide property might largely account for the immunity which some animals enjoyed towards some diseases, and that the effect might be regarded as the result of a chemical action exerted by the serum upon the microbe. This was, however, soon discovered not to be a general law, but rather an exception to a more general law, and to which fuller reference will be made hereafter. That this bactericide power is not a simple physical phenomenon, but is rather biological or vital in its nature, is supported by the fact that a moderate degree of heat destroys it, while it in no way modifies the other physical or chemical properties of the serum. It was natural that efforts should be made to discover a special substance on which this bactericide power depended, and various substances, known as defensive proteids, globulins, or alexines, or as diastatic in nature, have been described by various investigators, although their results can hardly be regarded as accepted or conclusive.

Other experiments have shown that, in certain cases, the blood-serum taken from an animal refractory to a certain microbe formed a medium in which the microbe could be successfully grown, thus tending to show that the influence was not the result of a simple microbicide power. In some cases, however, the interesting fact was revealed that a microbe grown in such serum lost, in some instances, its special pathogenic influence, whilst in other instances the reverse of this occurred. From these latter observations it follows that it cannot be accepted that blood-serum has any general or universal attenuating property any more than a bactericide power.

When it was ascertained that a microbe, inoculated into a refractory animal, might survive for some time at the point of inoculation, the question came to be asked if the blood-serum did not rather exercise its action by neutralising or destroying the substances produced by the microbe than by acting directly upon the microbe itself. This idea led to the discovery of what is now generally known as the antitoxic action of the blood-serum and other fluids in the blood.

In this relation it is necessary to state that microbes act in two different ways when introduced into the body. In one case the microbe multiplies and invades the body generally, this being what is known as infection by the microbe. In the other case, instead of the microbe multiplying and becoming generalised, it remains localised, and produces its injurious effects by the poisons, or toxines, which it produces, and which, by their absorption, produce what is technically known as an intoxication.

Two examples may be taken, in which the micro-organism plays a minor part to its toxines, viz., tetanus and diphtheria. To understand aright the bearing of this on our general subject, it is necessary to inform you that animals can be vaccinated against these two affections, and that a further interesting and important fact has been demonstrated, namely, that the blood-serum of animals so vaccinated can be used as a vaccine material for the prevention of these diseases in other animals. It is also necessary that I should remind you of the fact that microbes can be filtered out of the fluid in which they have been cultivated, the filtered fluid containing the toxines produced by the microbe. This toxic fluid may be investigated, and its powers and reactions tested.

The influence of blood-serum, when brought into contact with these toxines, was one of the first points to be investigated. It was found that toxin mixed with a small quantity of serum from an immunised animal could be injected with impunity into the body of an animal susceptible to extremely small doses of pure toxin. It was also, however, found that, if an animal was injected with toxin and serum at the same or at different parts of the body, the animal survived doses of the toxin many times stronger than was necessary to produce a fatal effect when the toxin alone was used. To many this action of the serum appeared to be exercised directly on the poison, and to be probably of a chemical nature, either destroying it or converting it into a harmless substance. To this property, or rather to the substance in the blood which exercised this striking influence, the name *Antitoxin* was given, and its action has been compared to that of a globulin or a diastase. In the two diseases mentioned, the quantity of serum containing the antitoxin necessary to prevent death is almost infinitesimal, it being calculated that one c.c. is sufficient to protect 70,000 mice against what would otherwise be a fatal dose.

Although this antitoxic action appears to be so marked in the two examples referred to, it is not a property which is found so generally existing in analogous cases as to permit its being formulated into a universal law. In the investigation of other diseases produced by microbes, and occurring in animals, it has been found, on the contrary, that the serum of vaccinated animals is able to prevent or cure the disease, while at the same time it possesses no true bactericide or antitoxic property. From these latter observations it is necessary to seek some other explanation of the curative or preventive action of the serum, to which it will be necessary to refer more fully afterwards.

These investigations show very clearly that the serum of blood is very far from being an inert constituent. Some further facts in this connection have some bearing upon the understanding of our subject. If, for example, the blood of another species is introduced into the body, or even mixed with the blood-serum, the blood-corpuscles are disintegrated and dissolved. This action of the serum is known as its globulicide action.

Another fact in this connection is that blood-serum in quantity, taken from one species of animal and injected into another, may produce symptoms of marked intoxication, even causing a fatal termination. A marked difference is thus shown to exist in the constitution of the serum in different species, and indicates very clearly the vital, rather than the inert nature of it, and its complex and variable composition.

As illustrating the differences in the serum of different animals, and the extent to which it is capable of being modified experimentally, it is necessary to refer to a number of diseases which have been experimentally investigated.

The first of these to which I may refer is produced by an organism known as the *Staphylococcus pyosepticus*, an organism which very rapidly produces death in rabbits when injected into their tissues. To this microbe the dog is completely refractory, that is to say, its injection into the dog produces no appreciable effect. Some of the blood of a dog injected into the peritoneum of a rabbit renders the rabbit proof against the action of the microbe, and the dog's serum is still more efficacious if the natural immunity of the dog has been reinforced by inoculating it with the microbe in question.

This observation, as you can understand, suggested most important possibilities in the direction of utilising the serum of animals, refractory to certain microbes, as a means of preventing their action in other animals. This, however, has not been found so applicable as this special case seemed to indicate. The existence, however, of a relative, if not of an absolute immunity, has been utilised by augmenting it in the manner I have indicated, and in using the serum of animals thus both naturally and artificially immunised for curative purposes.

Other means were also found of producing an artificial immunity, and one of the first diseases in which this was done was a disease known as hog-cholera, also due to a special microbe. This microbe injected into rabbits rapidly proved fatal, the microbe rapidly developing and multiplying throughout the rabbit's body. Notwithstanding the great susceptibility of the rabbit to this organism, it was found comparatively easy to vaccinate it against the microbe. To attain this, all that was necessary was to heat to a certain temperature a quantity of the blood taken from an animal dead of the affection, to inject small quantities of it, and to repeat the injections many times. These measures rendered the animal entirely immune to the fatal virus. Not only was this the case, but the blood of the animal so vaccinated exercised a preventive power when inoculated into others. At the same time it was shown, that, notwithstanding this preventive faculty, the blood-serum had no bactericide or antitoxic qualities, strictly so called.

This effect of heat at a certain limit in attenuating virus is extensively applicable, but there are other methods, also used successfully, to which I must refer, and it will make the subject more interesting if I illustrate some of these by reference to well-known diseases.

I may take diphtheria first, a disease due to a bacillus which develops at the seat of invasion, that being most commonly the throat. The bacillus is confined to the locality where it has become implanted, and does not become diffused throughout the body. It produces a toxin, to the absorption of which most of the symptoms are due. Here, as in other cases where the microbe is cultivated separately, it can be filtered out of the fluid which contains its toxin. This toxin can be produced of an extreme degree of virulence, and all the animals usually used for investigation, such as the rabbit, guinea-pig, dog, etc., are susceptible to it. Owing to this, there was considerable difficulty in working out a satisfactory method of preventive inoculation. It was found that the virus might be attenuated in various ways, and these it is unnecessary to dwell upon in detail; one of them, however, I must mention; it is this, that if the fluid containing the toxin were mixed with a quantity of a solution of iodine, an animal withstood a dose of the virus, thus mixed, that would by itself have proved fatal. By repeated injections of this mixture the animal was rendered immune to the diphtheria bacillus or its toxin.

You must always remember that the ultimate object of all these investigations is to find a method of inoculation which will be applicable to man, and the investigation of diphtheria had very markedly this for its object.

A satisfactory method of attenuation having been discovered, the fact that the horse was less susceptible to the diphtheria poison than most of the other animals tried indicated the direction of least resistance, and this animal was rendered immune by injections of the attenuated virus in the way I have indicated. It was then found that the blood-serum of the immunised horse had a protective effect, and even a curative one, when injected into other animals. At this stage it was deemed safe to try the serum in the human being, and as all of you doubtless know, this method has been extensively used, has been found of the greatest value, and has already been the means of saving very many human lives.

In this instance are illustrated two facts—one, the attenuation of a virus by mixing it with a chemical substance, this attenuation rendering it suitable for repeated inoculations, and these producing a condition of immunity in the animal inoculated with them; the other, that the possession of a degree of immunity determined the selection of the animal to be rendered wholly immune. So that in this the leading of nature is followed and utilised.

If we consider the mode of action of this antidiphtheritic serum, one of the views which is held regarding it is that by its admixture with the toxin, either within or without the body, the poison is destroyed by contact, or that the union of the two produces an inoffensive substance. But this theory is hardly tenable, for under certain circumstances the toxic effect is produced notwithstanding its admixture with antitoxic serum. This was the effect produced in some guinea-pigs which were at the time in perfect health, but had some time previously been inoculated against another disease. This illustrates the curious fact that these guinea-pigs must have had their constitution (to use the word in its popular sense) modified by this antecedent vaccination, and that modification, which in no way affected their health, rendered them even more than usually susceptible to the diphtheria toxin. The changes in the blood must thus be of an extremely subtle kind, and you can understand how very complex the conditions may be which have to be met. The main point, however, I wish to point out here is the evidence that this affords that the antitoxic effect is really not the result of direct chemical changes between the toxin and the antitoxin leading to the destruction of the latter, and is not comparable to the neutralisation of an acid with an alkali producing a neutral substance.

The next disease to which I shall refer is hydrophobia. This disease presents, so far, a peculiarity which is only shared by one other, for which there has been introduced a method of protective vaccination. The peculiarity is, that although the virus of the disease can be obtained, the microbe to which it must certainly be due has not been demonstrated, so that nothing whatever is known of it directly, only its products and its effects making its existence certain. The virus in this disease is present in its most concentrated state in the spinal cord, and it is by making an emulsion of that structure that the virus is obtained, mixed, of course, with the emulsified cord. This virus becomes weakened by exposure and drying of the cord, so that in the course of a few weeks it is entirely destroyed. As a consequence of this gradual attenuation of the virus, it can be obtained of any strength, and by inoculating animals first with a very weak virus, and then gradually increasing the strength, the animal so treated becomes refractory to the most powerful doses.

This is a still further example of the different ways in which attenuation can be produced, and this is the first instance I have given you in which mere hanging in dry air has been sufficient to lead to attenuation.

There is, however, still a further side to this, and which has bearings upon our general subject. If the blood-serum of an animal rendered immune be taken and mixed with the rabic virus, and left thus in contact with it, it has been found that the virus ultimately loses its power, and this is true whether the serum be taken from a vaccinated man or a vaccinated animal. The serum of a vaccinated animal may thus be used as a preventive vaccine; although the method appears to be inferior to Pasteur's original method.

Observations have lately been made upon the effect of the artificial digestion of this toxin, from which it appears that this may be an additional mode of attenuation, which might have some advantages if it proved to be equally efficacious with the original method. Many other examples might be given illustrating the fact that when animals are artificially rendered immune to disease, the blood-serum of the animal may be utilised for vaccinating other animals, and thereby rendering them immune. However interesting the details of these may be, I cannot attempt to take you over the whole field. I may, however, mention to you that this line of investigation has been followed in such important and well-known diseases as pneumonia, typhoid fever, cholera, and tetanus. In all these, animals which are specially susceptible to the action of the microbes associated with these diseases have, by this process of vaccination by attenuated serum, been rendered immune. In all of them the interesting question as to the precise mode of action of the curative or preventive serum arises.

One of the first theories as to the mode of action of the serum was that it is antitoxic, the idea, as I have already indicated, being that the antitoxin counteracted the toxin, and hence the use of the term "antitoxin," which has now become general. Experiments in another direction tended to support this view. It was found that animals could be readily rendered able to withstand very large doses of certain vegetable toxalbumins by giving to them small doses to begin with. It was further found that if the blood-serum from such animals was mixed with the poison, the mixture could be injected into fresh animals without causing them any inconvenience. From this it was naturally enough concluded that the blood of the immunised animal had attained the power of destroying the poison.

It is well enough known to you that the human body can become habituated to and proof against the action of poisonous substances, and no better example can be given of this than is seen in the innocuousness of tobacco in those accustomed to its use. The startling side of this action is the marked effect which is evidently produced on the blood, the blood-serum evidently becoming possessed of a new and special property. Whether the vaccination with blood from a smoker would mitigate or entirely annul the painful experiences of tobacco-poisoning is a question which has not been investigated to my knowledge, but it has sometimes appeared to me that the sons of a man who smokes are often saved the early troubles which some young smokers experience.

This power on the part of the body to become accustomed to a poison, which, even in small doses, is fatal under ordinary circumstances, is well illustrated in the important observations which have been published on serpent venom. It has been found that an animal can be rendered immune even to cobra poison, either by modifying the poison by the action of heat, or, preferably, by inoculating the animal with very minute doses of the active venom, so that there is obtained a progressive habituation. The venom can also be modified, and its activity diminished, by mixing it with a chloride of soda or lime.

The serum of animals thus vaccinated against venom by any of these methods possesses immunising properties. A mixture of cobra venom with a small quantity of serum from an immunised rabbit, may be inoculated into a fresh rabbit without producing any untoward action. Further, the injection into a rabbit of serum from an immunised rabbit enables the animal to tolerate without discomfort twice as much venom as would otherwise kill it. The serum has not only this protective action, but it even has a curative one, for it prevents a fatal issue even when injected some considerable time after the venom has been introduced. A further fact has been established, namely, that animals can be rendered immune by administering the pure venom to them through the stomach. It has also been shown that the serum of a serpent is an antidote to its own venom, and even to the venom of other species. The antivenin serum from an immunised animal, however, only protects another from the poison of the snake originally used.

In many of the instances to which reference has been made, it cannot be proved directly that the mixture of toxin with antitoxin, and its consequent neutralisation, is not due to a direct action of the latter upon the former. In the case of snake venom and antivenin serum this point can be settled, and throws an important light upon the whole question, although it cannot be regarded as necessarily applicable in all cases, or as the expression of a general law. The method is as follows:—If a mixture of venin and antivenin be heated to a given temperature the mixture loses its innocuousness. The antivenin is altered while the venin is not, so that the mixture is rendered lethal. This goes to show that the venin remains intact alongside the antivenin, or that it had formed a very unstable union with it. This method of settling this important question in other instances is not applicable, because in them heat affects equally the toxin and its antidotal serum. From this it appears that it cannot be assumed that the antitoxin acts by producing any very definite chemical change in the toxin, and yet, at the same time, its antidotal action is difficult to imagine without supposing that some such effect is produced.

The next point bearing upon our general subject to which I would draw your attention, and which has important relations to questions connected with blood-serum, is certain functions which the white blood-corpuscles or leucocytes have been shown to possess. Until quite recently the white corpuscles of the blood received little attention, and it is doubtful whether they were accredited with any important rôle apart from their being a possible source of red corpuscles. In consequence of this ignorance, the glands in which they were produced had not the place given to them to which they are entitled, in view of the recent light thrown on the function of the cells produced by them.

The new light thrown upon these cells is the outcome of investigations in connection with bacteriology.

It was found that when microbes were locally inoculated, the results which followed indicated that an effort was exerted by nature to combat and to counteract their harmful influence. The specially novel discovery in this connection was the action which the hitherto almost despised leucocyte played in this process. It was shown, for instance, that what was practically an active struggle took place between the leucocyte and the invading microbe. Under certain circumstances the leucocyte was victorious, in others the microbe. When the former was the case the leucocyte took the microbe into its interior and destroyed it by a process analogous to digestion in unicellular organisms, and this power led to these cells being named Phagocytes, and the process Phagocytosis. On the other hand, when the microbe was victorious it killed or paralysed the leucocyte, probably by the action of the toxines produced by it. The inflammation which occurred at the part thus became a beneficial process, which had, as one of its most essential elements, the local supply of an additional number of leucocytes. In addition, however, to a local increase of leucocytes, it has been found that in many instances there was an appreciable increase in the number throughout the blood generally, from which it was inferred that the toxin locally produced had a stimulating effect on the organs forming white blood-corpuscles. That this is so has been abundantly proved by a similar effect being produced when toxines, apart from the microbe producing them, were injected. Not only has this been shown to be the case, but, in addition, it has been shown that the introduction of antitoxic serum has in many instances a similarly stimulating effect upon these organs. In many cases the influence which the antitoxic serum has in stimulating and increasing the fighting power of the leucocyte can be demonstrated. In no case, perhaps, is this better seen than in the case of diphtheria, where, as a result of antitoxic inoculation, the leucocytes accumulate at the seat of the local invasion, and actively and successfully destroy the diphtheria bacilli, thus preventing the further development of toxin.

In various other instances the proportion of leucocytes in the blood is an indication of the virulence of the toxin being produced in the course of a disease of microbic origin. For it has been found that, as a rule, if the toxin be very virulent no increase of leucocytes takes place, the toxin having a paralysing effect upon their production. It thus follows that a toxin of a moderate measure of virulence stimulates the natural fighting power of the leucocyte, while a higher measure of virulence renders it helpless and passive.

I do not attempt to trace the steps by which this important discovery was made, but you can imagine what an attractive and almost startling discovery it was to find that there was in the body a standing army of this kind, its members flying about in the blood stream, ready to pounce upon and destroy any noxious matter or active microbe, and having depots scattered all up and down throughout the body, most numerous where the danger is greatest.

This phagocytic action of the leucocytes is so marked and so capable of demonstration in some cases, that some of the more ardent upholders of it seek to explain the preventive and curative effects of serum to the influence it exerts upon the leucocytes. They argue in this wise. The phagocytic action of the cells is assumed, and the important influence of the blood-serum is also acknowledged, for in some cases it is too striking to be denied. It is suggested that the constitution of the blood-serum depends a good deal upon the influence the leucocytes exercise, that, in fact, they elaborate substances which are required for the defence of the body, and that they give up these into the serum. It is contended that the action of the antitoxic serums is to stimulate the production of these defensive substances, and that in this way immunity is effected.

The subject is very complex, and I think it extremely improbable that any rigid explanation of the varied phenomena is applicable.

As to certain facts there can be no question, and as to certain effects there is none. Putting it in relief, the facts are, that certain toxines are fatal, that by various processes animals can be rendered proof against this fatal action, and that the serum of such animals renders other animals also proof against them. This is evidently and necessarily due to important modifications in the blood-serum, but what these precise modifications are have not yet been fully shown. That the leucocytes and the tissue in which they originate play an important part in the production of the effect is at least probable, since it has been found that it is impossible to render an animal refractory to at least certain toxines, as tetanus, if its spleen has been removed. While this is so, there is a still further reaching aspect of the question. The immunity is not, as it were, confined to the blood, it is more or less possessed by all the tissues and organs. This is proved by the fact that the milk of an animal rendered refractory to a toxin, is to a degree capable of conferring immunity upon another. Not only this, but the young born of an immunised parent are also more or less immune. This shows that the influence is a very far-reaching one, and that it really comes to be a vital modification of every cell, and capable of transmission to new generations of cells. This heredity of immunity has been shown to exist even in regard to snake venom, and it has been proved in regard to other and as deadly poisons.

It may not be out of place here to recall to you the powerful story of *Elsie Venner*, whose mother's life had been prolonged after she was bitten by a rattlesnake, while the daughter with impunity dwelt amongst and presented mental traits suggestive of those dangerous reptiles.

I must say that to my mind this aspect of heredity, or the suggestiveness of the facts in relation to heredity, give to heredity a very curious and a very real importance. And what heightens the curiousness of the facts is, that this hereditary immunity can be acquired by the parent being rendered immune through the stomach—this is true of serpent venom for instance, but is not true of all toxines, for some are destroyed by the digestive process when introduced into the stomach.

I, at the outset, indicated to you the importance of the thyroid secretion, and that it could be introduced through the stomach. I also dwelt upon its importance for the due performance of brain function and the manifestation of mind. I do not seek to push the analogy, for it would probably break down, and would probably be false, but one may be allowed to indulge the humorous and curious possibilities which the analogy suggests, without being called upon to defend them scientifically.

X. *The Tufted Duck in Scotland: its Increase and Distribution.* By J. A. HARVIE-BROWN, Esq., F.R.S.E., F.Z.S.

(Read 18th December 1895.)

The facts upon which the following conclusions are based have been communicated to the *Annals of Scottish Natural History,* and appear in the January (1896) number of that magazine.

The present paper treats somewhat more fully of the Continental distribution, and subsequent dispersal in England and Ireland, than was attempted in the portion exclusively confined to Scotland.

Since the *Annals* paper was printed off, I have received a letter from Mr J. G. Millais, in which a very early occupancy of Loch Leven is hinted at—presumably as a winter visitor—and which I consider of sufficient interest to quote here. Mr Millais writes as follows:—

"When I first began going to Loch Leven, in 1879, Sir Graham Graham-Montgomery's boatman was John Maunderston, a most observant and charming old man, and devoted to birds. He died about 1884, if I remember rightly. All his life he had studied birds, and had lived beside Loch Leven. I perfectly well recollect talking to him on the subject, and his saying that the tufted ducks had been on Loch Leven ever since he was a boy (he died at about seventy years of age), and that he had often heard his father speak of the same 'black and white dukers' *living and nesting there.* Personally, I have little doubt that Loch Leven has been favoured with their presence for a very considerable period—much longer, probably, than any place in Scotland, the superb feeding in the islands, and comparatively warm climate, are all such as would attract them. I have no written authority for saying that the birds were there at the beginning of the present century, but I believe what Maunderston told me about his father frequently referring to their presence on the lake."

Regarding these statements, I have no remarks to make at present, but I was in communication with Sir Graham

Graham-Montgomery, in the hope that something more definite regarding Mr Maunderston, and any possible written memoranda left by him, might have been preserved by his descendants, but I have ascertained nothing of sufficiently definite character.

I propose first to present some idea of THE CONTINENTAL DISTRIBUTION, down to the dates of Dresser's "Birds of Europe" (1878) and Gätke's "Heligoland" (1895). The first-named author says in effect:—Absent in Iceland; once recorded in Færöe in June 1872; found nesting in north and south of Norway, but nowhere numerous; Lake Enare, and north of Finland and Sweden, less numerously in the southern districts; not seen on the Delta of the Dwina [in 1871]; scarce on the Lower Petchora [only two examples met with in 1875]; but generally distributed in Central Russia; very numerous in the N. (?) Ural[1] and S.W. slopes; *not* in Poland, except on passage; nests in N. Germany in several places; occasionally in Denmark; and still rarer in Holland, Belgium, and north of France; and thence southwards, it is spoken of as wintering, or as passing on migration along the coasts, and by the Rhine valley.

Gätke tells us the Tufted Duck has only occurred at Heligoland in a few isolated instances, but remarks: —"This is less surprising, seeing that it is pre-eminently an Eastern species, its nests being rare and isolated in the north of Scotland and Norway, but becoming more frequent

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[1] I queried the quotation from Dresser as regards its distribution in North Russia, and have been in correspondence with him, and he agrees with me that there is probably a slip in the statement in The Birds of Europe (1878). He writes (23rd December 1895): "I have not had any reply from Menzbier *re* Tufted Duck yet, though he has answered two other queries. I wrote again, and directly I have an answer, will let you know. I should say," continues Mr Dresser, "'East of White Sea is correct,' and that also it should be 'the Urals on their south slopes.'" The above reference to distribution "east of the White Sea" is in reply to my criticism of the statement in Saunder's Manual of British Birds (*q.v.*, p. 435), in which the Continental distribution is spoken of thus—"beyond the Arctic Circle it is comparatively rare." I believe this latter description does not sufficiently confine the limits of its northern distribution, and a more southern latitude should be quoted. *Vide* Annals and Magazine of Natural History, April 1877, p. 163; July 1877, p. 119; and September 1877, p. 153.

in Northern Sweden and Finland, while Northern Asia forms its principal breeding area (*vide* 'Heligoland as an Ornithological Observatory,' p. 533. D. Douglas, Edinburgh)."

From the above remarks I conclude that the *original trend* of autumn or winter migration of this species was—as is the case with most ducks and swimming birds—from north to south; but that in course of time considerable deviation from the due north to south direction took place, as areas along the old route became congested. Also I think we detect the tendency on the Continent to disperse and extend the breeding areas on lines from easterly to westerly directions, leaving out, however, the "turning points"[1] (Gätke) before reaching Heligoland. The distribution along the British coasts seems to take place along the south to north or south-west to north-east spring fly-lines.

I think we can scarcely expect to find it extend to Færöe, Iceland, or Greenland as a breeding species for a long time to come, if at all, as that would entail an autumn or winter migration from localities still farther east and north, and a return again in spring. Thus, recorded occurrences of the birds in Færöe even as late as June (Feilden), and others in Shetland and Orkney in winter after stormy or exceptionally severe weather, indicate an expansion from the east or north-east. But Færöe is not, perhaps, suitable, because most of the lakes are rocky and very bare of vegetation, which conditions, even in more favoured climes, are not those which the species affects for nesting localities.

I cannot think that we at present get great accessions to the host in winter from Norway, as the bird is rarer along that seaboard; but that Finland and the districts east of the

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[1] Herr Gätke clearly explains that many species find their turning points from east to west migration *before* reaching Heligoland, passing down the Continental coast, and thence, no doubt, by the Rhine valley, and by the coasts of France and Spain, and it seems likely that England first, and afterwards Scotland, have been indebted for their first pioneers of the species to individuals which have overshot their north to south line in autumn, but have again returned by the same or nearly the same route in spring. In this connection, I recommend a perusal of Mr Wm. Brewster's appropriate article in the Memoirs of the Nuttall Ornithological Club, No. I., Bird Migration, part ii., pp. 11-22.

Muonio river and the great Lake Enare contribute *some* quota *viâ* the Bothnian Gulf and Baltic there is no positive reason to doubt.

That any, or at least many, cross the high backbone of mountains of the Scandinavian peninsula from Lapland and Finmark *at once* after leaving their summer quarters, upon an east to west route, is, I consider, *extremely unlikely*, and I cannot think we have any evidence to show that such is the case. The few pairs, or, let us say, the comparatively small community which is reported as nesting in Northern Norway, is more likely to have obtained its meagre supply from birds which, pursuing a course east to west along the North European coasts, have reached their turning point at the North Cape. In 1872 Herr R. Collett reported the species as "nowhere numerous" in North Norway, and in 1891 he is silent as to any increase. As Palmén has lucidly explained—Migration routes are not irregular, but can be geographically determined. These routes lead from the north to the south, for different species, in the most various directions; but, he adds significantly, "in places outside or between these routes the birds do not usually occur"—*i.e.*, the birds of the species specially referred to by him.

Indeed, as I think can be gathered from our entire accumulation of facts, this species does not appear to take delight in crossing any high ridges or chains of mountains when on passage to and fro either in autumn or spring. The tendency of the species is distinctly to become sedentary or stationary once it has taken up and occupied new breeding centres.

And this, I think, is the place where I desire to say—while I have spoken of, and will likely use again, the terms "lines of least resistance" and "general migration flight," I do not wish to be understood to mean thereby any reference to the higher air strata at which it has been shown that many birds travel. That is a somewhat different and possibly a more difficult branch of the subject. I am only speaking of the influence of land-contours as may be presented to bird's-eye views from comparatively low sky-altitudes when birds are approaching downwards and landwards for purposes of feeding, rest on a journey, or arriving at their summer or at their winter quarters. The great "general migration flight" is performed, as Herr Gätke tells us, irrespective of great river-valleys crossing the line of the migrants' aerial path. I conceive the great reasons for this to be that the birds have not nearly accomplished their journey nor reached their winter quarters on an east to west migration, *and also* that their requirements of rest or food have not necessitated their descent.

Moreover, the rivers east of the Baltic and White Sea—as travellers in North-east Europe and Siberia know—have higher banks on their eastern or right banks than on the western or left banks, and on their passage westwards the birds have no serious obstructions to surmount, when the full swing of the grand migration is developed, until the White Sea for some, the Baltic for others, and the backbone of the Scandinavian peninsula for yet others, are encountered, a few only passing round the North Cape.

For instance, as Gätke tells us, the Richard's Pipits annually visit and rest upon Heligoland in considerable numbers, and their breeding haunts are known to be east of Loch Baikal.

We must take into consideration also certain circumstances of climate and general suitability, as it is unreasonable to expect a species, in making its pioneer advances, to select localities which are unsuitable to its habits and food supplies —at least during its earlier movements. Later, when areas become crowded or over-populated, then and then only would it be reasonable to look for an expansion to areas of less suitable nature; and then and then only could we expect to find any species begin to undergo modifications in habits or food to suit new descriptions of *locales* and circumstances. When this later stage is reached, the next development takes place—the "selection of the fittest" in this struggle for existence and extension of range, or, otherwise, the extirpation of the extending lines.

That this extension is the result of special instinct or effort on the part of the birds themselves I cannot admit. This impulse is engendered by outside circumstances, or environing causes equally affecting the first pioneers and their after-followers. This I have illustrated before in several papers of a similar character to this one. Thus Capercaillie hens are the first to yield to pressure of population at a breeding centre, and by force of circumstances fly outwards and follow "lines of least resistance" or "avenues of escape." They are followed by the males in course of time, when the impulse becomes too strong to resist; but they are not followed, *because* the males know where to look for them, but because they are influenced—or governed—by the same circumstances, illustrating the same *Law in Nature*, which in the earlier stage affected the female pioneers. So fully has this been recognised by Scandinavian authorities, when speaking of this periodical outburst of males from previously populated centres, that they say of the Capercaillie cocks, that they "*forflyga sig*," or "fly they know not whither." It is not so-called "instinct" which enables the birds to find their partners, which have preceded them, but determining causes, outside of their will or "instinct"—a Law of Dispersal which seems to me to result in a natural outcome of following what has been termed—"*the lines of least resistance*." It is not chance, for there is no such item. In course of time the areas along these "lines of least resistance" become fully populated, and in the earlier progressive movements, only the likelier haunts are occupied. Later, when pressure of population takes place, new *lines of dispersal* are opened out, say right and left of the principal *avenues of escape*, and so, onward, and outward, the waves of distribution pass. But knowledge of these localities outside, or to right and left of the more beaten tracks, can only be attained by individuals after some years—it may be less or more—of biannual migration in *autumn and spring*. In such a procession, many are left, but perchance few are chosen. The best colonists take up the new abodes, the weak, *as a rule*, go to the wall.

Now, as regards the localities which appear to be most affected by the Tufted Duck, I believe that the following short description, in general terms, will suffice, at least to show the drift of my argument. So far as our facts teach us, the Tufted Duck affects lochs, lakes, or ponds of considerable size; also such as possess no great depths of water

—say 10 to 15 feet or shallower; which abound in their favourite food-supplies—plant-life, crustacea, and larvæ; which likewise contain islands, or have their shores deeply clad in luxuriant vegetable growth—aquatic or semi-aquatic preferred—and selecting the lochs at the lower elevations above sea-level to mountain lochs or tarns. The Tufted Duck being a true diving duck ("*Doucker*" or "*Dooker*" as it is named in common phrase with the Golden Eye, and some other species of *Fuligulæ*), it prefers comparatively shallow water of some expanse, and usually places its nest amid the densest growths of water- or land-plants it can find. According to the relative size and depth of various habitats will their numbers be small or great, if other amenities are present. Each pond, loch, or reservoir will hold its requisite supply, and rapid increase beyond the power of each to carry will result in (possibly sudden) decrease there, and sudden appearance elsewhere.

How admirably the sheets of water which at present attract them for breeding purposes fulfil these conditions in the eastern areas. Principal among these are:—

Yetholm and Hoselaw Lochs in Roxburghshire ("Tweed").

Lochs of various sizes in Selkirkshire.

Loch Leven in Kinross (Forth), and numerous smaller sheets of water in Fife. Loch Lindores (Tay), and the following in the same drainage area:—Lochs Dupplin, and mill-ponds in the same district. Loch Butterston and others near Dunkeld.

Lochs in the neighbourhood of Forfar—Rescobie, etc.

Loch Skene, Loch o' Park, and artificial lakes on Haddo, Aberdeenshire.

Loch Stemster, in Caithness.

And in the western areas:—The lochs which lie close to the Solway Firth in Wigtownshire and Kirkcudbright, and a group of lakes and reservoirs which lie near the eastern county marches of Renfrewshire ("Clyde"), and in a minor degree Loch Vassapol in Tiree.

These are the presently occupied head-centres of the Tufted Duck in Scotland, and it is still spreading and increasing annually.

There are, however, other equally suitable sheets of water as yet entirely unoccupied, and which must be for the present considered to be too far to the right or left of the main lines of the "general migration" flights, or of too difficult access. Of these, I may instance most prominently *Loch Spynie*, and many other lochs within the Moray Basin Watershed. I have not a single *undoubted* record of its nesting anywhere within this huge natural faunal area, up to the date of going to press, and this, as my readers will find, long after Caithness centre became populous, and long after Loch Leven "swarmed" with them. It appears to me that Moray is one of those curious blank spaces, so to speak, as regards *this* species, which Palmén refers to as lying "between the routes," and it is scarcely less curious to find, that the slopes which face the south and south-east, and are thus more easily accessible to birds approaching from an easterly or south-easterly direction, are at the present time mostly preferred on the East Coast of Scotland and England; while such as are on the north sides or face the west and south-west, or are most easily approached from the south-west, are witnesses to earlier occupation on the West Coast, though not so early as those upon the East Coast; or otherwise, the autumn flights are brought up by the suitable feeding or nesting haunts when pursuing their course across Scotland from north-east to south-west; *i.e., if such flights take place at all, even across our lowest watersheds, in normal conditions of weather, a possibility I cannot say I distinctly realise at present.*

The argument that more suitable localities happen to occur on these slopes facing the south-east than on those facing the north, *may be* partly a reason for their later occupancy of the latter, but is insufficient in itself, I consider, to account for this partiality. If there were no other reasons influencing dispersal, how can we account for such a rule being broken in the vastly favourable areas of the Moray Basin, west of the dividing mountains between "Dee" and "Moray," as shown by our present statistics?

I now come to consider such side lights as may be thrown upon their dispersal, by their past and present distribution in England and Ireland.

Without going into unnecessary detail, we find that the Tufted Duck is still spoken of, in the latest edition of "Yarrell's British Birds" (Saunders), as "best known as an autumn and winter visitor to this country," but the earlier records of its nesting in English localities are given, as also are its extensions to other and more northerly localities at later dates during the last few years, and farther south in Norfolk. It bred first at Malham Tarn in Yorkshire, and at Serlby in Nottingham, about 1849 to 1851, and at Osberton about 1854,[1] and has extended north to South Lancashire (in 1884) and South Yorkshire (1880), and farther to the south in Norfolk first as early as 1876. At present (*i.e.*, in 1885, date of issue of Saunders's "Yarrell") "its headquarters appear to be on the ponds at Newstead Abbey, Rainworth, Clumber, Welbeck, Rufford, in Nottinghamshire."

Since the above was written, I have received the following note from my friend Mr J. H. Gurney—"The breeding of the Tufted Duck in Norfolk was not established till 1873, and in 1876 it was placed beyond doubt by Professor Newton, who flushed and identified a Tufted Duck from six eggs at Stanford Mere, near Walton. In 1889 their numbers had increased to thirty breeding pairs on this piece of water, and, I am glad to say, they steadily hold their ground in suitable places in *West Norfolk, but they have not extended to the "Broads" on the east side of our county*" (J. H. G., *in lit.*, November 14, 1895). I have italicised the last passage, and it is further accentuated by correspondence on the subject with Professor Newton, and by the details given in Stevenson's "Birds of Norfolk," vol. iii., p. 211 *et seq.*

Professor Newton adds (*in lit.*, January 4, 1896) to other information:—"Though Tufted Ducks bred a good many years ago in Yorkshire, Northumberland, or Durham, and in Nottinghamshire—it has always seemed possible that my brother and I had something to do with the colonising of Norfolk. We had pinioned birds breeding at Elveden in the fifties, and, I think, did not always take up all the young, so

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[1] *Vide* Sterland and Whitaker's Birds of Nottinghamshire, p. 56, 1879.

that there were, if I remember right, two or three full-winged birds flying about when the place was sold in 1863 to Dhuleep Singh. Such birds, if they wanted to breed, would naturally find the Stanford and Tomston waters much more to their liking than the Elveden horse-pond, and I could well imagine their settling "down to such excellent accommodation." Further, Professor Newton says, that, at the present time, the Tufted Duck is far more abundant than the Pochard, although the latter began nesting there before it, and "availed itself of the Wild Fowl Act by at once becoming numerous."

Coming to Ireland. Thompson, writing in 1851, tells us it is rare in the north-west of Donegal, and "its scarcity in the south-west of Ireland accords with what we find to be the case in the south-west of England." But "Tufted Ducks are sent in quantity from various inland localities to Dublin market. . . . Along the eastern coast in particular they are numerous, two hundred having been seen in company in Carlingford Bay; in the bays of Drogheda and Dublin and in Wexford Harbour they are common. . . . It is common on lakes in Mayo." But, "in Kerry, the Tufted Duck was unknown to Mr T. F. Neligan in 1837," and but one bird had been recorded up to December 1849.

Now, in the north of Ireland, by Thompson's notes it would appear that it was a winter visitor, in the time of his observations, to Belfast Bay, and the latest of all the *Fuligulæ* to arrive, the date of their first arrival in 1839 and 1840, being considered early even in the month of December, but they are said to arrive earlier on fresh water—and to have been brought to him from the middle of November to April from Lough Neagh; and, he adds, "I have known them to remain there until May, on the 4th of which I saw one in 1856." It is *not spoken of definitely* as a breeding species, but it was supposed it may have nested once on Lough Neagh, as a fine male was brought to him thence on 17th June 1834. "It is the most common species of duck during winter, and remains until a late period of the spring in the little inland lakes of the County Armagh" ("Natural History of Ireland: Birds," vol. iii., p. 141 *et seq.*).

Mr R. Lloyd Paterson also remarks upon their abundance in Belfast Lough on the 21st January 1871, along with Scaups, Wigeon, and Wild Ducks, considering it no exaggeration to estimate the numbers seen of these species at 5000 on that one day; but there is no mention of the present species as a resident or a breeding species. (Further notes on "Some of the Swimming Birds frequenting Belfast Lough," a paper read before the Belfast Natural History, etc., Society on 21st April 1875.)

The remark has been made that the birds thus appearing in numbers on tidal estuaries and bays in Ireland, presupposes a prior winter visitancy of the sheets of water in the interior; but this does not affect the question of summer residency or dates of earlier records of nesting. Neither do I consider it proved by any means that the Tufted Duck is, *except when frozen out*, only a frequenter of fresh water.

Then at last Mr A. G. More, in the latest issue of his "List of Irish Birds, Etc." (Dublin, 1885), says:—"Regular winter visitor in small numbers, preferring fresh water. A few breed on Lough Neagh, Lough Beg, on the Shannon Lakes, and in the County Monaghan" ("Fowler in Ireland," p. 105): but in a circular, "Enquiries respecting some Irish Birds," dated 30th June 1895, he seems desirous of ascertaining fuller particulars of the nesting of the following species: —Wigeon, Tufted Duck, and Pochard. The date, therefore, of the first nesting of the Tufted Duck must have been recorded between the years 1875 and 1882, and the authority quoted by Mr A. G. More is Sir Ralph Payne Galway, whose book, above noticed, appeared in 1882. Mr A. G. More died in 1895.

In a letter dated 21st August 1895, Mr Lloyd Paterson informs me that "the Tufted Duck is now a regular breeder in different suitable localities in the north of Ireland, and probably in increasing numbers; and inquiry of my nephew, who knows more about it of late years than I do, confirms this. He tells me it breeds regularly, and, he believes, in increasing numbers, on Lough Neagh, and the adjoining loughs—Beg and Portmore—the latter a favourite nesting-place for, among others, the Shoveller. The Tufted Duck also breeds on Lough Erne, and is said to be increasing there too, but I could not say that any 'vast' increase has taken place anywhere. I think it may now be considered as 'breeding commonly,' *i.e.*, regularly, but not in large numbers. Want of systematic observation and inquiry prevents my answering your query as to when the present supposed increase began to be noticed. It breeds also in County Monaghan, and is reported from Donegal, but I have no information as to Lough Fearn. It is reported from several other Irish counties outside Ulster. Twenty to twenty-five years ago, I have seen as many as 400 in one 'paddling' in Belfast Bay. They are abundant on Lough Neagh in winter, and are sometimes taken in nets there, and at Lough Beg, and on the lower River Bann, where it leaves the lake; but I think such captures are more by accident than design. A few years ago, four were sent to me that had been so netted—these out of a much larger number." In a subsequent communication, Mr Lloyd Paterson tells me:—"The netting is done practically all round the lake (Neagh). The nets are set on the bottom by weighting with stones, holding them perpendicularly by corks. They are netted in thousands in 15 fathoms of water, also the Red-head or Pochard."

The principal interest of these side-lights of Irish distribution seems to me to be in the fact that the Tufted Duck was such an abundant winter visitor, and was so well known to be so, *long before* it was recorded as a breeding species in the east counties of England, and also *long before* it came to be known, or was obtained by the punt-shooters of the Solway Firth, as vouched for at the date of 1888 by the Rev. H. A. Macpherson in his work on the "Fauna of Lakeland."

Our blank in consecutive records in Ireland is somewhat of a stumbling-block, but so far as the ascertained facts indicate, the earlier records of its breeding were in the north, and near the northern extremities of its winter residence. The question naturally arises, Whence was Ireland *first* visited? Was it by the higher-flying squadrons which Gätke believes cleave the higher strata of atmosphere, which are bent upon the longest or overlapping journeys? I have myself before now witnessed both *actual* departure and *actual* arrival of several species from and at their breeding haunts; and I relate some of these personal experiences in another place *for what they may be considered worth.* (See under Oyster-Catcher, as an example, in the "Fauna of Moray," when issued.)

In conclusion, and as a resumé, my readers will, I believe, realise from the statistics given in detail in my previous paper in the *Annals,* that the record from Lewis Dunbar as *earliest breeding* of the species in Caithness, predates our first *earliest winter record* in Tiree by some ten years. Also that the *earlier winter or autumn record* in North Ronaldshay, and my own in the south of Shetland, most nearly correlate with the *first breeding record* in Tiree; and further, that the *earliest breeding* record in Orkney correlates also with that in Tiree. Now all this time the whole of the Moray basin has been almost unfrequented even in winter, but a few isolated occurrences have been recorded from the localities on the western watershed. We may still justly consider the whole of the Moray basin, and the Hebrides and West Ross and Skye, as blank as regards the residency of the species, and only visited *in severe weather,* with the exception of the few instances I have given—Loch Gown, etc. (*Annals,* 1896, p. 19), one loch on the north-west frontier of Moray, and possibly the Loch of the Clans and Loch Flemington.

Also that, while Caithness in the extreme north-east had become populous, Solway was almost a blank, though Ireland held them in thousands both in fresh water and in tidal areas at the same time, and for many years previous. And that south of the great Geological Fault contains earlier records of the birds breeding than anywhere to the north of it, and even a little earlier than Caithness. And that, as yet, the birds are only approaching—quite of recent years—a line drawn across Scotland about the centre of "Argyll" to the "Tay" watershed in the west, and breeding only, so far as recorded, in the island of Tiree.

The questions of interest raised by the foregoing account of the dispersal of the Tufted Duck seem to me to be:—In how far is Great Britain indebted to a direct expansion from easterly earlier centres of reproduction along the parallels of latitude; or, in other words, whence did we draw our earlier pioneers? Did they come to our shores first in winter or autumn, from congested areas of occupation in Central or Eastern Europe, and Asiatic sources south of the great isothermal line? or from more northern extensions of their Continental range—say from the later qualified and more lately populated areas in Lapland and the eastern portions of Northern Scandinavia? or, as some seem to believe, direct from the thinly populated areas of the western watershed of Northern Norway? How does it happen that Heligoland seems to remain almost entirely unvisited? Why is our Moray basin almost a blank, as also Færöe and the Outer Hebrides, and the west coasts of both England and Ireland? How has Caithness become populous—perhaps second in importance to Loch Leven only, and to the areas of Tay and Forth on the north side of the latter? Why have the whole areas of Moray and the fringing counties of the south side of the Firth of Forth been so long delayed in receiving a share of the wanderers? Why has Tiree yielded first record of its nesting anywhere north of Clyde in the west? *Now*, England bears the earliest group of dates, and that in Nottingham (1849 to 1851, to 1854), and in Norfolk again in 1873. In the latter county, as Mr J. H. Gurney informs us, "steadily holding its ground in suitable places in West Norfolk; but," he adds, "they have not extended to the 'Broads' on the *east* side of our county" at the present time. I would ask, Why is this? *Are the "Broads" less suitable?*

In Ireland, again, the earliest known nests appear to have been recorded between 1875 and 1882; but it also appears that no "vast increase" has taken place anywhere, although the quantities of birds seen in autumn and winter and spring are large enough. Irish naturalists allow that want of systematic observation may partly account for paucity of records, and the "beginnings of its increase" may therefore have been overlooked.

On the north-west coasts and Lake District of England, or south of the Solway, it is not even yet proved to have nested, and the late date of 1888 is given as its early appearance on the Firth; but, on the other hand, Wigtown and Renfrewshire, in the east (note it) of the county first, and in the west later on, became populated, and the Clyde tidal water populous. Then the area around Loch Lomond, or between Clyde and Loch Lomond, became, of late years, inhabited. But outside the Mull of Cantire we have as yet but scant records except from Tiree; and not until the winter of 1894-95 has it appeared abundantly, as coming into Mr Bisshopp's hands in Oban. In strong contrast to this are early accounts of it at Loch Awe, and its first appearance in Remony Bay, on Loch Tay, in the spring of 1880; and in the past winter of 1879-80 they had there "appeared and continued in unusual numbers all the winter," and that "most of the duck tribe appeared earlier by a month." (See Dewar's information.)

I could continue this analysis or resumé of my paper, and instance many other correlating groups of facts, but I feel I have occupied already too much time and space; yet I hope I have succeeded in grouping these facts throughout with sufficient incisiveness to enable others to compare them, and I trust the map accompanying the paper in the *Annals*, and the explanation facing it, along with the index to it, will assist in doing so.

Just lately we have read (and re-read) that in the Muonio River district of Russian Finland, Mr A. Sutton Davies "was surprised to find the Tufted Duck so common as it was." This is east or north-east and north of the Bothnian Gulf, and the Muonio River drains into it, rising far up among the mountains of the "*great divide*" of Scandinavia. The Muonio runs through a low and swampy country during the greater part of its course. The migration of the Tufted Ducks of this now populous area or centre in all probability follows the depression of the Baltic, and pursues a course down the coast of Holland to populate the Mediterranean in winter, *missing out Heligoland*, as other species do at their turning points; or if a few, or any, round the south coasts of Sweden, and come to us *then* from the east, they may equally miss out Heligoland in passing, or pass too high for observation, not lowering in flight, as it does not constitute their wintering area (see *Zoologist*, 15th September 1895, p. 331). East and north-east of the White Sea—so far as naturalists' observations have been recorded—let it be remembered the Tufted Duck is rare, or *was* rare, at all events, as late as 1871 and in 1875 (Petchora River and Dwina Delta), and we are not aware of any later increase in these parts.

How far these questions can be answered and these difficulties got over—I mean as regards the dispersal to our shores of Britain—may perhaps appear to those who are not already wedded to what may seem "a more reasonable and direct dispersal from the north direct," if they study carefully the facts we have tried to group in the body of the paper in the *Annals.* It only remains for me to say it *does appear to me* that there is a distinct dispersal from original centres in the east, westwards, influenced by the isothermal lines, and checked only by either vast expanses of ocean backed up by mountain chains intersecting the general course of their east to west migration. And I may perhaps be pardoned for thinking that our facts go to prove, or at least to suggest another possibility, which may shortly be stated as follows:—Tufted Ducks, as we know, are naturally of sedentary disposition. It seems almost that they first colonise towards the centre of their migration area. As I have endeavoured to illustrate, their fly-lines are interrupted by physical obstructions, notably mountain chains, and individuals first colonise closest up to these obstructions to their routes, and afterwards the surplus surges back as it were along the lines which on their previous migration offered least opposition or resistance (as individuals, not as the whole species). In fact—if this reading be correct—the Tufted Ducks first colonise areas suitable to their requirements, nearest to the limit of their individual *winter termini,* and subsequent dispersal takes place by the retrograde steps of their spring movement; or pressure of population may, and doubtless does, result in finally pushing many over these obstructions; but, *so far as* our present facts take us, there is little evidence indeed to show that our western and eastern areas of distribution of the species are indebted to the same avenues of approach.

It appears to me also, that possibly the converse state of things to that represented by the dispersal of this distinctly eastern species, may be shown in the dispersal of certain others—viz., a west to east dispersal, locally escalading our mountain chains by sheer force of accumulated numbers, after all easier outlets and "avenues of escape" have first been overcrowded by migration, and afterwards overcrowded by actual permanent occupancy. Facts long accumulated enable me to *at least indicate* this possibility in the case of two species—viz., the Goosander and Merganser—species of as eminently western or north-western origin and concentration, as the Tufted Duck is of earlier eastern occupancy. We also have numbers of facts which go to prove (or suggest, let us prefer to say) the courses of dispersal of many woodland species of totally different habits and powers, the movements of which, however, be it said, are often more intricate to follow.

Readers will find further remarks in the forthcoming volumes by Mr Buckley and myself on "The Moray Basin," which we trust may be found worthy of perusal under several species, especially under a woodland species—the Redstart.

Mr Hancock's records show it to have been a breeding species in Northumberland as early as 1859,[1] and Professor Newton writes me of what he considers the earliest record in Britain, viz., in Nottingham in 1851. I am not aware, however, of any nesting sites in Northumberland which are located within the watershed of Tweed.

XI. *Note on the Occurrence of the Larva of the Drone-Fly* (Eristalis tenax, *Linn.*) *as a temporary Endoparasite in Man.* By J. ARTHUR THOMSON, M.A.

(Read 18th December 1895.)

It has seemed to me useful to place on record what I believe to be, to say the least, very rare—the occurrence of the larva of the Drone-Fly (*Eristalis tenax*, Linn.) as a temporary parasite in man. I make this note from a zoological standpoint; the physician in charge of the case will take account of the medical aspects.

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[1] *Vide* Birds of Northumberland and Durham, p. 155.

On the 1st October, Dr D. M. Hutton, one of the residents in the Royal Infirmary, brought me a living larva, which, along with two others, had been passed *per anum* by a patient in one of Dr Wylie's wards. I have to thank Dr Wylie and Dr Hutton for the three specimens which I exhibit, and for allowing me to record the occurrence.

I had little difficulty in identifying the larva as the "rat-tail" larva of the Drone-Fly; on comparing it with a specimen kindly sent me by Dr David Sharp of Cambridge, I could only discern trivial differences.

Therefore I need hardly say that the parasite larva had a telescopic respiratory tail, a pair of double horn-like projections on the head, seven pairs of bristled stump-like appendages, and so on. The larvæ were long ago described by Réaumur, and have been recently studied by Wilkinson, Miall, Buckton, and others.[1] I am solely concerned here with noting their occurrence in man.

It is unlikely that this has not been noted before, but I have been unable to find a reference. Of course cases of "myiasis," due to various dipterous larvæ, have been often observed.[2]

As to their introduction into the patient, I am told that on 24th September he drank from a spring on Luffness Golf Links, and that in a few days he began to suffer from diarrhœa, etc. The three larvæ were passed on 1st October in the Hospital, but it may have been that these were not the first.

Although it is probable that the patient swallowed young larvæ along with the water drunk on the links, there are two zoological difficulties—(1) that the eggs are usually laid and the larvæ developed in stagnant water containing animal or fæcal matter, or in some moist carcase; and (2) that the period between the 24th September and 1st October is very short for the attainment of almost the full larval size.

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[1] Professor L. C. Miall, Natural History of Aquatic Insects (London, 1895).

[2] For a detailed bibliography see Professor M. Braun, Die Thierischen Parasiten des Menschen, 2nd ed., pp. 277, 278 (Würzburg, 1895); and Dr G. Alessandrini, Raro caso di parassitismo nell' uomo (*Sarcophaga affinis*), Boll. Soc. Rom. Stud. Zool., iv. (1895) pp. 278-89.

XII. *Some Newly-Hatched Specimens and a late Embryo of* Opisthophthalmus. By MALCOLM LAURIE, D.Sc., B.A., F.R.S.E., F.L.S., Professor of Zoology in St Mungo's College, Glasgow. [Plate IV.]

(Read 19th February 1896.)

While examining some of the Arachnida in the British Museum, my attention was drawn by Mr Pocock to two sets of newly-hatched Scorpions, which showed certain peculiarities of structure. Both lots belonged to the South African genus *Opisthophthalmus*, one being the young of *O. capensis* (Herbst) and the other the young of an undetermined species. Through the kindness of Dr Günther and Mr Pocock, I was able to examine some of the specimens minutely, and to cut a series of sections through one.

The peculiarity which strikes one at first sight is the presence of two long processes growing from the prosomatic region. The more prominent of these arises in front of the mouth and projects forward like a proboscis (Figs. 1-3, *a*). It has a length greater than that of the carapace, and is found in section to be a tube filled with trabecular tissue, and probably also containing blood-vessels. Though arising immediately in front of the mouth, it has no connection either with the œsophagus or with the powerful sucking muscles. The cavity appears to communicate with the general body space, but is not easily traced among the complex structures of this region.

The other process arises from the dorsal surface of the carapace. In *O. capensis* (Fig. 3, *b*) its point of origin is close behind, indeed almost between, the median eyes. It is bent forward, and lies along the carapace, projecting slightly beyond the front margin. In the other species (Fig. 2) the process arises about ·2 mm. behind the eyes, and lies directed backwards in a groove in the carapace. It fits so closely into this groove that it might easily be overlooked. It is shorter (measuring about 1 mm.) in this species than in *O. capensis*, and does not reach the hind margin of the carapace. This structure, like the preoral process, is hollow, and is filled with trabecular tissue and blood-vessels.

A further point which we may note in these newly-hatched specimens is the presence on certain of the tail segments (8th to 11th free segments) of paired bladder, like outgrowths from the dorsal surface. Similar structures have been described by Thorell as being present on some young specimens of the closely allied genus *Heterometrus.*

Among some adult specimens of *Opisthophthalmus capensis,* for which I am indebted to Mr Peringuey of the Cape Town Museum, I was fortunate enough to find a female containing embryos in a late stage of development. One of these is figured in Figs. 5-7, and we see that at this stage there is a very prominent horn-like structure arising from the back of the carapace. Careful examination shows this horn to be composed of two parts, lying one behind the other. The anterior, which forms the greater part of the horn, arises (Fig. 7) in front of the mouth, and bends back over the front of the head to join the posterior part. This posterior part arises from the dorsal surface of the cephalothorax, and extends for about half of the length of the anterior part, lying close to it, but apparently separate throughout. The horn formed by these two processes penetrates through the thick walls of the follicle round the cephalothoracic region, and projects freely among the tissues of the mother.

The 2nd to 7th free segments of these embryos are swollen out dorsally into large paired oval outgrowths, while the 8th to 11th segments bear smaller but similar structures. The last segment is free from any trace of outgrowths, and has the normal cylindrical form. While the follicle surrounding the cephalothoracic (prosomatic) region of the embryo is very thick and strong, that surrounding the free segments is very thin.

The most probable function of the horn-like prosomatic and bladder-like meso- and metasomatic outgrowths is that of absorbing nutriment for the embryo from the surrounding tissues of the mother.

The eggs of most scorpions contain, like those of other Arachnids, a large amount of yolk, on which the embryo nourishes itself during development. This is the case, roughly speaking, in the families of the Buthidæ, Bothriuridæ, and Ischnuridæ,[1] and in all these the egg early leaves the follicle in which it is formed and fertilised and passes into the ovarian tube of the mother, where it undergoes the greater part of its development.[2] In the family Scorpionidæ, however, the egg is very small and contains no food-yolk. It is formed at the end of a long diverticulum of the ovarian tube, and develops *in situ*, the embryo gradually extending downwards till it occupies the whole of the diverticulum.[3] It does not leave this position until it is fully developed. The nutrition of the embryo in these forms is provided for in the earliest stages by secretion from the cells lining the diverticulum. Later the embryo feeds on a solid cord of cells which terminates the diverticulum, which it crushes betwixt the cheliceræ. In connection with this mode of nutrition, the cheliceræ are developed long before the other appendages, and provided with a chitinous plate on the inner surface of the last joint. In the ordinary scorpions (*Euscorpius*, *Centrurus*, etc.), on the other hand, the development of the cheliceræ is delayed, and while the rest of the appendages appear in order from before backwards, the cheliceræ do not appear till after the other five prosomatic appendages. In *Opisthophthalmus* the modification of the cheliceræ for this function has produced a most abnormal structure (Fig. 8), the last joint being enlarged out of all proportion, and distorted in shape. The chitinous plate on its inner surface is somewhat smaller and simpler than in *Scorpio.*

The later embryos of *Scorpio fulvipes* have dorsal outgrowths similar to those of *Opisthophthalmus,* and there is little doubt they serve to absorb nourishment from the surrounding tissues. The young of the Scorpionidæ are not,

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[1] For a list of the forms in which the different modes of development occur, see Annals and Mag. Nat. Hist., March 1896.

[2] Brauer, Zeitschr. wissensch. Zoologie, vols. lvii. and lix.; and Laurie, Quart. Jour. Micros. Soc., vol. xxxi.

[3] Laurie, Development of *Scorpio fulvipes,* Quart. Jour. Micros. Soc., vol. xxxii.

on the whole, larger in proportion at birth than those of the other scorpions, but those of *Opisthophthalmus* are markedly so. Newly-hatched specimens of *O. capensis* measure 15 mm. in length, the length of the mother being 75 mm. They are, however, proportionately fewer in number. The cord of cells on which the embryo nourishes itself is, on the other hand, smaller in *Opisthophthalmus* than in *Scorpio*, and it is probably in relation to these two facts, of the large size of the young and the small size of the cord, that we have the additional nutritive arrangement of processes from the prosomatic region.

Thorell suggests that the outgrowths from the tail segments in the young of *Heterometrus* are respiratory in function. It is quite possible that this is so, and that the prosomatic outgrowths of *Opisthophthalmus* have the same function after birth, as the stigmata of the lung-books do not appear to be open in these young specimens.

In such a widespread and ancient group as the Scorpions, one is entitled to expect peculiar modifications in many respects. In the external structure the variations are remarkably small, while the types of development are very different. A third type of development seems to exist in *Vejovis*, the eggs of which are comparatively small, and apparently devoid of yolk. They develop, however, in the ovarian tube like those of *Euscorpius*, *Androctonus*, etc. Doubtless many further interesting points exist in various species, could one only get the material; but the majority of the specimens collected go to our big museums, and, once registered in their catalogues, there is but little chance of examining their internal structure.

A further point of interest in connection with the newly-hatched specimens of *Opisthophthalmus* is the position of the central eyes. In all the Scorpionidæ these have a somewhat posterior position compared with the members of the other families. In *Heterometrus* they are farther back than in *Scorpio*, and in *Opisthophthalmus*, as its name implies, they are very far back, farther back even than in *Heterometrus*. It is interesting, then, to find that in the young individuals the eyes approximate to the normal position. Instead of being situated well behind the middle of the carapace, they are, in the young of *O. capensis,* exactly in the middle, and in the young of the other species ·25 mm. nearer to the anterior than the posterior margin.

Description of Plate.

Fig. 1. Newly-born *Opisthophthalmus* sp., from ventral surface. The basal joints of the anterior limbs have been pulled apart to show the mouth, *m*; × $\frac{7}{1}$.

Fig. 2. Dorsal view of same specimen; × $\frac{7}{1}$.

Fig. 3. Dorsal view of *Opisthophthalmus capensis;* × $\frac{7}{1}$.

Fig. 4. Tail segments of *O. capensis.*

Fig. 5. Embryo of *O. capensis*, dorsal surface; × $\frac{2}{1}$.

Fig. 6. Embryo of *O. capensis*, side view. *co*, solid cord of cells terminating the follicle.

Fig. 7. Embryo of *O. capensis*, side view of cephalothorax, the follicle being removed.

Fig. 8. Right chelicera from same embryo, viewed from inside. x, chitinous plate.

XIII. *Report on a Collection of Marine Dredgings and other Natural History Materials made on the West Coast of Scotland by the late George Brook, F.L.S.* By Thomas Scott, F.L.S., Mem. Soc. Zool. de France, Naturalist to the Fishery Board for Scotland. [Plate V.]

(Read 15th January 1896.)

On the 4th of October last year (1894) my friend, Mr F. G. Binnie, formerly assistant to the late Mr George Brook, wrote to me concerning a collection of marine dredgings and other material that had been made by Mr Brook at various places on the West Coast of Scotland. Mr Binnie, with consent of Dr Woodhead, one of Mr Brook's executors, suggested that I might undertake the examination of the material, and, if found sufficiently interesting, prepare a report on the results of the examination of it. In the letter referred to, Mr Binnie says, "Amongst the material that belonged to the late Mr George Brook there is a set of dredgings from the West Coast of Scotland, collected by him while cruising in his father's steam yacht 'Dotterel.' In the collection there are a good many Crustacea, some other invertebrates, and a few fishes. We are most anxious that the material should be worked up and not wasted, so that Mr Brook may get some credit, even though it be posthumous."

The collection soon afterwards was handed over to me, and, as Mr Binnie anticipated, the examination of it has proved to be interesting. A record of the results of the examination is embodied in the following report, which I now desire to submit to the Royal Physical Society of Edinburgh.

GENERAL DESCRIPTION OF THE COLLECTION.

Before proceeding to give a record of the various organisms contained in the collection, the following brief description of the collection itself may be of interest. The material was collected by means of the beam-trawl, the dredge, and the tow-net; tow-net gatherings, however, formed but a small part of the collection. The material forming the collection was contained in upwards of two hundred bottles and tubes of various kinds, but they were chiefly of small size. It was collected for the most part during the months of July, August, and September 1887, but it also included one or two small gatherings made in 1886 and in 1888. Moreover, it was collected at various localities,—as, for example, in Loch Fyne; in the vicinity of the Island of Mull, and in Loch Linnhe; off Ardnamurchan; in the Gairloch; in the vicinity of the Island of Skye; and at one or two places in the Outer Hebrides. The material was also collected at various depths, from close inshore down to 100 fathoms. The contents of a few of the bottles were somewhat decomposed, owing to the partial evaporation of the spirit, and in one or two instances the labels were scarcely legible, but otherwise the collection was in fairly good preservation. Greater attention appears to have been given to the collection and preservation of the larger invertebrates rather than to the more minute kinds; nevertheless, by carefully overhauling the larger forms,—washing off and collecting the mud and sand adhering to them—and by a careful examination of the finer matter in the bottom of some of the bottles, a considerable number of micro-Invertebrata have also been obtained, as will be seen by referring to the Table of Distribution.

The Vertebrata, which are represented by the fishes, are few in number. The Invertebrata consist chiefly of Mollusca, Crustacea, Echinodermata, and Foraminifera; a few other groups, as the Tunicata, Annelida, and Polyzoa, are also represented, but only by a small number of species. About 344 species in all have been more or less satisfactorily determined, but as a considerable number of them are moderately common and generally distributed, I have not considered it necessary to refer to these common forms in the body of the report, but have included them in the Classified List and Table of Distribution at the end, so that only the rarer species will be specially noticed.

DETAILED DESCRIPTION OF THE COLLECTION.

In proceeding to describe more particularly the various groups of organisms represented in the collection, as well as the rarer and more interesting species, it will be better to do so according to some recognised method. I propose, therefore, in the general arrangement of the various groups, to adopt the classification used by Professor Nicholson in his "Manual of Zoology," but beginning with the higher forms first. Then as to the classification of each of the groups, and especially of those that are more numerously represented in the collection, I have endeavoured, as far as possible, to follow the arrangement and nomenclature of recent and authoritative works on each particular group.

The fishes are arranged here in the order in which they occur in the late Mr Day's work on British Fishes. The Mollusca are all arranged and named according to part iv. of Dr Norman's Catalogues ("Museum Normanianum"). In the arrangement of the Crustacea, I have followed part iii. of Dr Norman's Catalogues for the "higher" Crustacea, and Professor Henderson's "Decapod and Schizopod Crustacea of the Clyde" has also been consulted; the Amphipoda are arranged and named in accordance with vol. i. of Professor G. O. Sars' "Crustacea of Norway," recently published; Dr Brady's "Monograph of the British Copepoda" has been followed in the arrangement of that group; while in the arrangement of the Ostracoda the Monograph by Drs Brady and Norman has been consulted. Professor Jeffrey Bell's recently published "Catalogue of the British Echinodermata" is followed as to the Starfishes and Echini; while with regard to the Foraminifera the arrangement and nomenclature are those of part viii. of Dr Norman's Catalogues.

A considerable amount of time and care have been bestowed on the examination of the material, and the identification of the various organisms contained in it, and I desire in connection therewith to acknowledge my indebtedness to Mr William Eagle Clarke, F.L.S., of the Museum of Science and Art, Edinburgh, for identifying the fishes in the collection; to Dr G. W. Chaster, of Southport, Lancashire, for revising the list of Foraminifera, and identifying the more obscure and difficult species; and to Rev. T. R. R. Stebbing and Professor W. A. Herdman, F.R.S., for assistance with other groups; while my son has prepared drawings of what appears to be an undescribed Amphipod.

The following is a tabular view of the chief groups represented in the collection, their principal subdivisions, and the number of species belonging to each:—

Names of the chief Groups represented in the Collection.	Names of the principal Subdivisions.		Number of Species belonging to each of the principal Subdivisions.		Number of Species belonging to each of the Groups.
Fishes,					12
Mollusca,	Cephalopoda,			2	99
	Pteropoda,			1	
	Gasteropoda,	Opisthobranchiata,	7	49	
		Prosobranchiata,	38		
		Polyplacophora,	4		
	Scaphopoda,			1	
	Pelecypoda,	Tetrabranchiata,	38	46	
		Dibranchiata,	8		
Brachiopoda,					2
Tunicata,					4
Polyzoa,					1
Arachnida,					2
Crustacea,	Brachyura,			9	148
	Anomoura,			9	
	Macrura,			1	
	Carida,			10	
	Schizopoda,			5	
	Isopoda,			3	
	Amphipoda,			38	
	Phyllopoda,			1	
	Cladocera,			2	
	Ostracoda,			26	
	Cōpepoda,			40	
	Cirripedia,			4	
Annelida,					7
Gephyrea,					1
Rotifera,					1
Echinodermata,	Crinoidea,			1	13
	Ophiuroidea,			3	
	Asteroidea,			5	
	Echinoidea,			2	
	Holothuroidea,			2	
Actinozoa,	Alcyonaria,			2	3
	Zoantharia,			1	
Hydrozoa,					4
Spongozoa,					1
Foraminifera,	Miliolidæ,			9	46
	Lituolidæ,			5	
	Textulareidæ,			7	
	Lagenidæ,			12	
	Rotuliidæ,			8	
	Nummulinidæ,			5	
Infusoria,					3

FISHES.

The fishes that fall to be noticed in this report are mostly of small size, and with few exceptions are all of more or less frequent occurrence around our shores. They are—*Trachinus vipera*, *Gobius Ruthensparri* and *Gobius minutus*, *Callionymus* *lyra, Lepadogaster Decandolii* and *Lepadogaster bimaculatus, Motella cimbria, Hippoglossoides limandoides, Rhombus* (*Zeugopterus*) *norvegicus, Pleuronectes cynoglossus, Zeugopterus punctatus,* and *Neroplius æquoreus.*

Of these, perhaps the rarest and most interesting species is *Rhombus* (*Zeugopterus*) *norvegicus,* Günther. This is one of the more recent additions to the British fish-fauna. There were two specimens of this species in the collection, and both were of small size. One of the specimens was from Loch Bracadale, Skye, and measured 1·87 inch (47·5 mm.); the other was obtained in the Gairloch, West Ross-shire, and measured 2·3 inches (58·0 mm.). *Rhombus norvegicus* is described and figured by Dr Günther in vol. xv. of the *Proceedings of the Royal Society of Edinburgh.* There is also an interesting note on the same species, accompanied by a very good figure of an East Coast specimen, by Professor M'Intosh, St Andrews, in part iii. of the *Twelfth Annual Report of the Fishery Board for Scotland.*

MOLLUSCA.

Of the 96 species of Mollusca obtained in the collection, only a small number are of special interest; the others are all more or less common and generally distributed. A large proportion of the species are also represented by only one, or at most by a few specimens each; while, on the other hand, and in contrast to these, there are a few species that are represented by a considerable number of specimens. For example, *Trochus zizyphinus* (or *Zizyphinus zizyphinus,* as it is named in the Table of Distribution) was represented by at least five dozen specimens, most of them, however, young. *Lima elliptica* is another species that was numerously represented; so also were *Pecten pes-lutræ* (*Pecten septemradiatus*), *Nucula nucleus, Leda minuta, Corbula gibba,* and *Astarte sulcata,* but these were exceptional cases.

Among the Mollusca contained in the collection that appear to be of more or less interest, mention may be made of the following:—Among univalves, *Philine scabra,* a small but pretty shell, that has the outside covered with microscopic sculpture resembling a succession of chain-links; *Murex erinaceus,* a somewhat rare Scottish shell, and seldom obtained living; *Trophon barvicensis,* a rare and pretty univalve. *Modiolaria nigra* (the corded mussel) is another comparatively rare shell, adult specimens especially being uncommon. This species is represented in the collection by three or four young shells. *Cuspidaria* (Neæra) is an interesting and peculiar genus of shells much sought after by collectors, and is represented in the collection by one species, *Cuspidaria cuspidata. Pandora inæquivalvis, Lyonsia norvegica,* and *Poromya granulata* are also represented in the collection, and may be described as rare shells; for though the distribution of *Pandora* extends from the Channel Islands to Shetland, it is not so common as its distribution is wide; the same may be said of *Lyonsia* and *Poromya. Lyonsia* appears, however, to be more generally distributed, and of more frequent occurrence than either of the other two.

BRACHIOPODA.

Of Brachiopoda only two species occur in the collection, namely, *Terebratulina caput-serpentis* and *Crania anomala.*

CRUSTACEA.

The Crustacea are largely represented in the collection, no fewer than 148 different kinds having been identified, including species belonging to nearly all the important subdivisions. Though the so-called higher Crustacea are fairly numerous, one only calls for special remark, namely, *Xantho rivulosa,* Risso. This species is represented in the collection by two small specimens obtained from the deep water (80-100 fathoms) off Loch Buy, Mull. The claws have the distal portion of both fingers very dark coloured, and, moreover, the movable finger is also distinctly grooved, and is one of the characters that distinguish this species from *Xantho florida.* It may be of interest to state that during last summer I obtained a specimen of *Xantho rivulosa* in the Moray Firth, from which it does not appear to have been previously recorded.

Among the Anomura in the collection there are, at least, five species of hermit crabs, and of these *Spiropagurus Hyndmanni* and *Spiropagurus lævis* may be specially mentioned. The one has comparatively broad hands, in the other the hands are more elongate and polished, and in the living animal there is usually a red but not very well-defined band, extending the whole length of this hand, and sometimes branching off to the fingers. *Munida rondeletii,* another species of the Anomura in the collection, is of interest because of its remarkably long chelipeds. A considerable number of specimens of *Munida* occurred in a gathering from Loch Spelve.

Five species of Schizopods were obtained in the collection, viz.,—*Mysidopsis didelphys, Mysis flexuosus, Mysis inermis, Mysis lamornæ,* and *Neomysis vulgaris.* The latter occurred in great abundance in a gathering from Loch Dow. *Mysis lamorne,* when alive, is of a bright red colour, and its eyes are large and black.

The next group deserving of special notice is the Amphipoda. I find it difficult to select species for reference here, for almost all of them are of interest. *Hyperia galba,* with its large beautiful eyes, is not nearly so plentiful on the West Coast as it is on the East Coast of Scotland. I was therefore the more surprised to find a considerable number of specimens in Mr Brook's collection. *Lysianassa costæ, Phoxocephalus Holbölli, Ampelisca assimilis, Haploops tubicola,* and *Leucothoe Lilljeborgii* are all of special interest. *Eusirus longipes,* a somewhat rare species with curious gnathopods, occurred in considerable numbers in a gathering from Loch Linnhe near Fort William. *Dexamine spinosa* appears to have a distribution the reverse of that of *Hyperia galba;* this *Dexamine,* though not uncommon on the West Coast, is, so far as my experience of it goes, much rarer on the East Coast—I do not have a single East Coast specimen in my collection. *Cheirocrates Sundewalli, Gammaropsis erythrophthalmus* (with its red eyes), *Pleonexes gammaroides,* and *Podocerus Herdmanni,* are also all more or less interesting. A species which has the posterior gnathopods armed with enormous claws was represented only by a fragment, consisting of the anterior half, extending from the head to the second gnathopod. I have not been able to identify this with any British species, and therefore submit the following description:—

(?) *Mæra Brooki,* sp. n. [Pl. V., Figs. 1-6.]

Description of the Species.—Cephalon nearly as in *Mæra othonis* (M.-Edw.), lateral corners produced and narrowly rounded. Eyes small. Superior antennæ elongated and slender, and closely resembling those of *Mæra othonis,* but the flagellum is proportionally somewhat longer; accessory appendage about twice the length of the last joint of the peduncle, and six-jointed, terminal joint very small. Inferior antennæ somewhat similar to those of *Mæra othonis,* as are also the mandible palp, and other oral parts (Figs. 1-4). Anterior gnathopoda rather slender, densely setose; propodos nearly equal in length to the carpus, oblong oval in form; palm imperfectly defined (Fig. 5). Posterior gnathopoda strong and powerful; propodos subcylindrical, length equal to fully twice the breadth, lower margin slightly convex, and with a distinct and broadly rounded but shallow prominence anteriorly; dactylos very powerful, longer than the propodos, and reaching to about the middle of the carpus, not much curved except towards each end, the inner edge near the base but slightly posterior to the prominence on the lower margin of the propodos, is produced into a shallow triangular process (Fig. 6).

Remarks.—Only the anterior moiety of this Amphipod was obtained; it is only provisionally ascribed to the genus *Mæra.* It is apparently a male specimen, and all the parts of it that could be utilised resemble more or less closely the parts similar to them in *Mæra othonis,* with the exception of the second gnathopods, which are unlike those of any other known to me; and as the species is apparently undescribed, it gives me much pleasure to add to it the name of Mr Brook.

The abnormal Amphipoda are only represented by three species, viz., *Phtisica marina, Protella phasma,* and *Caprella acanthifera.*

Of the Phyllopoda there is but one species—*Nebalia bipes;* and of the Cladocera, two species—*Podon* and *Evadne.*

The Ostracoda.—Twenty-five species belonging to this group were obtained in the collection, but they are species that are all more or less commonly distributed around our shores.

The Copepoda.—There are forty species of this group, a considerable number of which are of special interest. *Isias clavipes,* for example, has very few Scotch records. *Labidocera Wollastoni* has not previously been recorded from the Scottish seas. *Ectinosoma atlanticum*, a slender species, with moderately long tail setæ, and of which there was no Scotch record till within recent years, was comparatively common in a gathering from Upper Loch Fyne. *Ameira longicaudata* and *Laophonte depressa* are two species added to the British list within recent years, and not before reported from the West Coast. *Porcellidium viride*, a representative of a curiously depressed group of Copepods, occurred in a gathering from Loch Bracadale, Skye. *Cyclopicera nigripes*, a handsome species, with the swimming-feet all more or less dark coloured, was obtained in a gathering from Loch Spelve, and in another collected off Duart, Island of Mull. *Bomolochus Soleæ*, a parasite Copepod on the black sole (*Solea vulgaris*), is from Lochnell Bay (Loch Linnhe), and is now first recorded for the West of Scotland. Another new West Coast record is the curious *Monstrilla rigida* (I. C. Thompson); it was obtained in a gathering from Mauchrie Bay, Arran. An interesting paper on the genus *Monstrilla*, by Gilbert Bourne, was published a few years ago.

The Cirripedia are represented by only four species—*Scalpellum vulgare*, *Balanus crenatus*, *Balanus Hameri*, and *Peltogaster paguri*.

ECHINODERMATA.

One or two interesting species belonging to this group have been obtained in the collection. The Rosy feather star, *Antedon bifida* (Pennant) = (*Comatula rosacea*, Forbes and others), was obtained both in the adult form and in the young stalked (crinoid) stage; it occurred in gatherings from the deep water of Loch Buy, Mull; the Gairloch, West Ross-shire; and Loch Boisdale, Outer Hebrides. The Bird's-foot starfish, *Palmipes membranaceus*, is from two localities—viz., off Loch Buy and the Gairloch. The small and comparatively rare *Echinus norvegicus* was also obtained in the deep water of Loch Buy, Mull.

FORAMINIFERA.

The Foraminifera that have been identified in the collection number forty-six species, a few of which appear to be moderately rare.

TABLE CONTAINING A CLASSIFIED LIST OF ALL THE SPECIES OBSERVED IN THE COLLECTION DESCRIBED IN THE PRECEDING REPORT, AND SHOWING THE LOCALITIES WHERE THEY WERE OBTAINED.

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom (above Narrows).	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
FISHES.																			
Trachinus vipera, Cuv. and Val.,	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Gobius Ruthensparri, Euph.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *minutus*, Gmel.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Loch Dow.
Callionymus lyra,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Lepadogaster Decandolii, Risso,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
,, *bimaculatus* (Don.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Motella cimbria (L.),	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	
Hippoglossoides limandoides (Bloch),	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	
Rhombus (*Zeugopterus*) *norvegicus*, Günther,	...	...	...	...	...	...	...	...	...	...	...	×	...	×	...	...	...	...	
Zeugopterus punctatus, Bloch,	...	...	...	...	×	...	...	...	...	...	...	...	...	×	...	...	...	...	
Pleuronectes cynoglossus (L.),	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	
Neroplius æquoreus (L.),	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	West Coast.

MOLLUSCA.																			*(The words "West Coast" are used where the label was illegible.)*
CEPHALOPODA.																			
Sepiola Rondeletii, Leach,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Rossia macrosoma (Del. Ch.),	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
PTEROPODA.																			
Limacina retroversa (Flem.),	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
GASTEROPODA.																			
Doris tuberculata, Cuv.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *Johnstoni*, A. and H.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Dendronotus arborescens, A. and H.,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
Eolis papillosa, Lin.,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
Scaphander lignarius, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Philine scabra, Mull.,	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Aplysia punctata, Cuv.,	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Mangelia costata, Don.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *brachystoma*, Phil.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Bela turricola (Mont.),	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	
,, *Trevelyana*, Turt.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Neptunea antiqua, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Buccinum undatum, Lin.,	...	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...	...	...	
Nassa reticulata, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *incrassata*, Ström.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Murex erinaceus, Lin.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Trophon truncatus, Ström.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *barvicensis*, Johnston,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Purpura lapillus, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Trivia europœa, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Aporrhais pes-pelecani, Lin.,	...	...	...	...	...	...	×	...	...	...	×	...	...	×	...	...	...	...	
Trichotropis borealis, Brod. and Sow.,	...	...	...	...	...	×	...	...	...	×	...	...	...	...	...	...	...	...	
Turritella terebra, Lin.,	...	...	...	×	...	...	×	...	...	...	...	...	...	×	...	...	...	...	

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom (above Narrows)	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
Littorina rudis, Maton,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Lacuna divaricata, Fabr.,	...	...	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Rissoa parva, Da Cos.,	...	...	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *violacea*, Desm.,	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Cingula semistriata, Mont.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Capulus hungaricus, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Velutina lævigata, Penn.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Lunata catena, Da Cos.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *pulchella*, Risso,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	
,, *Montagui*, Forbes,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
Turbonilla rufa, Phil.,	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	
Phasianella pullus, Lin.,	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Zizyphinus zizyphinus, Lin.,	...	...	×	...	×	×	...	...	...	...	×	...	...	...	...	...	...	×	
,, *millegranus*, Phil.,	...	...	...	×	...	×	×	×	...	...	...	...	...	...	...	...	...	...	
Gibbula magus, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *cineraria*, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *tumida*, Mont.,	...	...	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	
Emarginula crassa, Sow.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *fissura*, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	×	×	...	...	...	
Puncturella noachina, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	

Helcion pellucidum, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	Off Jura.
Patella vulgata, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
POLYPLACOPHORA.																			
Chiton facicularis, Lin.,	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *cinereus*, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *ruber*, Lin.,	...	...	×	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	
,, *lævis*, Penn.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
SCAPHOPODA.																			
Dentalium entalis, Lin.,	...	...	...	×	...	...	×	×	...	...	...	...	...	...	...	...	...	...	
PELECYPODA.																			
Anomia ephippium, Lin.,	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Lima Loscombii, Sow.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *elliptica*, Jeff.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Pecten varius, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *tigrinus*, Müll.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
,, *striatus*, Müll.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *pusio*, Lin.,	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	
,, *pes-lutræ*, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
,, *opercularis*, Lin.,	...	...	...	...	...	×	×	...	...	...	×	...	...	...	...	...	...	...	
Mytilus edulis, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Modiola modiolus, Lin.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	×	West Coast.
Modiolaria marmorata, Forbes,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
,, *discors*, Lin.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
,, *nigra*, Gray,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Pectunculus glycimeris, Lin.,	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	×	...	...	
Nucula nucleus, Lin.,	...	...	...	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	
,, *nitida*, Sow.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Leda minuta, Müll.,	...	...	...	×	...	...	×	×	...	...	...	...	...	...	...	...	...	...	
Astarte sulcata, Da Cos.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom(aboveNarrows)	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
Astarte compressa, Mont.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *triangularis*, Mont.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
Cardium echinatum, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *fasciatum*, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Lævicardium norvegicum, Speng.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Tapes virgineus, Lin.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
Dosinia lincta, Pult.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Venus ovata, Penn.,	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *fasciata*, Da Cos.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	×	
,, *casina*, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Axinus flexuosus, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Psammobia tellinella, Lamk.,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	...	
Solen pellucidus, Penn.,	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	
,, *siliqua*, Lin.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Mactra subtruncata, Da Cos.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	
Mya arenaria, Lin.,	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *truncata*, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Corbula gibba, Olivi,	...	...	...	×	...	...	×	×	...	...	...	...	...	...	...	...	...	...	
Saxicava rugosa, Lin.,	...	...	...	×	...	...	×	...	...	...	×	...	...	×	...	...	...	×	
Lucina spinifera, Mont.,	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Telene Balthica, Lin.,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	

Abra alba, S. Wood,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Off Jura.
,, *nitida*, Müll.,	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
Cuspidaria cuspidata, Olivi,	...	...	...	×	...	...	×	...	...	×	...	...	...	...	...	...	...	...	
Pandora inæquivalvis, Lin.,	...	...	...	×	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
Lyonsia norvegica, Chemn.,	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Poromya granulata, Nyst.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
BRACHIOPODA.																			
Terebratulina caput-serpentis, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Crania anomala, Müll.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
TUNICATA.																			
Ascidiella aspersa,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Eugyra glutinans (Moll.) = *Molgula arenosa* (Ald. and Han.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	
Botryllus Schlosseri,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	Jura(E. coast of)
Appendicularia,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
POLYZOA.																			
Scrupocellaria reptans (Lin.),	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	
Cellaria fistulosa (Lin.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
ARACHNIDA.																			
Pycnogonum littorale,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Nymphon? sp.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.						Outer Hebrides.	
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom (above Narrows)	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
CRUSTACEA.																			
BRACHYURA.																			
Portunus depurator, Lin., . . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	
Xantho rivulosa, Risso, . . .	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
Cancer pagurus, Lin., . . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	
Hyas coarctatus, Leach, . . .	⋮	⋮	⋮	×	×	×	⋮	×	×	⋮	×	×	⋮	×	⋮	⋮	⋮	×	
Inachus dorsettensis, Penn., . . .	⋮	⋮	⋮	⋮	⋮	⋮	×	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	
Stenorhynchus longirostris, Fabr., . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	
Ebalia tuberosa, Penn., . . .	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
„ *tumefacta* (Mont.), . .	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
ANOMURA.																			
Eupagurus bernhardus, Fabr., . . .	⋮	⋮	⋮	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
„ *Prideauxii*, Leach, . . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	West Coast.
„ *pubescens*, Kroyer, . . .	⋮	⋮	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	
Spiropagurus Hyndmanni, Thomp., . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	?	
„ *lævis*, Thomp., . . .	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	⋮	⋮	⋮	⋮	⋮	⋮	
Porcellana platycheles, Penn., . . .	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	×	

Porcellana longicornis, Penn.,	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Galathea squamifera, Leach,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	
Munida Rondeletii, Bell,	...	...	...	...	×	...	×	×	...	...	...	...	...	×	...	...	...	...	
MACRURA.																			
Nephrops norvegicus, Lin.,	...	...	...	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	
CARIDA.																			
Crangon vulgaris, Lin.,	...	...	...	×	...	...	...	...	×	...	...	×	...	...	...	...	...	...	
,, *Allmanni*, Kin.,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
,, *nanus*, Kroyer,	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	
,, *spinosus*, Leach,	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Virbius varians, Leach,	...	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	×	
Hippolyte spinus, Sow.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
,, *Gaimardi*, M.-Edw.,	...	...	...	...	×	...	...	...	...	...	...	...	...	×	...	...	...	×	
,, *pusiola*, Kroyer,	...	...	...	...	...	...	×	...	×	...	...	...	...	×	...	...	...	...	
Pandalus annulicornis, Leach,	...	...	...	...	×	...	...	...	×	...	...	×	...	×	...	...	...	×	
,, *brevirostris*, Rathke,	...	...	...	...	×	...	...	...	×	...	...	×	...	...	...	...	...	...	
SCHIZOPODA.																			
Mysidopsis didelphys, Nor.,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Mysis flexuosa, Müll.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *inermis*, Rathke,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *lamornæ*, Couch,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Neomysis vulgaris, Thomp.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Loch Dow.
ISOPODA.																			
Idotea marina, Lin.,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Astacilla longicornis, Sow.,	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	
Jæra albifrons, Mont.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.

Name of Species.	Localities.																		Remarks.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
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AMPHIPODA.																			
Hyperia galba (Mont.),	...	...	...	...	...	×	...	...	...	...	...	...	...	×	...	...	...	...	
Lysianassa costæ (M.-Edw.),	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Aristias Audouiniana (Sp. B.),	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Tryphosa Hörringii, Boeck,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Phoxocephalus Holbölli (Kroy.),	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Harpinia neglecta, G. O. Sars,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Ampelisca assimilis, Boeck,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Haploops tubicola, Lillj.,	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Amphilochus manudens, Sp. B.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Metopa Bruzelii (Goes),	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Cressa dubia (Sp. B.),	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
Leucothoe Lilljeborgii, Boeck,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Halimedon Mülleri, Boeck,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Paramphithoe bicuspis (Kroy.),	...	...	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	
,, *monocuspis*, G. O. Sars,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Eusirus longipes, Boeck,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Apherusa bispinosa (Sp. B.),	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Paratylus Swammerdami (M.-Edw.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *vedlomensis* (Sp. B.),	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	
Dexamine spinosa (Mont.),	...	...	...	×	×	...	×	...	...	...	...	...	...	...	...	...	...	×	

Gammarus marinus, Leach,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *locusta*, Lin.,	...	...	...	...	×	...	...	...	×	...	...	...	...	...	...	...	...	...	
Melita obtusata (Mont.),	...	...	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	
Cheirocrates Sundewalli, Rathke,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
Microdeutopus gryllotalpa, Costa,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Aora gracilis, Sp. B.,	...	...	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	×	
Gammaropsis erythrophthalma, Lillj.,	...	...	...	×	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
Amphithoe rubricata (Mont.),	...	...	...	...	...	...	×	...	×	...	...	...	...	...	...	...	...	×	
Pleonexes gammaroides, Sp. B.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Podocerus falcatus (Mont.),	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	×	
,, *pusillus*, G. O. Sars,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *Herdmanni*, Walker,	...	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	
Erichthonius abditus (Temp.),	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Corophium Bonelli, M.-Edw.,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
(?) *Mæra Brooki*, sp. n.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
Phtisica marina, Slabber,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Protella phasma (Mont.),	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Caprella acanthifera, Leach,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
PHYLLOPODA.																			
Nebalia bipes, Fabr.,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
CLADOCERA.																			
Podon sp.,	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Evadne Nordmanni, Loven,	×	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	
OSTRACODA.																			
Loxoconcha impressa, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	West Coast.
,, *guttata*, Norman,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *tamarindus*, Jones,	...	...	...	×	...	...	...	...	...	...	×	...	...	...	...	...	...	×	
Xestoleberis depressa, G. O. Sars,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Cytherura nigrescens, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
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Cytherura sp.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *acuticostata*, G. O. Sars,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *cellulosa*, Norman,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Cytheropteron nodosum, Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *multiforum* (Norman),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Sclerochilus contortus, Norman,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Paradoxostoma variabile, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *flexuosum*, Brady,	...	...	...	×	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
,, *Hodgei*, Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Cythere confusa, B. and N.,	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	
,, *porcellana*, Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *Robertsoni*, Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *villosa*, G. O. Sars,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *concinna*, Jones,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *antiquata*, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *Jonesii*, Baird,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Cytheridea papillosa, Bosquet,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Eucythere declivis, Norman,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	West Coast.
Krithe bartonensis, Jones,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
Philomedes interpuncta, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Asterope Mariæ, Baird,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,

COPEPODA.

Calanus finmarchicus (Gun.),	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	
Pleuromma armatum (Boeck),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	
Pseudocalanus elongatus (Boeck),	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Acartia bifilosa, Geisb.,	×	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	
Temora longicaudata, Lub.,	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Centropages hamatus (Lillj.),	...	×	...	...	...	...	...	...	...	...	...	...	...	×	...	×	...	...	
Candace pectenata, G. S. Brady,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	
Parapontella brevicornis (Lillj.),	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Isias clavipes, Boeck,	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Anomalocera Patersonii, Temp.,	...	×	[illegible]	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	
Labidocera Wollastoni, Lub.,	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Oithona spinirostris, Claus,	×	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	×	...	
Ectinosoma atlanticum (B. and R.),	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *melaniceps*, Boeck,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
Longipedia coronata, Claus,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Ameira longicaudata, T. Scott,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Laophonte horrida (Norman),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
,, *thoracica*, Boeck,	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *depressa*, T. Scott,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
,, *hispida* (B. and R.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Enhydrosoma curvatum (B. and R.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Dactylopus tisboides, Claus,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
,, *similis*, Claus,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Thalestris mysis, Claus,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
,, *rufocincta*, Norman,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
,, *Clausii*, Norman,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
,, *longimana*, Claus,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Westwoodia nobilis (Baird),	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	,,
Harpacticus chelifer (Müll.),	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...	...	
Zaus spinatus, Goodsir,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Porcellidium viride, Phil.,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
Idya furcata (Baird),	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	
Acontiophorus scutatus (B. and R.),	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	

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Cyclopicera gracilicauda (G. S. B.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *nigripes* (B. and R.),	...	...	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	
Bomolochus soleæ, Claus,	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	
Monstrilla rigida (I. C. Thomp.),	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Chondracanthus sp.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Lernæopoda salmonea, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Caligus rapax, M.-Edw.,	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...	,,
CIRRIPEDIA.																			
Scalpellum vulgare, Leach,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Balanus crenatus, Bruz.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *Hameri*, Ascan.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	,,
Peltogaster paguri, Rathke,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
ANNELIDA.																			
Aphrodita aculeata,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Polynoe sp.,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	Jura.
Phyllodice sp.,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	

Nereis sp.,	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	×
Serpula triquetra,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...
,, *contortuplicata*,	...	...	...	...	...	×	...	...	...	...	...	...	...	...	×	...	...	...
Pectenaria belgica (Pallas),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...
A Nemertean sp.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
GEPHYREA.																		
(?) *Phascolosoma vulgare*,	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
ROTIFERA.																		
A triangular compressed form,	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ECHINODERMATA.																		
CRINOIDEA.																		
Antedon bifida (Penn.) = *A. rosacea*, Flem., and young stalked-stage.	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	×
Ophiura ciliaris (Lin.),	...	...	...	×	...	...	...	×	×	...	...	...	...	...	...	...	..	...
,, *albida*, Forbes,	...	...	...	×	×	...	...	...	×	...	...	×	...	×	...	...	...	...
Ophiothrix fragilis (Abilg.),	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	×
ASTEROIDEA.																		
Astropecten irregularis, Linck.,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Asterias rubens, Lin.,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	..	...	...
Palmipes placenta (Penn.),	...	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...
Solaster endeca (Lin.),	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Henricia sanguinolenta (Müll.),	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×

NAME OF SPECIES.	LOCALITIES.																		REMARKS.
			Mull.				Loch Linnhe.					Skye.					Outer Hebrides.		
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom(above Narrows)	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
ECHINODEA.																			
Echinus miliaris, Lin.,	...	...	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
,, *norvegicus*, Dub. and Kor.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Brissopsis lyrifera, Agass. and Des.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
HOLOTHUROIDEA.																			
Thyone raphanus, Dub. and Kor.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *fuscus* (O. F. Müll.),	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
ACTINOZOA.																			
ALCYONARIA.																			
Pennatula phosphorea,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Virgularia,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	,,
ZOANTHAREA.																			
Adamsia palliata,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.

HYDROZOA.																			
Antennularia ramosa,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Plumularia pennata,	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	
Tubularia indivisa,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Haliclystra (*Lucernaria*) *auricula*,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	
SPONGOZOA, Norman.																			
Hymeniacidon ? sp.,	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	
RHIZOPODA.																			
Foraminifera.																			
Biloculina elongata, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *depressa*, d'Orb.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Spiroloculina planulatæ, Lamk.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *limbata*, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Sigmoilina celata, Costa,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Miliolina seminulum, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *trigonula*, Lamk.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *subrotunda*, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *bicornis*, W. and J.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Reophax difflugiformis, H. Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *fusiformis*, Will.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Haplophragmium pseudospirale, Will.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *glomeratum*, H. Brady,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *Canariense*, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Textularia (*Spiroplecta*) *sagittula*, Defr.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *gramen*, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *trochus*, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Verneuilina polystropha, Reuss,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Bulimina marginata, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.

NAME OF SPECIES.	LOCALITIES.																			REMARKS.
			Mull.				Loch Linnhe.					Skye.						Outer Hebrides.		
	Upper Loch Fyne.	Mauchrie Bay, Arran.	Carsaig Bay.	Off Loch Buy.	Loch Spelve.	Duart to Lady Rock.	S.E. shore, Lismore.	Lochnell Bay.	Off Fort William.	Linn of Morven.	Off Ardnamurchan.	Loch Bracadale to Talisker.	Portree to Essehill.	Gairloch.	Loch Broom (above Narrows)	Shiant Bank.	Loch Seaforth.	Calway Channel (Loch Boisdale).	
Bolivina punctata, d'Orb.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Cassidulina lævigata, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Lagena lævis, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *striata*, d'Orb.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *sulcata*, W. and J.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *costata*, Will.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *Williamsoni*, Alcock,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *squamosa*, Mont.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *Orbigniana*, Seq.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Nodosaria pyrula, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Cristallaria rotulata, Lamk.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *vortex*, F. and M.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Polymorphina gibba, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *soraria*, Reuss,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Discorbina globularis, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *rosacea*, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
,, *orbicularis*, Terq.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Planorbulina mediterranensis, d'Orb.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Truncatulina refulgens, Montf.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *lobatula*, W. and J.,	...	...	...	×	...	..	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Pulvinulina repanda, F. and M.,	...	...	...	×	...	..	...	...	...	...	...	...	...	...	...	...	...	...	

Rotalia Beccarii, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Nonionina umbilicata, Mont ,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
,, *turgida*, Will.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	West Coast.
Polystomella Crispa, Lin.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
,, *striato-punctata*, F. and M.,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	,,
Operculina ammonoides, Gron.,	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
INFUSORIA.																			
Ceratium tripos,	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...	...	...	
,, *fusus*,	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	
,, *fuscus*,	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	

EXPLANATION OF PLATE V.

? *Mæra Brooki*, ♂.

Fig. 1. Front part of cephalon, with superior and inferior antennæ; ×12.
Fig. 2. Mandible and palp; ×32.
Fig. 3. Second maxilla; ×64.
Fig. 4. Maxillipedes; ×32.
Fig. 5. First gnathopode; ×16.
Fig. 6. Second gnathopode; ×16.

XIV. *Results of Meteorological Observations taken in Edinburgh during the Year* 1895. By R. C. MOSSMAN, F.R.S.E., F.R.Met.Soc.

(Read 18th March 1896.)

During the past year the ordinary bi-daily observations have been taken at the usual hours, and with the instruments described in former reports. Since 1st May readings of earth temperature have been made daily at 9 A.M. Three thermometers are in use, the bulbs being buried in ordinary garden mould under grass, at depths of 3, 12, and 22 inches. The day-to-day changes at 9 A.M. have been calculated, as well as similar values for the air temperature at that hour. The mean variability of temperature from the average of the maximum and minimum thermometers has also been computed (see *Proceedings*, vol. xii., p. 336). The averages with which the monthly values have been compared are for periods ranging from 25 to 132 years. Means will subsequently be available for most of the elements for over 100 years, but the reduction of the accumulated mass of climatological data has proved much more tedious than was at first anticipated, and some time will elapse before the means for the long period will be available.

REMARKS ON THE METEOROLOGY OF 1895.

January.—The great frost which rendered the year 1895 such a memorable one, viewed from a meteorological standpoint, commenced this month, the mean temperature of which was 31°·8. During the month the thermometer never rose above 41°·0, this being the lowest maximum recorded during any month in the past 55 years. In February 1855 the same low absolute maximum temperature was registered. Sunshine was deficient, with the result that the days were relatively colder than the nights, the cloudiness of which checked terrestrial radiation. Up to the 17th, only 10 hours bright sunshine was registered, but thereafter comparatively sunny conditions prevailed. There was a great excess of Polar winds. Snow fell frequently during the last week, the heaviest fall occurring on the evening of the 24th, when at 8.40 P.M. a vivid flash of lightning was observed. This was the coldest January since 1881, and one of the calmest, gales being virtually absent.

February.—The severe frost continued during the first three weeks of February, the mean temperature of which was 28°·2. From the 6th to the 10th inclusive the thermometer never rose to the freezing point, the absolute minimum falling to 11°·9 on the 8th, this being the lowest reading recorded in February since 1823. The average temperature of the month was 31°·2, being 7°·8 below the 50 years mean. The nights were relatively colder than the days by over a degree, the clear skies favouring nocturnal radiation. The lowest maximum observed was 24°·5 on the 7th, on which day the mean was 20°·3, being the lowest recorded during the frost. The precipitation, chiefly in the form of snow, was small, and amounted to half an inch. An absolute drought prevailed during the sixteen days ending with the 22nd. The barometer was high throughout, while sunshine was abundant after the 4th. Since 1764 only two colder Februarys have been experienced, the average temperature in 1838 being 29°·8, while in 1855 the mean was 30°·6. The average temperature of the two months, January and February, was 31°·5, being the lowest since 1838, when the mean was 30°·2. During the two months under review, the distribution of pressure was of an abnormal type, being as a rule highest in the north and east, and lowest in the south and west. With these conditions, the gradients were for easterly and northerly winds, which were much above the average in point of frequency.

March.—On the whole, mild unsettled weather prevailed during the greater part of this month, only one frost being recorded after the 5th. There was little sunshine, the recorder showing a total of only 63 hours, as against 72 hours in February. This was the dullest March for 7 years. Owing to the large amount of cloud, the temperature of the days was 1°·0 below the average, while the nights were 1°·8 warmer than usual. It is worthy of note that the maximum temperature from 29th December 1894 to 13th

March 1895 was only 46°·3. Influenza, which had begun to develop lethal activity during the month of February, prevailed this month with the virulence of a plague, the death-rate shooting up to more than double the average, with an enormous mortality from diseases of the respiratory organs, especially among the aged. Many children fell victims to the prevailing epidemic of measles. By the end of the month the health of the city was about normal.

April.—Little sunshine was recorded during the first and last weeks, when the barometer was low, and nearly all the month's rainfall was recorded. The last frost of the season occurred on the 14th. A warm spell occurred from the 20th to the 25th, when the mean temperature was 6° above the average. Auroras were observed on the 13th and 14th. The rainfall amounted to little more than half the average, but with this exception the meteorological elements were about normal.

May.—Remarkably fine weather prevailed throughout, over 200 hours bright sunshine being recorded, this being the sunniest May since 1884. Insolation was very strong, the day temperatures being 4°·4 above the average, but the night temperatures only 2°·0. The rainfall was deficient, all falling between the 17th and 25th, when several thunderstorms were experienced. The last 5 days were phenomenally warm, the shade maxima exceeding 70° every day. Vivid sheet lightning was observed on the evening of the 30th, on which day the air was very dry, the humidity, even at 7 P.M., being 45 per cent. There was an excess of northerly winds.

June.—Although sunshine was in excess of the average, the precipitation was above the normal quantity, no less than half the rainfall being recorded on the 18th and 19th. Severe thunderstorms were experienced on the latter date, accompanied by torrents of rain. Thus between 11.7 and 11.40 A.M., 0·53 inch of rain fell, of which 0·40 inch fell in 21 minutes. Another thunderstorm occurred at 1.30 P.M., when 0·13 inch of rain and hail fell in 10 minutes. Thunderstorms were also recorded on the 29th and 30th. A severe squall took place at 5.37 P.M. on the 26th, when the temperature fell rapidly, after touching 78°·3 at 3 P.M.

July.—Cool and wet weather prevailed during nearly the whole of July, the distribution of pressure being essentially cyclonic. The month opened with showery, thundery conditions, but a dry spell commenced on the 4th, and lasted till the 10th, after which the temperature did not once touch 70°, the weather turning very cold and wet, with but little sunshine. The shade maxima recorded on the 25th and 26th were phenomenally low for the season, being only 53°·0 and 52°·3 respectively. Thick mist prevailed, accompanied by heavy rain, 1·63 inch alone falling on the 26th, while in the 3 days ending with the 27th an average rainfall of 1 inch per diem was precipitated. On the days under review, including the 28th, not a single gleam of sunshine was recorded. The wind attained the strength of a gale on the 9th, but the air movement for the whole month was very small.

August.—This month was characterised by a great rainfall, an excess of cloud, a pressure considerably below but with the temperature above the normal. Rain fell on 24 days, while the sunshine recorder showed the miserable total of 101 hours, being the least by 20 hours recorded in August during the last 18 years. The mean temperature of the month was nearly 2° *above* the average, the excess being largely due to nocturnal warmth. Thunderstorms, with their accompanying torrential rains, were of common occurrence; although the most noticeable downpour of the month took place on the 22nd, without any electrical disturbance. On the day under review, the Richard pluviograph recorded 0·86 inch of rain between 4.15 and 5.7 P.M., one of the heaviest falls observed here in so short a time.

September.—Unusally fine weather prevailed throughout. The only dull period was from the 14th to the 17th, two-thirds of the total rainfall being recorded on the last day. The mean temperature of the month was 58°·6, the highest for September since 1846, when the mean was 59°·3, this month being the only warmer September recorded since the Edinburgh record commenced in 1764. The unusual warmth was unequally partitioned between the day and night, the mean of the maxima being 5°·4 above the average, while the average of the minima exceeded the normal by 3°·8. The weather during the last week was phenomenally warm, the maximum noted on the 25th, viz., 78°·3, being absolutely the highest recorded so late in the season during at least the last 55 years. In 1868 the thermometer rose on the 6th of the month to 81°·7, while in 1891 a reading of 79°·8 was recorded on the 12th, these being the only warmer September days noted during over half a century. Westerly winds were greatly in excess of their normal frequency, while calms were also considerably above the average.

October.—Taken as a whole, this month was cold and ungenial, the mean temperature being 3° below the average, and no less than 14°·4 below the mean of September. The greatest fall in the mean temperature of the two months previously observed was 12°·2, in 1843. The first 3 weeks were comparatively mild and rainy, but the 10 days ending with the 30th were exceptionally cold, their mean temperature being 38°·3. Snow showers fell on the 24th, 25th, 26th, and 28th, there being about 2 inches on the ground on the morning of the 28th. The greatest number of days with snow previously observed in October since 1764 was three, in 1782 and 1819, although individual snowstorms have yielded a greater depth.

November.—November was mild, wet, and stormy, with a total absence of anything approaching wintry weather; the thermometer in the Stevenson's screen never falling below 33°·3. This was the highest minimum observed during any of the last 55 Novembers. There was a great deficiency of sunshine, barely half the average being recorded. An unusual feature was the comparative prevalence of Polar winds, but unaccompanied by the depression of temperature with which they are usually associated. A very fine aurora was observed on the evening of the 9th.

December.—Little sunshine was recorded, there being a total of only 18 hours, or 8 per cent. of the total possible, this being no less than 11 per cent. below the average. Temperature was below the normal, the days being two degrees and the nights half a degree under the average, the dull conditions thus accounting for the greater depression observed in the day temperatures. The month opened with strong winds, the mean air movement on the 4th being 22·5 miles per hour, this being the stormiest day of a year singularly free from severe gales. Throughout the remainder of the month the wind never exceeded a strong breeze. Snow fell on the 6th, 12th, 21st, 26th, and 28th. On the latter date it snowed very heavily from 1 to 4 P.M., but was succeeded by rain, there being little left on the morning of the 29th. The year closed with a dense fog.

NOTEWORTHY PHENOMENA IN THE METEOROLOGY OF 1895.

Highest barometric reading 30·775 inches, on January 30th, at 9 P.M.

Lowest barometric reading 28·357 inches, on November 11th, at 3 A.M.

Highest temperature in shade 78°·3, on June 26th and September 25th.

Lowest temperature in shade 11°·9, on February 8th.

Greatest range of temperature 29°·3, on June 7th.

Least range of temperature 2°·2, on July 25th and 26th.

Highest temperature in sun's rays (black bulb thermometer in *vacuo*) 135°·3, on June 26th.

Greatest excess of sun maximum over shade maximum 64°·6, on July 9th.

Lowest temperature on grass 7°·0, on February 8th.

Greatest difference between minimum on grass and in shade 10°·6, on February 21st.

Sunniest day May 8th, with 13 hours 33 minutes bright sunshine, being 86 per cent. of the total possible.

Stormiest day December 4th, average velocity of wind 23 miles per hour.

Greatest daily rainfall 1·63 inch, on July 26th.

	Barometer at 32° and Mean Sea-Level.					Temperature in Shade 4 Feet above Grass.																
																Difference from Average 50 years.						
	Highest in Month.	Lowest in Month.	Monthly Range.	Mean Pressure.	Difference from Average 50 years.	Highest in Month.	Lowest in Month.	Range.	Mean of all the Highest.	Mean of all the Lowest.	Mean Daily Range.	Mean Temperature.	Mean Variability of Temperature.	Greatest Daily Range.	Least Daily Range.	Mean Max.	Mean Min.	Mean Daily Range.	Mean Temp.	Mean Variability of Temp.	Diff. from Aver. 132 years, Mean Temp.
	Ins.	Ins.	Ins.	Ins.	Ins.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January, . . .	30·775	29·000	1·780	29·766	*·030*	41·0	19·0	22·0	36·2	27·5	8·7	31·8	2·0	14·0	3·2	*6·5*	*5·3*	*1·2*	*6·0*	*1·2*	*5·1*
February, . . .	30·711	29·504	1·207	30·162	**·313**	46·3	11·9	34·4	37·1	25·4	11·7	31·2	2·9	20·5	3·3	*7·2*	*8·4*	**1·2**	*7·9*	*0·0*	*7·3*
March, . . .	30·242	28·643	1·599	29·631	*·210*	55·3	27·0	28·3	45·9	36·2	9·7	41·0	2·6	18·2	2·7	*1·0*	**1·8**	*2·8*	**0·4**	*0·3*	**0·4**
April, . . .	30·408	28·996	1·412	29·850	*·037*	61·9	29·5	32·4	52·6	39·4	13·2	46·0	2·7	22·5	4·6	**0·6**	**1·8**	*1·2*	**1·2**	*0·0*	**1·1**
May, ...	30·616	29·660	0·956	30·117	**·190**	74·8	38·5	36·3	62·0	44·1	17·9	53·0	2·7	26·0	6·5	**4·4**	**2·0**	**2·4**	**3·1**	*0·1*	**2·9**
June, ...	30·486	29·517	0·969	30·045	**·114**	78·3	37·6	40·7	65·5	48·0	17·5	56·6	2·7	29·3	7·9	**1·9**	**0·2**	**1·7**	**0·9**	*0·1*	**0·8**
July, ...	30·230	29·399	0·831	29·784	*·088*	74·7	45·5	29·2	64·0	50·3	13·7	57·2	2·1	22·2	2·2	*1·6*	*0·3*	*1·3*	*0·9*	*0·4*	*1·2*
August, . . .	30·185	29·245	0·940	29·763	*·091*	77·0	44·6	32·4	65·8	53·0	12·8	59·4	2·4	20·3	2·4	**0·8**	**2·7**	*1·9*	**1·8**	*0·2*	**1·6**
September, . .	30·389	29·249	1·140	30·053	**·170**	78·3	41·0	37·3	66·4	50·8	15·6	58·6	2·4	26·0	3·3	**5·4**	**3·8**	**1·6**	**4·6**	*0·2*	**4·7**
October, . . .	30·558	28·823	1·735	29·800	**·006**	62·8	27·4	35·4	50·1	38·4	11·7	44·2	3·0	21·8	4·6	*2·9*	*3·0*	*0·0*	*3·0*	**0·1**	*3·2*
November, . .	30·590	28·357	2·233	29·784	*·021*	55·5	33·3	22·2	47·8	39·0	8·8	43·4	2·7	18·1	2·7	**1·0**	**2·5**	*1·5*	**1·7**	*0·4*	**1·4**
December, . . .	30·447	28·789	1·658	29·691	*·144*	51·9	25·5	26·4	41·9	33·5	8·4	37·7	2·9	17·5	4·0	*1·9*	*0·6*	*1·3*	*1·2*	*0·3*	*0·9*
Year, ...	30·775	28·357	2·418	29·870	**·014**	78·3	11·9	66·4	52·9	40·5	12·4	46·7	2·6	29·3	2·2	*0·6*	*0·2*	*0·4*	*0·4*	*0·2*	*0·4*

Note.—In the columns headed "Difference from Average," the heavy type indicates an excess, and the italic a defect.

	Rainfall.				Relative Humidity. Saturation = 100.					Vapour Pressure.				Solar and Terrestrial Radiation.							
	Total Fall.	Max. in 24 hours.	Diff. from Average 25 years.	No. of days on which ·01 in. or more fell.	At 9 A.M	At 9 P.M.	Mean.	Maximum.	Minimum.	9 A.M.	9 P.M.	Mean.	Weight of Vapour in cubic foot of Air.	Maximum in Sun.	Mean.	Average Excess over Shade Maximum.	Greatest Excess over Shade Maximum.	Minimum on Grass.	Mean.	Mean Difference from Shade Min.	Greatest Difference from Shade Min.
	Ins.	Ins.	Ins.		%	%	%	%	%	In.	In.	In.	Grs.	°	°	°	°	°	°	°	°
January, ...	1·77	·34	*0·66*	17	81·6	79·2	80·4	100	38	·146	·146	·146	1·60	81·0	51·9	15·7	45·2	15·1	23·5	4·0	8·0
February, ...	0·56	·24	*1·42*	7	79·9	79·6	79·8	100	18	·136	·136	·136	1·48	86·0	67·4	30·3	45·1	7·0	20·0	5·4	10·6
March, . . .	2·80	·66	**0·83**	19	84·0	84·9	84·4	99	32	·217	·211	·214	2·46	104·3	78·6	32·6	51·8	22·3	32·4	3·8	8·6
April, . . .	1·17	·31	*0·89*	15	74·3	81·6	78·0	98	39	·242	·239	·240	2·72	129·0	98·9	46·3	60·1	24·7	36·2	3·2	6·1
May, . . .	1·42	·64	*1·67*	11	73·9	79·5	76·7	100	39	·312	·297	·300	3·42	129·3	108·2	46·2	59·5	33·6	40·1	4·0	6·5
June, . . .	2·88	·74	**0·78**	16	69·0	81·0	75·0	97	45	·346	·326	·336	3·74	135·3	115·9	50·6	60·1	32·9	44·9	3·1	8·7
July, . . .	4·66	1·63	**1·30**	14	74·7	83·2	79·0	100	45	·364	·359	·362	4·06	127·7	109·9	45·9	64·6	41·5	47·7	2·6	5·5
August, ...	5·12	·86	**1·64**	24	81·8	85·2	83·5	98	41	·407	·395	·401	4·45	131·0	112·1	46·3	63·8	40·7	50·2	2·8	6·1
September, . .	0·63	·40	*2·27*	12	79·4	84·7	82·0	100	45	·389	·379	·384	4·23	125·5	108·6	42·2	60·4	35·5	46·3	4·5	8·8
October, ...	3·30	·58	**0·90**	19	81·4	83·2	82·3	100	55	·240	·235	·238	2·68	106·7	81·6	31·5	51·0	22·0	33·5	4·9	9·1
November, . .	2·60	·42	*0·04*	23	85·7	86·6	86·2	98	65	·236	·243	·240	2·85	89·0	68·7	20·9	40·0	24·9	35·2	3·8	7·5
December, . .	2·27	·40	*0·18*	18	83·7	83·7	83·7	97	60	·195	·193	·194	2·25	79·4	53·1	11·2	32·0	21·2	30·2	3·3	8·3
Year, . . .	29·18	1·63	*0·68*	195	79·1	82·7	80·9	100	18	·269	·263	·266	3·00	135·3	87·9	35·0	64·6	7·0	36·7	3·8	10·6

Note.—In the columns headed "Difference from Average," the heavy type indicates an excess, and the italic a defect.

	Bright Sunshine for Hour ending Greenwich Time.																	Percentage of possible Duration.	Difference from Average 30 years.	Greatest in One Day.	Greatest Percentage of possible in 1 Day.	No. of Sunless Days.	Diff. from Average 30 years.	Cloud 0–10.			Horizontal Air Movement.				
	A.M.								P.M.								Total.							9 A.M.	9 P.M.	Mean.	Total Movements.	Mean Velocity per hour.	Greatest in 24 hours.	Estimated Wind Force, 0–12.	Mean Rainband, 0–6.
	5	**6**	**7**	**8**	**9**	**10**	**11**	**Noon.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**															
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	%	%	Hrs.	%						Mls.	Mls.	Mls.		
January, .	...	...	...	...	...	1·15	6·85	7·23	8·32	7·95	3·92	·08	...	...	...	...	35·50	15	*6*	4·5	58	13	**2**	6·4	5·3	5·8	3767	5·1	225	0·89	1·11
February, .	...	...	...	...	3·55	6·78	10·80	11·98	11·53	11·67	9·02	4·69	1·85	·13	...	...	72·00	27	**1**	6·8	68	5	*0*	5·4	4·9	5·2	2644	3·9	315	0·66	0·91
March, . .	...	...	...	1·60	5·30	8·05	8·61	9·42	9·72	7·42	5·39	6·65	2·69	·50	...	...	63·35	18	*12*	8·4	71	9	**2**	8·4	6·4	7·4	5322	7·2	412	1·29	1·24
April, . .	...	1·58	3·91	5·81	6·86	10·50	12·80	12·02	10·60	11·83	13·10	13·98	11·63	8·65	·90	...	124·17	29	*1*	11·8	84	3	*2*	8·3	6·9	7·6	4933	6·8	330	1·12	1·24
May, . .	1·58	7·50	11·27	10·81	13·11	14·52	16·88	17·05	14·55	14·75	15·36	16·80	16·63	15·20	12·88	2·30	201·19	40	**8**	13·6	86	3	*1*	6·5	5·5	6·0	2754	3·7	248	0·68	1·32
June, . .	6·37	13·45	15·78	14·47	14·10	14·55	10·05	14·20	15·08	15·11	14·30	13·45	14·56	12·13	12·81	3·11	203·52	39	**11**	14·8	85	1	*2*	6·9	5·2	6·0	2672	3·7	235	0·82	1·43
July, . .	3·19	7·47	8·63	9·50	11·30	11·86	11·85	11·37	11·39	10·94	12·85	11·10	9·85	5·86	1·95	·11	139·22	26	*3*	12·8	75	5	**1**	8·2	7·1	7·6	3503	4·7	330	0·97	1·38
August, .	...	·03	3·52	4·98	7·45	9·03	9·61	13·02	7·91	10·78	8·23	9·65	8·27	6·60	2·44	...	101·52	22	*8*	8·3	56	2	*3*	8·9	7·2	8·0	3308	4·5	326	0·82	1·41
September,	...	...	·53	3·00	12·58	16·67	15·44	16·35	19·56	18·50	16·39	15·97	14·28	7·27	·75	...	157·79	41	**10**	10·3	77	3	*1*	5·0	4·9	5·0	3642	5·0	378	0·87	1·08
October, .	...	...	...	...	3·69	13·08	16·75	15·78	16·10	14·02	10·22	8·19	1·85	...	...	...	99·68	31	**2**	8·5	76	6	*1*	5·2	6·0	5·6	4014	5·4	360	0·90	1·13
November,	...	...	...	...	·05	2·39	6·75	8·88	9·85	8·22	6·45	1·22	...	...	...	...	43·85	14	*10*	5·8	68	13	**4**	8·3	7·7	8·0	4613	6·4	485	1·02	1·16
December,	...	...	...	...	...	...	1·92	3·63	6·36	4·88	1·73	·02	...	...	...	...	18·54	8	*11*	4·1	58	18	**4**	8·0	6·2	7·1	5443	7·3	540	1·29	1·09
Year, . .	11·14	30·03	43·64	50·17	77·99	108·58	128·31	141·43	140·97	136·07	116·96	101·80	81·61	56·34	31·73	5·52	1262·29	28	**1**	14·8	86	81	**3**	7·1	6·1	6·6	46,615	5·3	540	0·94	1·21
	591·29 hrs.								671·00 hrs.																						

Note.—In the columns headed "Difference from Average," the heavy type indicates an excess, and the italic a defect.

Wind from Observations made at 9 A.M. and 9 P.M. Number of Days it blew from certain directions.

	1895.									Difference from Average 100 years—Percentage excess or defect.								
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.
January, .	7	3	5	3	1	0	8	3	1	**19**	**6**	**6**	**1**	*4*	*22*	*8*	**3**	*1*
February, .	3	2	7	3	1	0	3	5	4	**7**	**2**	**16**	**3**	*3*	*23*	*23*	**10**	**11**
March, . .	6	3	4	1	0	3	12	2	0	**14**	**3**	*1*	*5*	*6*	*7*	**8**	*3*	*3*
April, . .	3	2	9	0	1	3	10	1	1	**4**	*5*	**9**	*8*	*1*	*2*	**8**	*5*	*0*
May, . . .	3	5	8	2	1	0	9	2	1	**5**	**3**	*3*	**1**	*1*	*11*	**5**	**1**	*0*
June, . .	1	2	10	1	1	1	12	2	0	*1*	*3*	**9**	*1*	*1*	*9*	**9**	*0*	*3*
July, . .	2	3	6	2	2	2	12	0	1	**3**	*0*	*1*	**3**	**2**	*7*	**3**	*0*	*3*
August, . .	2	1	1	2	0	4	18	0	3	**3**	*3*	*14*	**1**	*4*	*2*	**19**	*6*	**6**
September,	2	1	0	0	1	1	16	3	6	**3**	*4*	*14*	*6*	*3*	*13*	**19**	**3**	**15**
October, .	7	2	3	0	1	0	16	1	1	**18**	**1**	*1*	*9*	*4*	*19*	**18**	*4*	*0*
November, .	2	3	6	2	2	2	12	0	1	**2**	**6**	**9**	*2*	*0*	*12*	**6**	*8*	*1*
December, .	0	0	5	6	1	1	14	2	2	*4*	*4*	**7**	**11**	*4*	*19*	**11**	*0*	**2**
Year, . .	38	25	64	21	12	17	145	23	20	**6**	*0*	**1**	*1*	*3*	*12*	**8**	*1*	**2**

Number of Times the Following Phenomena were observed.

													Difference from Average 125 years.				
	Halos.	Rainbows.	Thunder-storms.	Lightning.	Aurora.	Snow.	Hail.	Frost in Shade.	Frost on Grass.	Mist.	Mist on Arthur's Seat.	Gales.	Thunder-storms.	Snow.	Hail.	Mist.	Gales.
January, . .	2	0	0	1	0	11	1	26	30	1	2	0	*0*	**6**	*0*	*0*	4
February, . .	0	0	0	0	1	6	0	22	27	3	3	0	*0*	**2**	*1*	**2**	4
March, . . .	4	0	0	0	1	3	3	5	15	1	4	1	*0*	*2*	**1**	*0*	2
April, . . .	3	0	0	0	3	0	3	4	7	2	6	2	*0*	*2*	**1**	**1**	0
May, ...	3	0	4	1	0	0	2	0	0	4	10	0	**3**	*1*	**1**	**2**	1
June, . . .	1	1	3	0	0	0	4	0	0	2	4	0	**2**	*0*	**4**	*0*	1
July, ...	1	0	3	0	0	0	0	0	0	2	6	1	**1**	*0*	*0*	**1**	0
August, . . .	0	0	5	0	0	0	0	0	0	0	1	0	**4**	*0*	*0*	*1*	1
September, . .	1	0	1	1	0	0	0	0	0	4	4	1	*0*	*0*	*0*	**3**	1
October, . .	2	0	0	0	0	4	2	3	14	1	3	0	*0*	**4**	**1**	*1*	3
November, . .	0	1	0	0	1	0	0	0	10	1	3	3	*0*	*1*	*1*	*0*	0
December, . .	0	0	0	0	1	5	2	8	18	3	0	3	*0*	**2**	**1**	**2**	1
Year, . . .	17	2	16	3	7	29	17	68	121	24	46	11	**10**	**8**	**7**	**9**	18

Note.—In the columns headed "Difference from Average," the heavy type indicates an excess, and the italic a defect.

	Earth Thermometers.				Variability of Temperature, Earth Thermometers.			
	3 ins.	12 ins.	22 ins.	Air Temp. at 9 A.M.	3 ins.	12 ins.	22 ins.	Air Temp.
	°	°	°	°	°	°	°	°
January,	...	...	...	...	...	...	...	...
February,	...	...	...	...	...	...	...	...
March,	...	...	...	...	...	...	...	...
April,	...	...	...	...	...	...	...	...
May,	60·8	57·0	53·3	57·9	2·0	0·8	0·6	4·6
June,	58·7	56·8	54·9	58·9	2·2	0·6	0·6	3·7
July,	57·7	57·7	56·6	58·4	1·4	0·7	0·3	3·2
August,	58·5	58·3	57·1	58·9	1·9	0·5	0·3	2·7
September,	55·8	56·8	56·0	58·7	2·7	0·5	0·4	4·3
October,	43·7	48·0	49·3	44·0	2·0	0·8	0·5	2·9
November,	40·9	42·7	43·3	42·6	1·8	0·6	0·4	3·1
December,	35·8	38·5	39·7	38·0	1·7	0·6	0·3	3·2
Year,	...	...	...	...	...	...	...	..

XV. *River Temperature.* Part III. *Comparison of the Thermal Conditions of Rivers and Ponds in the South of England.* By H. B. Guppy, M.B., F.R.S.E.

(Read 18th March 1896.)

In their thermal behaviour rivers and ponds present some points of striking contrast, and these differences no doubt find some expression in the composition of their respective floras and faunas, as well as in the habits and life-history of the plants and animals concerned. Whilst not broaching upon a very novel subject, the writer here endeavours to give scientific precision to differences in the temperature of ponds and rivers, such as must have often come under the notice of the experienced angler and the field naturalist. The observations covered about two years, and were made on the Thames at Kingston, and on the numerous ponds in that neighbourhood. In the first part of this paper some of the principal features of the thermal regime of the Thames were discussed, and the surface-temperatures of rivers and ponds were there contrasted. In alluding again to some of the principles there laid down, it will be assumed that the reader has previously become acquainted with the data there given.

A river of ordinary swiftness, unchecked in its course by locks and weirs, displays about the same temperature throughout its mass, or at most the variation would be only one or two degrees in its different parts even on a hot summer day.[1] On the other hand, a pond, four feet deep and well stocked with *submerged* aquatic plants, varies considerably in temperature. On a warm summer afternoon the difference between the marginal and bottom temperatures would be from 15° to 20°, whilst the surface temperature would be 9° or 10° higher than that at the bottom. In spring and autumn the variations in temperature between different parts of a pond are usually less, and in winter they almost disappear. When a pond is clear of such weeds the contrast in its temperatures is much less than when it is full of plants, on account of the circulation of the water being unimpeded. A similar effect is produced by the floating leaves of such plants as the water-lilies, the *Limnanth, Polygonum amphibium,* and *Potamogeton natans,* which, in summer, preserve the coolness of the water and maintain much the same temperature all over the pond. However, I am dealing here only with ponds full of submerged plants, such as *Ranunculus aquatilis (circinatus), Myriophyllum spicatum, Ceratophyllum demersum, Zannichellia palustris, Potamogeton crispus, P. obtusifolius, Scirpus fluitans,* etc., a circumstance that must not be forgotten whilst perusing this paper.

Rivers also differ greatly from ponds in their small daily range. This contrast is, of course, greatest in sunny weather. Whilst the Thames even in summer does not usually vary more than 2° in its temperature during the twenty-four hours, a pond will vary 6° or 7° at its surface, 1° or 2° at the bottom, and some 20° at its margins. In spring and

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[1] Since writing the first part of this paper, a perusal of Dr Forster's recent Memoir on the Rivers of Europe has convinced me that the Thames owes its marginal heating to its locks and weirs. Left to nature, the river would display but little heating at its margins.

autumn the amount of a pond's daily fluctuation of temperature will be often reduced, and in winter it almost disappears.

It follows from these facts that the comparison of the thermal conditions of a pond and of a river is a task of much complexity. Although the mean temperature of a river is readily ascertained on account of the small daily range and the slight variations of temperature in the different parts of the moving mass of water, it is almost impossible, at least in the warm half of the year, to obtain such an estimate for a pond. At its margins it exhibits, in the great daily fluctuations of temperature, the thermal conditions of a ditch; at the bottom, in the central portions, it resembles a river in its small daily range; and in the rest of its mass it displays a great variety of temperatures, due largely to the different depths, and to the arrangement and habits of the plants that there thrive.

In order to illustrate the great diversity in the thermal conditions of ponds full of submerged plants, I have incorporated some of my results in Table I. The Black Pond, Oxshott, where *Scirpus fluitans* abounds, together with *Hypericum elodes, Sphagnum,* and other plants, is typical of a pond in a boggy district. *Ceratophyllum demersum* is the prevailing plant of its habit in the Home Park Pond; whilst the Bushey Park Pond is largely occupied by *Myriophyllum.* There are usually one or two plants in a pond that, in giving their character to the plant-life, also mainly influence the thermal regime. Such plants I have just named. In the following table the temperatures of these ponds are contrasted with those of the Thames and of the air. The extremes only are here represented, and every intermediate condition is to be found between the cool bottom-waters and the heated marginal shallows. The water-temperature always rises where the submerged plants are densely gathered. Thus, in the centre of the Black Pond, where the surface was clear of plants, its temperature in the afternoon of June 19th was 79°·8, whilst the thermometer placed in a dense floating mass of *Scirpus fluitans* indicated 82°; and in another part of the pond, where *Hypericum elodes* and Bog Moss filled up a depth of 18 inches, the surface was 88° and the bottom 73°, or a change of 1° for each inch in depth, a common feature of the thermal regime of a ditch in a summer day. The observations on the Home Park Pond are of particular interest with regard to *Ceratophyllum demersum.* During this hot summer of 1893, I frequently took the temperature in the shallows where this plant was thriving, and here, where the afternoon temperature was frequently over 80° and sometimes as high as 90°, it flowered and produced abundant mature fruit. Incidental reference to the thermal conditions required by this plant for reproducing itself from seed will be found in the first part (vol. xii., p. 296) of this paper, but a full discussion of the matter will be found in *Science Gossip* for November 1894.

In sunny weather the thermal regime of a pond is to a large extent regulated by the plants that live in it. Submerged plants like *Myriophyllum*, *Ceratophyllum*, and *Zannichellia* favour the heating process by impeding the free circulation of the water; and, as before remarked, plants with large floating leaves, like the water-lilies and the *Limnanth*, keep the temperature cool. A multitude of other influences, however, are always at work. Upon the position of a spring and on the situation of an affluent great differences often depend. Whilst the temperature at one end of a pond may be under the influence of the agencies regulating that of the air, at the other end it may be far more equable on account of the control of a perennial spring. A fresh breeze on a sunny day causes the lee side to be some degrees warmer than the opposite border. A pond with a shallow outlet loses its heated surface-waters, whilst one with a deep outlet loses its cool bottom-waters. Ponds without affluents or effluents heat up rapidly. In fact, as I have elsewhere observed, "no two ponds possess precisely the same thermal regime, the determining conditions being almost infinite in their variety" (*Science Gossip*, October 1894).

On referring to Table I. we notice that, however much a pond may differ from a river in its thermal behaviour, its bottom-waters exhibit much the same conditions all through the year. The resemblance is not only concerned with the small daily range of one or two degrees, but also with the actual readings of the thermometer. Observations on other ponds point to the same conclusion. This is only true, however, of ponds of ordinary depth, namely, 4 or 5 feet. As indicated in Table I., a pond 7 or 8 feet deep, as in the case of the Queen's Mere, Wimbledon, has a bottom-temperature that is in summer four or five degrees cooler than the Thames, the diurnal range being almost nil.

Although, as before remarked, it is not possible to compare the mean temperature of a pond in its entirety with that of a river, yet, by contrasting their several features, we can bring certain facts into prominence that deserve the attention of the student of the conditions of aquatic life. The observations on which the estimates for ponds, as given in Table II., are based, were for the most part systematically made. But a large number of occasional observations have also been here employed, and, in fact, during two years I rarely went out without taking a thermometer with me.[1] It will be noticed in this Table that, contrasted in the monthly means, the thermal conditions of ponds and rivers appear in their true proportions. Isolated observations, such as occur in Table I., are rather apt to exaggerate the differences. The divergence, however, between a pond and a river is sufficiently striking in these respects; and in the varying temperature of the one, and in the uniform temperature of the other, we have conditions that would very differently affect aquatic life.

It is probable that the diverse thermal conditions of ponds and rivers find their fullest expression in the varying habits of a water-mollusc. It should, however, be remembered that the contrast is greatest in summer and least in winter, when, in fact, there is but little difference in this respect between a pond and a river, as is evidenced in Tables I. and II. Except in very sluggish rivers, a mollusc enjoys much the same temperature in any part of a river, whether at the surface, on the bottom, or at the borders. All the year round the temperature does not usually vary more than one or two degrees in the twenty-four hours, and the change

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[1] I may here take the opportunity of expressing my sorrow at the death of Mr John Gunn, who, as Secretary of the Society, gave me valuable assistance in the early part of this inquiry.

from day to day is of the same amount. On the other hand, in a pond during ordinary summer weather a mollusc has the choice of a great variety of temperatures. It may prefer the cool bottom-waters, with a temperature, for instance, of 65°; or it may creep beneath the surface film, where the temperature is 10° higher, viz., 75°; or it may æstivate in water 2 or 3 inches deep at the margins, where the temperature is between 80° and 85°. Nor is this all. At the bottom, as above remarked, it experiences not only a temperature near that of a river, but a temperature with a similar limited daily range of a degree or two; and, as far as the thermal conditions are concerned, we might expect that the molluscan fauna of a free-flowing river would find its counterpart in the molluscan life of the bottom of a pond. If the creature ascended to the surface, it would experience a daily range of temperature of 6° or 7°; whilst in the marginal shallows it would be exposed to a fluctuation of temperature of as much as 15° or 20° in the day and night. It is, therefore, legitimate to suppose that these variations in a pond's temperature in summer, which exist, though usually to a less marked extent in spring and autumn, are reflected in the divergent habits of river and pond molluscs. Marked differences should be found between them as regards their æstivation, the deposition of their spawn, the hatching of the eggs, the behaviour of their fry, and in the age and size adults attain.

The differences in the thermal behaviour of ponds and rivers will affect plant-life in a multitude of ways. In Part I., pp. 295, 296, I have endeavoured to show how the absence of surface-heating in a river, and its presence in a pond, may be reflected in the budding, flowering, and fruiting periods of aquatic plants. It is conceivable that they may also influence the form of a plant, as in the case of the various forms of *Callitriche aquatica* and *Ranunculus aquatilis.* Those kinds of the first-named plant that possess submerged linear leaves and floating rosettes of obovate leaves behave differently in winter in a pond and in a perennial spring. In a pond the floating rosettes die and disappear in winter, and others are produced in April, the plant in its winter dress bearing only submerged linear leaves. In a perennial spring, or in the upper waters of a river, like the Wandle at Hackbridge—that is, entirely under the control of such springs, the floating rosettes remain through the winter. Then, again, there is a form of *Ranunculus aquatilis* that in winter possesses only submerged linear leaves. Shortly before it flowers in the spring season, it produces broad, rounded floating leaves, and the difference between the plant in its winter and summer dress is very striking. The form, *R. fluitans*, that is found in running streams, and has no floating leaves, might be induced to develop them if exposed to the surface-heating of a pond.

Everything in plant-life is behindhand in a river in comparison with a pond. The seeds floating in the drift germinate some weeks later, and the flowering and fruiting processes are, in a corresponding degree, postponed. The temperature of 50°·0 is, in this climate, a critical temperature, as the year advances, for aquatic plant-life, not only as regards germination, but also as concerns the growth of the bud. It was attained by the Thames in 1893 on March 31st, and in 1894 on March 29th; whilst, in the marginal shallows of the ponds, it was reached in the middle of February. It is in these marginal shallows that floating seed-drift collects, and, as a result, the floating seeds germinate much earlier in a pond than in a river, and the floating buds, bulbs, and rootstocks commence their growth at a correspondingly early date. On account, also, of the relatively great surface-heating of a pond, the flowering process is greatly forwarded. During the hot summer of 1893 the highest temperature attained by the Thames was 75°, and for twenty-five days its temperature was 70° or over. In the cooler summer of 1894 the maximum Thames temperature was 73°·3, and the days during which the river maintained a temperature of 70° and over were ten in number. During hot weather, when the river-temperature was 70°, it was not uncommon, in the case of ponds filled with submerged plants, to find a surface-temperature of over 80°. Though this surface-heating is not exhibited by ponds covered with the large floating leaves of such plants as our water-lilies, our *Limnanth*, and some of our *Potamogetons*, it is the characteristic feature of ponds filled with plants like *Myriophyllum*, *Ceratophyllum*, *Zannichellia*, *Scirpus fluitans*, etc. It is indicated in Table II. that in sunny summer weather the surface of such a pond is, on the average, between six and eight degrees warmer than that of the river.

In concluding this part of the paper, I would point out that, as yet, we have everything to learn concerning this important subject. For the student of the conditions of aquatic life, the real inquiry has yet to be begun; and it would be dangerous to attempt to harmonise facts of observation, such as are given in this paper, with the habits of aquatic plants and animals without a general grasp of the intricate questions involved. When we investigate the thermal economy of a pond, or of a stream, we are but examining a single portion of a great thermal system which, in the first case, comprises both the road-splash and the inland sea, and, in the second, begins with the mountain rill and ends in the river.[1]

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[1] In Science Gossip for October 1894, I have attempted such a bird's-eye view of the subject. For further reference to the influence of springs, see a paper by the author in Quart. Jour. Roy. Meteor. Soc., January 1895.

[TABLE I.

TABLE I.

Comparison of the Temperature on particular Days of Ponds near Kingston, and of the Thames at that town. (These are selected cases, the mass of the author's observations being worked up in Table II.)

	Centre of Pond.						Margins of Pond.			Thames.			Air in Shade.		
	Surface.			Bottom.											
	Aft.	Sunr	Diff.	Aft.	Sunr	Diff.	Aft.	Sunr	Diff.	Aft.	Sunr	Diff.	Aft.	Sunr	Diff.
Black Pond, February 4, 1893,	44·5	..	..	44·5	..	..	..	..	..	44·5	..	..	47·0	..	..
" March 28, 29, ,,	52·5	47·5	5·0	49·5	47·5	2·0	62·0	44·0	18·0	48·5	46·5	2·0	60·5	33·0	27·5
,, April 24, ,,	65·0	..	..	61·0	..	..	76·0	..	..	60·5	..	..	77·0	..	..
,, June 19, 20, ,,	80·5	71·7	8·8	71·0	70·0	1·0	88·0	69·0	19·0	73·0	71·0	2·0	87·0	60·0	27·0
,, September 12, 1892,	65·5	..	..	63·0	..	..	..	..	..	62·0	..	..	70·0	..	..
,, November 10, ,,	48·0	..	..	46·5	..	..	..	..	..	47·0	..	..	50·0	..	..
,, December 2, ,,	41·0	..	..	41·0	..	..	..	..	..	42·0	..	..	39·0	..	..
Home Park, August 14, 1893,	81·0	..	..	72·0	..	..	90·0	..	..	73·2	..	..	84·0	..	..
Bushey Park, ,, 15, ,,	82·0	..	..	73·0	..	..	87·0	..	..	74·0	..	..	86·0	..	..
Queen's Mere, June 14, 15, ,,	70·0	67·0	3·0	62·7	62·5	0·2	71·0	67·0	4·0	66·9	..	..	81·0	53·0	28·0
,, May 3, ,,	60·2	..	..	56·0	..	..	..	..	..	60·0	..	..	70·0	..	..

Note.—All the ponds, except the Queen's Mere, were 4 to 5 feet deep, and well stocked with submerged aquatic plants, as indicated in the text. The Queen's Mere was 7 to 8 feet deep and clear of weeds, characters that explain its relatively low plane of temperature, and the slight marginal heating.

The lengths of the ponds are as follows:—

Black Pond, Oxshott, ...	350 yards.
Home Park Pond, ...	250 ,,
Bushey Park Pond, ...	200 ,,
Queen's Mere, Wimbledon, ...	150 ,,

By the "surface" of a pond I mean the upper 3 inches in the deep parts. By the "margins," shallows 3 inches deep are implied. The Thames is here assumed to be a free-flowing river that exhibits the same temperature throughout its mass. The locks and weirs, however, by retarding the current and increasing the depth, tend to elevate the plane of temperature, so that the differences between the river and pond temperature, indicated in this Table and in Table II., would normally be somewhat greater. The same self-recording instrument employed in taking the bottom-temperatures of the Thames (Part I., p. 292) was here employed. The afternoon temperatures were taken at the "maximum" hour.

TABLE II.

Comparison of the Mean Temperatures of the Ponds (stocked with Submerged Plants) around Kingston, with those of the Thames in the same Locality, from data obtained 1892–94.

Month.	Centre of Ponds at a depth of 12–18 inches.										Margins of Ponds where 3 inches deep.			Surface of Ponds.	Bottom of Ponds.
	Mean Max.			Daily Mean.			Diurnal Range.				Mean excess of Ponds Max. Temp. over that of River on Sunny Days.	Diurnal Range of Ponds.		Mean excess of Ponds Max. Temp. over that of River on Sunny Days.	Compared with River in Temp. and Diurnal Range.
							Sunny Weather.		Cloudy Weather.						
	River.	Ponds.	Diff. of Ponds.	River.	Ponds.	Diff. of Ponds.	River.	Ponds.	River.	Ponds.		Sunny Weather.	Cloudy Weather.		
January,	36·2	36·0	− 0·2	35·9	35·4	− 0·5	1·0	1·5	0·5	1·0	1·5	In spring and summer varies between 10° and 20°; in winter about 5°.	Much reduced always.	Slight.	About the same as river all the year through. See Table I.
February,	42·6	43·2	+ 0·6	42·2	42·1	− 0·1	1·5	3·0	0·8	1·5	4·0			Slight.	
March,	47·0	49·2	+ 2·2	46·5	47·7	+ 1·2	2·0	4·0	1·0	2·0	7·0			2·0 – 3·0	
April,	55·8	58·8	+ 3·0	55·1	57·3	+ 2·2	2·0	4·0	1·0	2·0	9·0			3·0 – 5·0	
May,	62·1	65·1	+ 3·0	61·4	63·2	+ 1·8	2·5	5·0	1·2	2·5	10·0			6·0	
June,	65·9	69·2	+ 3·3	65·2	67·0	+ 1·8	2·0	6·0	1·0	3·0	12·0			6·0 – 8·0	
July,	68·0	72·0	+ 4·0	67·3	69·8	+ 2·5	2·5	6·0	1·2	3·0	12·0			6·0 – 8·0	
August,	68·8	72·4	+ 3·6	68·1	70·2	+ 2·1	2·5	6·0	1·2	3·0	12·0			6·0 – 8·0	
September,	60·5	(64·0)	+ 3·5	59·8	62·2	+ 2·4	2·5	(5·0)	1·2	(2·5)	10·0			(6·0)	
October,	54·5	(56·5)	+ 2·0	53·9	55·0	+ 1·1	2·0	(4·0)	1·0	(2·0)	8·0			(4·0)	
November,	43·1	42·4	− 0·7	42·6	41·4	− 1·2	1·5	2·5	0·8	1·3	5·0			2·0	
December,	41·7	40·0	− 1·7	41·3	39·4	− 1·9	1·0	(1·5)	0·5	(1·0)	2·0			Slight.	
Mean,	53·8	55·7	+ 1·9	53·3	54·2	+ 0·9	1·9	4·0	0·9	2·1	7·7			4·0	

Note.—The ponds observed were those of Richmond Park, Bushey Park, Home Park, Oxshott, Esher, West End, Wimbledon, etc. The Thames observations were made in 1893, as well as those in the centre or deeper parts of ponds; but a large number of occasional observations, made also in 1892 and 1894, have been worked in when dealing with the diurnal range, and the marginal, surface, and bottom temperatures of ponds. The figures in brackets are in part estimates. The river observations for 1893 were made every other day, and the pond observations contrasted with them about ten times a month. For the characters of some of the ponds, and on the method of observation, *vide* the note attached to Table I. The results for the Queen's Mere have not here been utilised, as it is clear of weeds.

TABLE III.

The Temperature of the Thames at Kingston and Greenwich.

Month.	Kingston.[1]												Greenwich.[2]		
	August 1892–July 1893.						August 1893–July 1894.						1845–1879.		
	A	B			C		A.	B			C		A		
	River Max.	River Mean.	Air Mean.	Diff of River Mean.	Air Max.	Air Min.	River Max.	River Mean.	Air Mean.	Diff. of River Mean.	Air Max.	Air Min.	River Mean.	Air Mean.	Diff. of River Mean.
August, . .	66·3	65·6	..	..	..	..	68·8	68·1	65·7	+2·4	75·9	57·9	64·4	62·6	+1·8
September, .	60·2	59·5	..	..	..	..	60·5	59·8	57·2	+2·6	66·3	50·3	59·9	57·9	+2·0
October, . .	49·6	49·0	..	..	..	..	54·5	53·9	51·4	+2·5	58·2	46·2	52·9	50·7	+2·2
November, .	47·1	46·6	..	..	..	..	43·1	42·6	42·1	+0·5	45·7	38·2	44·3	42·3	+2·0
December, .	38·8	38·4	..	..	..	..	41·7	41·3	40·2	+1·1	44·1	35·7	40·4	39·8	+0·6
January, . .	36·2	35·9	37·3	−1·4	40·5	33·6	39·3	39·0	38·7	+0·3	41·8	35·0	39·4	38·9	+0·5
February, .	42·6	42·2	42·4	−0·2	48·4	37·2	42·6	42·2	41·6	+0·6	46·6	37·4	40·7	40·4	+0·3
March, . .	47·0	46·5	46·5	0·0	57·8	36·7	46·2	45·7	45·0	+0·7	53·8	37·7	43·6	42·8	+0·8
April, . . .	55·8	55·1	52·5	+2·6	65·0	42·2	54·8	54·1	51·6	+2·5	61·2	44·2	50·0	48·7	+1·3
May, . . .	62·1	61·4	57·6	+3·8	69·2	48·4	56·1	55·4	50·7	+4·7	59·7	44·1	56·3	54·4	+1·9
June, . . .	65·9	65·2	62·4	+2·8	73·3	53·1	62·4	61·7	59·5	+2·2	68·5	52·1	62·6	60·6	+2·0
July, . . .	68·0	67·3	64·2	+3·1	73·6	56·8	67·6	66·9	63·0	+3·9	71·9	56·2	65·7	63·9	+1·8
Means, . .	53·3	52·7	..	..	...	..	53·1	52·6	50·6	+2·0	57·8	44·6	51·7	50·2	+1·5
							August 1894.								
							64·2	63·5	60·6	+2·9	68·8	54·7			

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[1] The Kingston observations were made by myself, those for the river every other afternoon under the railway bridge at the hour of maximum temperature (Part I., p. 300), and those for the air by self-registering instruments in my back garden, about a third of a mile from the river. The air means have been obtained by dividing the sum of the mean minimum and mean maximum by two, and applying Marriott's corrections for Greenwich. One of Negretti and Zambra's Reference Thermometers, certified at Kew, was employed as a standard instrument, with which all others were from time to time compared. The instruments were lowered to a depth of 18 inches below the surface, and kept there four or five minutes. The river means are based on my observations of the diurnal range, to be subsequently given.

[2] The Greenwich river observations were made with self-recording instruments on board the "Dreadnought" and the police-ships anchored in the stream. The thermometers were placed in a perforated trunk attached to the ship's side, two feet below the surface. The air observations are those of the Observatory, 160 feet above the river, but no correction has been made. The years 1857 and 1870 are not included in the series (Airy in Proc. Roy. Soc. Lond., vol. xxxiv.).

XVI. *Nests and Eggs of the Emus and the Cassowary of Australia.* By A. J. CAMPBELL, Esq., Melbourne. Communicated by JOHN J. DALGLEISH, Esq. [Plate VI.]

(Read 18th March 1896.)

It is with pleasure I ask your Society to accept a short treatise on the Nests and Eggs of the present Struthious Birds of Australia.

In directing special attention to these noble and harmless birds, it is sad to reflect that, in all probability, these feathered giants will be amongst the first members of our avifauna to be swept off the face of the earth by the rapid and ever-advancing tide of civilisation, and, perhaps even sooner than we anticipate, be numbered with the extinct Moas of New Zealand and the more recently defunct Emus of Tasmania and Kangaroo Island.

However, as far as the present Emus and the Cassowary are concerned, they are still in the hands of Australians for good if they (the people) choose. Provincial parliaments may pass enactments for the proper protection of birds and animals, but it surely rests with the people to see that these laws are strictly observed.

In the matter of the form of this article, I have followed the method which I have adopted in dealing with papers on the "Nests and Eggs" of other families of Australian birds, read before various scientific societies in Australia.

DROMAIUS NÔVÆ HOLLANDIÆ, Latham.

(Emu.)

Figure.—Gould, Birds of Australia, fol., vol. vi. pl. 1.

Previous Descriptions of Eggs.—Gould, Birds of Australia (1848), also Handbook, vol. ii., p. 203 (1865); North, Cat. Nests and Eggs Aust. Mus., p. 292 (1889).

Geographical Distribution.—Australia in general.

Nest.—Usually a flat bed or platform composed of grass or other herbage plucked by the bird round about the site, and trampled down. Sometimes bark, pieces of sticks, and leaves of trees are used, intermingled with a few of the bird's own feathers. Shape generally oval, about 4 feet by 2½ feet in size, and about 2 inches in thickness. Situation in open country usually near the base of a tree or stump, at other times in rank herbage or in the dry bed of a *Polygonum* swamp. Some authorities state that on the plains the eggs are deposited on the bare earth, while in the Mallee country the nest is formed almost entirely of strips of bark plucked from these trees by the bird.

The nest or bed is constructed or augmented as the laying and incubation of the eggs proceed.

Eggs.—Clutch, usual average 9, but varies from 7 to 18. Elegant ovals in shape, a few exceptions being more swollen about the centre. The appearance of a collection of freshly-gathered unblown specimens is very beautiful; the surfaces are rough (not unlike shagreen), with granulations of dark green upon a shell of light metallic or verdigris green. In some clutches the granulations are so closely placed and flattened or squeezed down as to hide completely the interstices of light green. In such instances the eggs are of a more uniform dark green. The granules are slightly lustrous, but as incubation proceeds become much darker and polished, while the interstices become bluer or dingy in shade. Dimensions in inches of a normal clutch of 8 eggs:—(1) 5·62 × 3·62; (2) 5·56 × 3·62; (3) 5·5 × 3·68; (4) 5·5 × 3·68; (5) 5·5 × 3·62; (6) 5·43 × 3·68; (7) 5·31 × 3·5; (8) 5·06 × 3·31. The eggs in this clutch are somewhat lengthened ovals. No. 2 is much lighter in colour, caused by the granulations being more scattered over the shell (an exception not unfrequently seen in a set), while No. 8 is noticeably the smallest in the set.

Another clutch of 8 rather small but beautiful eggs gives average dimensions of 5·05 × 3·37 inches per egg. A remarkably regular-sized set of 12 gives 5·22 × 3·59 inches, while in a set of 13 of exceedingly dark green specimens (as explained by reason of the granulations completely covering the lighter coloured part of the shell), the average measurements are 5·16 × 3·66 inches.

Weight of 9 examples of various sizes selected promiscuously when full:—The smallest weighed 16¼ oz., the heaviest 23½ oz.—average of the 9 barely 20½ oz.

Observations.—It is always a pleasant occupation to read, write, or diffuse information about such a notable and noble creature as the Emu. The "King of the Australian fauna" the bird has been fitly termed. Whether seen in private reserves, parks, or in the open, the Emu always arrests attention. Even the bushman who has seen hundreds of Emus in the wilds, will always glance at the bird or remain to admire its handsome eggs.

Considering that the Emu is such an important and ornamental bird, soon likely to become scarce, or altogether extinct, as is now the case in Tasmania, it is somewhat remarkable that so little information is published with regard to this giant amongst the feathered tribes. If we wish to augment our knowledge of the habits of this most interesting bird, we should do so without loss of time; because, however the bird may hold its own in the little disturbed districts of the interior, it is becoming astonishingly scarce within, say, 200 miles of the sea-board, and will rapidly become more so, except the parliaments, and especially the people, aid in its protection. It has been for many years extinct in Tasmania and Kangaroo Island. The colony of Victoria, where comparatively few Emus now remain, will soon rank with those islands. What few birds do remain, perpetual protection to them and their progeny might rightly be applied, nay, demanded. The meagre protection existing in that colony is faulty, inasmuch as the close season for Emus only commences on the 14th June in each year, whereas some of the birds lay in April and May. In the neighbouring colony of New South Wales, Emus are protected absolutely for a period of five years commencing 1893. However, the law there is almost a dead letter, and, as I myself have witnessed, is more honoured in the breach than in the observance.

Gould's far-seeing remarks should be written in capital letters:—"And now a word to Australians, particularly to those who are interesting themselves about acclimatising animals (sparrows and rabbits, and such like vermin, may I add) from other countries—wishing for things they have not, and neglecting those they possess. . . . I must content myself by praying that protection may be offered to that noble bird, the Emu. . . . How much will the loss of this fine bird be regretted by every right-minded person who claims Australia as his fatherland!"

In addition to many notes supplied to me by friends favourably situated, I made a special but albeit brief excursion during the breeding season last year (1895) into the Wakool district of Riverina, to gather information personally with regard to the Emu. I was fortunately favoured with an invitation to stay at "Strathdon," the farm of my friend Mr Neil Macaulay (in fact, to Neil and his brothers I have been indebted on different occasions for information as well as for specimens), which is situated in the midst of the best Emu country; and I was still further fortunate in falling in with a professional Emu-eggers' camp, pitched by permission within one of Mr Macaulay's paddocks. I went hunting with these Emu-eggers (there were four in camp) and "caught on" much of their experiences gained during the last three seasons; some of their information, being either confirmatory of what was already known, or being altogether original, was exceedingly valuable to me.

A few of the earlier breeders lay towards the end of April or after the autumnal rains, some in May, while the majority have laid by June or July, the young appearing during August and September. Of course, eggs may be seen as late as August, but on account of the lengthened incubation needed, they may have been deposited weeks previously. The hunters informed me the first young noticed by them that season (1895) was at the end of June. Mr Murdoch Macaulay, to whose kindness I am indebted for a specially selected set of eggs, informs me in the season of 1891 the Emus did not commence to lay till the middle of May. The laying period is much regulated by the rainy season of the year, and they do not lay, or only do so in small proportions, when the seasons are droughty or bad.

With regard to the maximum number of eggs laid by

Emus, I cite the following Riverina data:—Mr George Warner saw a clutch containing 16 eggs on the Tulla run; Mr D. Parker, a hunter, took on the 26th May 1895, on Nyang, 17 eggs from one nest, and, remarkable to state, the eggs were in two tiers, 12 in the bottom and 5 above; but I think Mr Neil Macaulay takes the record with 18, which he counted in a nest at Dunvegan. I have no records of 15 eggs, but know of several instances of 14.

As a test for the general average number of eggs laid by the Emu, the following statement shows a certain number of nests containing 7 eggs and over, found during two successive seasons in Riverina.

1894.			**1895.**		
Found by Messrs Macaulay Bros.			Found by Emu-Eggers' Camp.		
Date.	Nest.	Eggs.	Date.	Nest.	Eggs.
10th May, .	1	9	April,	1	10
27th ,, .	1	7	May,	1	17
27th ,, .	1	12	,,	1	12
28th ,, .	2	(each 7) 14	,,	3	(each 11) 33
31st ,, .	1	10	,,	4	(each 10) 40
3rd June, .	4	(each 8) 32	,,	2	(each 8) 16
3rd ,, .	1	11	June,	1	12
3rd ,, .	1	12	,,	2	(each 9) 18
8th ,, .	1	8	,,	7	(each 8) 56
8th ,, .	1	7	,,	1	7
9th ,, .	1	8			
9th ,, .	1	10			
21st ,, .	1	9			
6th July, .	1	9			
10th ,, .	1	8			
11th ,, .	1	8			
12th ,, .	1	10			
Total, . .	21	184	Total, . .	23	221
Average, $8\frac{16}{21}$ eggs per nest.			Average, $9\frac{14}{32}$ eggs per nest.		

Nests.	Eggs.
21	184
23	221
44	405

Combined average, . . $1 = 9\frac{9}{44}$ or 9·2.

The incubation of Emu eggs takes about eight weeks. A reference to a record kept at the Zoological Gardens, Melbourne, shows that in 1892 young were noticed there on the 57th day after the male bird commenced to sit.

The male bird takes the task of incubation, during the day at all events. This has been proved by birds being pushed from the nest, run down by dogs, and dissected on the spot. I unintentionally "aided and abetted" in this cruel act, but once only. Then I can plead in extenuation that the bird was started accidentally when we were kangarooing. Hunters invariably endeavour to keep their hounds off brooding Emus.

It has not been proved satisfactorily that the female never sits or never relieves the male at night, but it has been proved she lays at night, or between sunset and sunrise. A hunter while on the rounds to his traps tested two nests, examining them every night and morning. He found an egg was deposited every second day between sunset and sunrise, and I can vouch for his statement. However, other observers are at variance on this point. One says, when the Emu commences to lay she deposits an egg every day until the clutch is completed. Another, referring to a pair of birds he watched closely in his private reserve, says: "The laying was commenced and continued for about a month, until there were 9 eggs in the nest."

The males tend the brood of young when hatched, but up to what age? I have seen a female accompanied by the previous season's nearly grown birds. This may be a reason why her lord tends to the current brood, while it is also an argument against any supposition that she relieves her mate on the nest at night.

In answer to a query of mine in the columns of *The Australian*, the following most interesting reply was received from a correspondent in South Gippsland (Victoria), and published in the issue of the 9th October 1886:—

"The Emu's nest was not in a bush paddock, but in a small rye-grass paddock of about four acres close to the homestead, such paddock being clear of timber or trees except a few pines and willows, and is enclosed by a paling fence and live hedge. The hatching was completed at the expiration of eight weeks from the time the bird commenced to sit, but it would depend whether the bird sat very closely or not if the hatching would be completed one or two days before or after the expiration of the eight weeks. There were four young birds brought out, of which two, unfortunately, were drowned shortly after, and the remaining two are now alive and thriving admirably. The male bird still takes charge of the young ones, and protects and nestles them, and will not permit the female or any others of the species to approach them, and he is at times quite fierce in his jealous care of the young. I may say that during the term of incubation the female was kept out of the paddock in which the nest is situated for as long as a fortnight at a time, and was occasionally allowed to go into it, but she never took any part in the hatching process. The male bird, who was watched during the time he was sitting, was not seen to leave the nest during the daytime, and if he fed at all it must have been at night."

Mr Dudley Le Souëf, the Assistant-Director of the Zoological Gardens, Melbourne, has obligingly favoured me with the following significant note:—"Female (Emu) killed accidentally just when finished laying. Male bird hatched and reared five young himself."

Why do Emus lay during winter, when the great majority of birds breed during spring and summer?—an interesting question. We are aware that such birds as Finches and Parrots usually lay towards the end of spring or in summer, when the grass-seeds, etc., are ripe enough for their young. So I suspect the Emu, which lays during winter, because the eggs, taking a long term of incubation, are hatched just as the tender blades of grass and herbage sprout on the first approach of spring, and upon which the young Emus feed.

I might now venture to give my Emu-nesting experiences in company with the hunters previously referred to. The locality is near the Neimur, a billabong (or ana-branch) of the Edwards River, and may be characterised as flat, open, forest country, where red-gum (*Eucalyptus rostrata*) fringes the course of the streams, now mostly waterless. Back from and between the watercourses are short box-tree (another species of *Eucalyptus*) flats. In paddocks where the trees are "rung" for pastoral purposes, they appear dull and dead, relieved only by the green suckers springing from their base, and in keeping with the ground, which is clothed with the dead herbage of last season's growth. An occasional dry bed of a *Polygonum* swamp adds to the monotony of these box-flats, while "a rise" of graceful pines (*Callitris*) is a cheerful contrast to the sight.

Being winter, the days are calm and cloudless, as a rule, with much warmth in the sunshine, while the nights are cold, clear, and frosty.

We perambulate the country on foot, or sometimes take horseback, spreading out and proceeding in line. The nest is nearly always discovered by the Emus starting up and running directly away swiftly through the bush. Not much time is lost in finding her, or rather his, starting-point, and there is revealed a solid oval of large and beautiful dark-green eggs, side by side, touching or nearly so, with all their long diameters running in the one direction, or with the long way of the oval. If the eggs be warm, either one or other of their ends feels cold to the touch. I suppose embryologists can assign a reason for this.

The hunters tell me that occasionally, on going through country quietly and coming suddenly upon a sitting bird, he will extend his neck out upon the ground as if to escape observation before being forced to run. In one particular instance an old bird sat so closely to his charge that he had to be removed with the aid of a stick. The clutch (14 eggs) was nearly hatched, which accounted, no doubt, for the poor bird's unwillingness to quit.

The eggs gathered are placed down the legs of old pants, in arms of singlets, or rolled in cravats, the division between each egg being tied tightly with string, the garments when charged resembling so many strings of great squat-shaped sausages. These rings of eggs are now carried round the hunter, over his shoulder and under the opposite arm. The next ring is balanced *vice versa;* and should the clutches be large in number and weighty, a third ring in the shape of a collar is placed round the horse's neck.

The following is the data of some of the nests I examined on the spot:—

1. 10th June 1895. Nest placed among dry herbage about a foot high (chiefly *Calocephalus*), 3 feet from the base of two small trees (one dead). Herbage plucked from round about, mixed with a few of the bird's own feathers, and formed into a bed about 4 feet in diameter. Eggs 8 in number.

2. Nest situated 6 feet from base of medium-sized dead tree. Seemed to be a good layer of dry *Calocephalus* tramped down into the form of an oval bed, 4 feet long by 2½ feet broad. Eggs 8.

3. 11th June. Nest situated 4 feet from base of tree in a comparatively open locality, composed of bark, grass, and herbage, evidently gathered or plucked from close round about by the sitting bird, there being a clear space or ring 1½ foot broad surrounding the bed, which was oval in shape, 4 feet by 2½ feet in dimension. Eggs 8. Sitting bird, after being flushed, was unhappily run down by the dogs. On dissection it proved to be a male.

4. 12th June. Nest in a slight hollow in a patch of herbage, chiefly cane-grass, locally so called, in open timber. As usual the grass was cleared up well immediately round about and formed into a good bed, 5 feet long by 3 feet broad, and about 2 inches in thickness. Eggs again 8. This nest, from which I flushed the bird, was only 50 yards from a frequently used buggy track.

5. Nest placed under small dead tree, with some sprouting saplings from base. Bed formed of dead leaves (*Eucalyptus*) and grass in addition to a few of the bird's feathers, but chiefly the *Eucalyptus* leaves evidently plucked from the branchlets above. Eggs 8, and 1 fractured shell. This nest was picturesquely situated, being protected in front by dead branches, and made a splendid photograph.

6. 13th June. Nest found about 50 paces from a wire boundary fence, and under a small tree with branching suckers from base, surrounded with a few large fallen sticks;

altogether with the beautiful green eggs forming a pretty picture. There was the usual amount of bedding for the eggs, which were an uncompleted clutch of 6. The bird was not sitting, but was seen loitering not far distant. In the uncertain light (it being sundown) the bird appeared to be the female.

As I was sure the eggs in the last-mentioned clutch were perfectly fresh, I brought one full to my home in Melbourne. It weighed 1 lb. 7½ oz. (a weight about equal to a dozen ordinary domestic fowl's eggs), the shell weighing 3 oz., leaving a nett result of 20½ oz. This quite filled a medium-sized frying-pan, making a substantial breakfast for a family. Contrary to expectation, the flavour was, if anything, milder than that of the domestic fowl's which was cooked afterwards in the same pan for comparison; therefore some palates may consider the Emu's eggs tasteless, but we proved it a delicacy. Moreover, the appearance when cooked was clean and tempting; the yolk was light yellow; the albumen firm but semi-transparent, not an opaque white, when cooked, like an ordinary fowl's egg, nor so glutinous as a Mutton-bird's (Petrel) or other sea-fowl's. To boil an Emu's egg, I believe, takes about twenty minutes.

The aboriginals cook Emu's eggs by boring a small hole at one end, and violently shaking the contents into the hot ashes of their camp fire; every few minutes the shaking is renewed, while the whole mess is turned repeatedly until properly cooked.

While mentioning about aboriginals, they only appreciate Emu's flesh, although sometimes white men use the oil. The aboriginals stalk and spear the bird by stealth, but like better to wait at a water-hole where birds come to drink. When the Emu is on his hunkers at the water's brink, the dusky hunter in ambush drops a tomahawk or spear upon the unsuspecting bird. In parts of Central Australia the natives taint the water with a weed of narcotic propensities, thus stupefying the birds that drink. On this subject Professor Baldwin Spencer remarks:—"Attention is drawn to the curious use which the natives make of some plants, such as pituri. In certain parts of Central Australia, as, for example, to the south of Lake Amadeus, a decoction is made of the leaves of the plant, which is found growing amongst the sandhills, and the liquid is placed where the Emu can drink it, the result being that the bird is stupefied, and falls an easy prey to the spear of the native.

To show how prolific Emus are still in some parts of Australia, likewise to demonstrate how flagrantly the "Game Act" is broken, during the season 1894, according to a Sydney newspaper, a boundary rider in Queensland sold in or sent to that city 1123 Emu eggs, which realised 12s. per dozen, or a total value amounting to more than his wages for the year.

With reference to the question whether Emus swim or not, Mr Geo. F. Armitage (Mildura) thoughtfully sent the following note:—"On Christmas 1893 I was travelling to Swan Hill from Mildura in the steamer 'Ellen,' when, rounding a bend of the river, I was astonished to see, about 100 yards ahead, a small flock of five Emus just taking the water (from the Victorian side). They either did not see the boat, or were oblivious of danger, for they swam on in order to reach the opposite bank, and although the boat dashed right into the midst of them, scattering some to one side, and some to the other, so that they became perfectly deluged with water, they soon righted themselves, and reached the shore in safety, where they rejoined their companions who, apparently, had previously crossed."

I alluded to the extinct species of Emus that formerly inhabited Tasmania and Kangaroo Island. That of the former place may have been the same, but most probably differed from the mainland species; but the following interesting note, received from Professor Newton (Cambridge), 1894, shows that the Kangaroo Island form was distinct:— "It may interest you to learn (if you are not aware of it) that MM. Milne-Edwards and Oustalet have recently published a memoir showing that the *Dromaius ater* of Vieillot was a good species, distinct from *D. novæ-hollandiæ* (the Emu) and also the *D. irroratus* (Spotted Emu). It seems to have been peculiar to Kangaroo Island, where, I daresay, it has been long ago extirpated. The French expedition under Baudin found it there in 1803, and brought away three living birds, which survived at Paris for several years, and a skeleton and stuffed skin are in the museum there. It might be worth while now to look for bones on the island. I have long suspected that this species was distinct, but several people whom I asked about it declare that it was not. It was very much smaller than the common Emu, and darker in colour."

I shall conclude my observations on the Emu with a pretty scene I witnessed in Riverina one balmy day in September. After a tedious plodding with a buggy and pair through flooded lignum country, we emerged on a grassy rise where we noticed Emus gamboling—running sideways, kicking, etc. Seeing they were hemmed in by water on one side, and by a fence on the other side, we put the horses hard to their collars, and are soon galloping amongst a splendid flock of twenty-eight birds, some being remarkably large and dark. At the imminent risk of our flying vehicle colliding with tree-stumps and fallen logs, we enjoy a merry spin with the fleet-footed birds. How graceful is their high-stepping action! We can hear the peculiar rustling noise of the feathers caused by the birds in rapid motion. When a bird puts on a spurt, or goes at top speed, it carries its body together with neck extended at an angle of about 45° with the plain. Of course the fine birds soon distance us by making "tracks," amid wreaths of water spray, through a flooded shallow, while we wheel and continue our own track.

DROMAIUS IRRORATUS, Bartlett.

(Spotted Emu.)

Figure.—Sclater, Trans. Zool. Soc., iv., pl. 76 (1862).
Previous Descriptions of Eggs.—Campbell, Victorian Naturalist (1888); North, Cat. Bds. Aust. Mus. (1889).

Geographical Distribution.—Northern Territory (probably), West and North-West Australia, interior of South Australia, and Victoria (accidental).

Nest.—Similar to that of the common Emu (*D. novæ-hollandiæ*), being a flat bed of herbage upon the ground.

Eggs.—Clutch, average 8-10. As in the other variety, a maximum of 18 has been reported. Of the usual elliptical form, both ends being alike in shape, superficially in appearance like shagreen or rough American cloth; general colour of a beautiful dark green, but if examined closely only the raised or rough particles or granulations of the shell will be found to be dark green, and which, at certain angles of light, are polished and assume a very dark indigo colour, while the interstices are of a light green. In general appearance the eggs resemble those of the common Emu. Dimensions in inches of a proper clutch:—(1) 5·25 × 3·68; (2) 5·25 × 3·62; (3) 5·18 × 3·62; (4) 5·18 × 3·62; (5) 5·06 × 3·56; (6) 5·0 × 3·62; (7) 5·0 × 3·62.

Observations.—Whether the Spotted Emu is a distinct or good species I am hardly prepared to state. However, during my visit to Western Australia I gathered what information I could referring to the Emus, and although the common bird certainly inhabits that territory, there appears to exist a spotted variety also, which exhibits a preference, so it is reported, to the "silver" grass country of the interior, and possibly extending its range to the north-west. That it also wanders far eastward is known by the fact that a specimen of the Spotted Emu taken in Victoria is in the National Museum, Melbourne.

The two species, as contrasted in Gould, represent the feathers of the spotted variety as being barred or spotted alternately with dull white and grey, with a marginal tip of black, whereas the feathers of the common variety are grey only, tipped with black. The general appearance of the whole coat of the spotted bird is frequently of a decided brownish tinge. This I observed in skins I saw used as mats in some of the dwellings of the West Australians.

On my return home from Western Australia, Captain Thomas W. Smith, of the Government schooner "Meda," had thoughtfully forwarded a young Emu which was taken in the north-west. The bird remained on my premises until it grew out of all proportion to the size of its quarters, therefore was transferred to the Zoological Gardens, where it developed into a splendid male bird, with more of a reddish tinge about his coat, while the feathers are sooty grey (not pale grey), and darker down the centre, compared with the eastern birds in the same enclosure. He mated with an eastern bird. Result, a maximum clutch of 18 eggs, which unfortunately were deserted after the male had incubated them about fourteen days.

It was particularly fond of the children. When they romped the bird would do so too, racing round the yard and gamboling about, occasionally "planting," with its neck outstretched along the ground, as if hiding. The bird would devour almost anything. One day a pedlar called, was wroth because his basket of wares was not patronised, and while holding forth as to the iniquitous conduct of the householder, "Spottie," as we called the Emu, because his juvenile plumage was decidedly spotted, stole up quietly from behind, and commenced throwing thimbles and trinkets of trifling value down his throat.

I found some confusion of dates existed among West Australians as to when the Emu lays there, some saying autumn or winter, others affirming positively that spring is the time. Probably all are right, as the breeding season is greatly affected by the seasons of rain. The following notes are culled from Mr Tom Carter's letters to me. During a season of distressing drought in 1891, he writes from Point Cloates:—"Shot an Emu (female) in very poor condition. Doubtless hard up for water, the nearest known pool being 40 miles distant, and I do not know if that be dry too. The natives say the Emus drink the sea. A shepherd killed one on the beach a short time ago." Again: "Emus are drinking salt-water and dying in numbers."

Another season, Mr Carter writes under various dates:—"March 20. Shot female with large clutch of eggs within her."

"Minilga, May 18. Emu eggs brought in by natives."

"Gascogyne, May 25. Five eggs (Emu) seen in nest."

Mr Douglas Cadden, who kindly forwarded me, in 1886, a fine clutch of 7 eggs of the Spotted Emu from the Murchison district, says the birds usually lay there about May and June; while in the south-west, Mr A. J. Bussell (Wallcliff) writes: "Emus lay according to the season, but never earlier than the middle of June, or later than middle of August."

In 1889, when I visited Western Australia, young Emus about a week old were observed on the last day of October by an employé of Wallcliff. In that case the eggs would have been laid towards the end of August.

CASUARIUS AUSTRALIS, Wall.

(Australian Cassowary.)

Figure.—Gould, Birds of Australia, fol., suppl., pls. 70 and 71.

Previous Descriptions of Eggs.—Ramsay, Proc. Zool. Soc., p. 119 (1876); Campbell, Victorian Naturalist (1886).

Geographical Distribution.—North Queensland.

Nest.—A bed of sticks, leaves, and such-like vegetable débris, usually placed near the base of a large tree in dense scrub.

Eggs.—Clutch 4 to 6; some authorities state 3 to 5; of a graceful elliptical form, and superficially like shagreen or rough American cloth, but not so rough or granulated as the Emu's (*Dromaius*) egg. General appearance in colour, beautiful light pea-green, but if examined vertically the raised rough particles only of the shell will be found to be green, while the minute interstices are greenish-white. Dimensions in inches:—(1) 5·56 × 3·75; (2) 5·43 × 3·81; (3) 5·43 × 3·62.

Observations.—The eggs of the Cassowary are especially interesting, not only for their great beauty, but for being the largest and amongst the rarest of Australian eggs. The splendid birds themselves possess a limited habitat, being confined to a narrow strip of coastal scrub country, about 300 miles in length, in Northern Queensland, the southern boundary being the Herbert River (where the birds are now almost unknown), the northern limit being the Cooktown district in York Peninsula.

On account of the Cassowary's naturally restricted area being taken up by planters and others, the noble bird should be rigorously protected, or it will as surely soon become extinct as the Emus of Tasmania and Kangaroo Island. It has been suggested that the large scrub-clad island of Hinchinbrook, adjacent to the mainland, be a reserve for the perpetual protection of Cassowaries. A more suitable place for the purpose could not well be found.

Really little is yet known of the habits of the Cassowary—a great bird full of speculative interest to naturalists, inasmuch as it is supposed to be one of the living representatives, or, perhaps, the surviving contemporary of such large extinct birds as the Moas of New Zealand. The Australian Cassowary was first discovered by the late Thomas Wall, naturalist to the expedition commanded by the ill-fated explorer Kennedy, and was described as *Casuarius australis* in the *Sydney Morning Herald,* 3rd June 1854. The second specimen was shot, September 1866, by Mr R. Johnson, Inspector of Police—now Police Magistrate, Queensland. The bird is still called in some parts of that colony Johnson's Cassowary.

Dr E. P. Ramsay, in the *Proceedings of the Zoological Society* for 1876, furnishes an exceedingly interesting account of the Cassowary.

I fully concur with Dr Ramsay's remarks about the wariness and shyness of the Cassowary, and repeated his experience by returning without a specimen, although my companions and myself endeavoured persistently to obtain a bird in the flesh, which we wanted for a museum. Once we divided our party for a week—two proceeding 20 miles in one direction, and two a like distance in an opposite direction. Frequently we noticed the bird's fresh tracks by the banks of streams, but at the end of our appointed time we returned to our starting-point (camp) without "yun-gun," as the aboriginals call the Cassowary, or in pigeon-English, "big-fellow chookie-chookie."

A considerate selector (*i.e.,* a person who selects and dwells upon the land under Government regulations), hoping to do us a service, brought us a mangled skin, which had every appearance of having been skinned with his axe.

It is difficult to understand how such a bulky bird as the

Cassowary can push its way through the entanglement of vines, canes, and creepers in such a rapid, free, and easy manner as it is credited with. To aid the bird in so quickly threading the scrub when pursued, no doubt its sloping horny helmet, and the long quills of the spurious wings, play an important part.

I had the opportunity of viewing a handsome pair of full-grown Cassowaries, the property of Mr B. Gulliver, at Acacia-Vale Nurseries, Townsville (Queensland). They were beautiful creatures in their jet-black, hair-like coats, shorter in build, and with much more powerful legs than the Emu. The head and neck were destitute of feathers, but covered with a beautiful blue and pink skin, there being also two small pinkish lobes of wattle hanging from the breast or neck. The birds stood about 4 feet high, but when fully erect were a foot higher. Their horny helmets should have been about 6 inches in length, but these headpieces had been considerably battered down in various duels, for both birds were males. To fight one another they have been observed to clear at a single bound a dividing fence 7 or 8 feet high. They were fed almost entirely on the fruit of the papaw-tree (*Carica papaya*), cut up into morsels about an inch or so square, which are taken between the points of the mandibles, and by a graceful uplifting of the head jerked into the gullet. When a bird is scared or alarmed it makes a most peculiar ventriloqual sound, repeated five or six times. To produce this noise the bird is seemingly put to an immense effort. It doubles its head downwards, placing its skin close to its neck, all the back and rear feathers being erected, while, with spasmodic jerks, it pumps, so to speak, a sound resembling distant thunder. Mr B. Gulliver captured these Cassowaries when young in the Cairns district in October 1883.

The handsome pair of eggs which I described in 1886 were from the collection of Dr T. P. Lucas. The following year Mr Joseph Barker, in my interest, annexed from the natives (aborigines), just as they were about to cook and eat them, two specimens, fresh and beautiful. The eggs, which were found in the Cardwell district 3rd October, reached my collection safely. Mr Barker, who is a keen field observer, happened to be at Oak Hills, in the same district, during one of Mr K. Broadbent's (the able collector attached to the Queensland Museum) visits. I understand together they found a Cassowary's nest in September 1886 containing 3 fresh eggs. The nesting place was merely a hollow on a dry, stony ridge in the centre of a dense scrub.

Mr Lumholtz, in his fascinating book "Among Cannibals," referring to the Cassowary under date 6th October (1882), says:—"Natives brought me 2 eggs and a young bird just hatched. Eggs, 3 in number, are frequently laid at long intervals. In this instance there was the bird just hatched, one egg almost hatched, and another egg the contents of which could easily be blown. Thus we see that the young are not hatched all at one time, and that the female must therefore take care of them while the male bird is sitting."

As in the Emu, so in the Cassowary, upon the male devolves the task of incubating the eggs. The laying season may be said to be from the end of August or the beginning of September to October, and the period of incubation probably seven weeks or over.

I do not recollect ever seeing a published description of the young of *Casuarius australis.* About the end of January 1891 I saw in Melbourne four young Cassowaries (presumably about three or four months old) that were captured in the Johnston district of Northern Queensland. Down the back was a broad, dark stripe, succeeded by two others on either side, then by smaller ones (two or three) more or less indistinct or broken as they approached the stomach, the interstices and stomach being dirty brown or yellowish-white; wattles on face and neck white, and feet also whitish; bill also whitish, but upper mandible bluish-black, with greenish tinge before the eyes. Eyes steel blue, transforming intermittently, in the daylight, into a greenish shade.

XVII. *On* Sigillaria Brardii, *Brongt., and its Variations.* By R. Kidston, F.R.S.E., F.G.S. [Plate VII.]

(Read 15th April 1896.)

The genus *Sigillaria* has usually been divided into three, though sometimes into four groups or sections, according to the value placed on the characters derived from the structure of the bark and the arrangement of the leaf-scars.

I. *Clathraria,* Brongniart. Stem not ribbed. Leaf-scars placed upon more or less prominent contiguous rhomboidal cushions, which are separated from each other on all sides by well-defined furrows.[1] *Type.—Sigillaria Brardii,* Brongt.

II. *Leiodermaria,* Goldenberg. Stem not ribbed. Bark smooth, and generally ornamented with fine irregular longitudinal lines and finer transverse striæ. Leaf-scars distant, not placed on prominent cushions. *Type.—Sigillaria spinulosa,* Germar.

III. *Rhytidolepis,* Sternberg. Stems bearing prominent vertical ribs, on which are placed the more or less distant leaf-scars. *Type.—Sigillaria scutellata,* Brongt.

IV. *Favularia,* Sternberg. This is derived from forms included in Section III. The stem is ribbed, and the leaf-scars are placed close together, separated by transverse furrows, and occupy the greater portion of the rib. The ribs are thus more or less divided into sub-hexagonal areas, the lateral angles of which alternate with those on the neighbouring ribs, and thus impart to the longitudinal furrows a more or less zig-zag course. *Type.—Sigillaria elegans,* Sternb. sp.

The first three sections are those which have been most generally employed.

In 1888 Weiss announced that from the examination of a fine series of specimens from Wettin, it was shown that

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[1] Weiss has substituted the term *Cancellata* for this group. *See* Foss. Flora d. jüngst. Stk. u. d. Rothl., p. 158, 1871.

Sigillaria Brardii, Brongt., passed by gradual transitions into *Sigillaria spinulosa*, Germar, and that this latter plant was therefore only a condition of the former.[1] This discovery showed that at least some of the Clathrarian and Leiodermarian *Sigillariæ* were merely different conditions of the same species. And further, in certain conditions, the leaf-scars of *Sigillaria Brardii* sometimes assume an arrangement having a superficial resemblance to the Favularian group. This is seen to some extent in the upper portion of my Fig. 1.

Shortly after the announcement by Dr Weiss of the identity of *Sigillaria spinulosa*, Germar, with *Sigillaria Brardii*, Brongt., Mons. Zeiller figured several specimens of *Sigillaria Brardii*, one of which showed the organic union of the Clathrarian and Leiodermarian forms on the same specimen,[2] —the upper part of this specimen corresponding absolutely with *Sigillaria Brardii*, Brongt., and the lower portion with *Sigillaria spinulosa*, Germar. It was also further shown that *Sigillaria rhomboidea*, Brongt., only represents an intermediate condition. The specimen which I figure on Plate VII., Fig. 1, shows the union of *Sigillaria Brardii*, Brongt., and *Sigillaria denudata*, Göpp., on the same specimen.

A most elaborate memoir on the Clathrarian *Sigillariæ*, commenced by the late Dr E. Weiss, was issued in 1893 under the joint authorship of Dr E. Weiss and Dr T. Sterzel. It forms part ii. of *Die Sigillarien d. preuss. Steink.-u.-Rothl.-Gebiete.*[3] The accuracy of description, and the correctness and beauty of the plates which accompany the letterpress, make this work of the greatest value to all students of this most difficult class of fossil plants. Whatever opinion one may hold as to the system of nomenclature adopted by these authors in their work, they never leave any doubt as to the form of the plant to which their names and descriptions refer.

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[1] Zeitsch. d. deut. geol. Gesell., 1888, p. 566.

[2] Bull. Soc. géol. d. France, sér. 3, vol. xvii., p. 603, pl. xiv., fig. 1, 1889.

[3] Die Sigillarien der preussischen Steinkohlen-und-Rothliegenden-Gebiete, II. Die Gruppe der sub-Sigillarien, Abhandl. d. König. Preuss. geol. Landesanstalt, Neue Folge, Heft 2, Berlin, 1893, pp. i-xvi, 1-255, with atlas of twenty-eight plates.

Weiss, in recognising the great variability of *Sigillaria Brardii,* and the numerous forms assumed by different portions of the species under varying conditions of growth,—forms to which, in many cases, specific names have been given, and which were supposed to belong to different sections of the genus,—proposes the name of *Sigillaria mutans,* under which he includes *Sigillaria Brardii* with all its forms and varieties. Hence *Sigillaria Brardii,* Brongt., which was originally described as *Clathraria Brardii,* by Brongniart in 1822, and which is the type of this section of *Sigillaria,* is reduced to a *form* of *Sigillaria mutans,* Weiss. In addition to *forms,* these authors name several *varieties* of the forms, which result in such combinations of names as *Sigillaria mutans,* Weiss, forma *Brardii,* Brongt. sp., var. *ottonis,* Göpp. sp.

This system of nomenclature is open to many serious objections.

Notwithstanding the admitted variability of the species, "*Brardii*" was the name originally given to the first described specimen of the plant, and there is no dispute as to the plant Brongniart intended to distinguish by this name, therefore the substitution of the specific name "*mutans*" for "*Brardii*" is inadmissible, and against all laws of priority in nomenclature. The species always has been known, and must continue to be known, as *Sigillaria Brardii,* Brongt., even although the various conditions of *Sigillaria Brardii* vary so considerably, and embrace many forms that were formerly regarded as distinct species, such as *Sigillaria spinulosa,* Germar, *Sigillaria rhomboidea,* Brongt., *Sigillaria denudata,* Göpp., etc. When it is known that these are only different parts and conditions of *one* species, the distinguishing of these and other forms by distinctive names seems to have been carried too far in the work before us. To illustrate what I mean, I may mention the specimen of *Sigillaria Brardii,* Brongt., figured by Zeiller in the *Bull. Soc. géol. d. France,* 3^{e} sér., vol. xvii., pl. xiv., fig. 1, which is given by Weiss and Sterzel as *Sigillaria mutans,* forma *Brardii,* Brongt. sp., var. *typica,* Sterzel[1] (upper portion), while the

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[1] *Loc. cit.*, p. 132.

lower portion of the *same* specimen is described by them as *Sigillaria mutans,* forma *Lardinensis Brardii,* Sterzel.[1] It may be convenient to distinguish some of the chief forms, especially when unattached to typical examples of *Sigillaria Brardii,* by such varietal terms as *forma spinulosa, forma denudata,* etc., but the fewer of such distinctive appellations, the less likely will there be misapprehension as to the value of such names. Students of fossil botany must acquaint themselves with the variations occurring in this plant both in regard to the presence or absence of cushions to the leaf-scars, and in their disposition on the stem; but to distinguish the innumerable forms occurring in *Sigillaria Brardii* by distinctive names can only overload an already too much burdened synonymy. Very few examples of *Sigillaria Brardii* are *similar,* though they are specifically *identical.* I therefore place *Sigillaria mutans,* Weiss, with its numerous named *forms* and *varieties,* among the synonymy of *Sigillaria Brardii,* Brongt.

Under their *Sigillaria mutans,* Weiss and Sterzel describe and figure a great number of forms and varieties, and it is clearly shown that many of the Leiodermarian and Clathrarian *Sigillariæ* are only different conditions of the same plant. It does not, however, follow that all the *Sigillariæ* which have been placed in the *Leiodermariæ* group merely represent certain states of Clathrate species, for, as far as one can see at present, such Leiodermarian species as *Sigillaria camptotænia,* Wood sp., are essentially distinct from those of the other groups.

Weiss suggests that the Leiodermarian forms of *Sigillaria Brardii* (*S. spinulosa, S. denudata,* etc.) may represent the older condition of the plant,—a condition brought about by the increase in girth of the stem and its enveloping bark, which causes the leaf-scars to be drawn apart, and the prominence of the cushion effaced. In some cases this may explain the formation of Leiodermarian conditions, but it is certainly not the cause of all. In the specimen I give on Plate VII., Fig. 1, from Staffordshire, the *Sigillaria denudata* portion is immediately followed by the *Sigillaria Brardii* part.

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[1] *Loc. cit.,* pp. 110, 136.

Here the Leiodermarian condition is not brought about by an increase in girth in the stem, but is evidently produced by a rapid upward growth of the plant which distanced the leaf-scars, and prevented the formation of the "cushions." A similar condition of circumstances is seen occasionally in the *Rhytidolepis* section, and examples of such have been figured by Lesquereux [1] and Zeiller.[2] The approximation of the leaf-scars also usually occurs in the *Rhytidolepis* group in the region of the cone-scars, caused evidently by the drain on the resources of the plant in supporting the fructification.

In the various forms of *Sigillaria Brardii*, the form of the leaf-scar varies very little.

The description of *Sigillaria mutans*, as given by Weiss and Sterzel, is partly adopted here in my description of *Sigillaria Brardii*, with which it is synonymous.

SIGILLARIA BRARDII, Brongniart.

[Plate VII., Figs. 1 and 2.]

1822.	*Clathraria Brardii,*	Brongt., Class. d. végét. foss., p. 22, pl. i., fig. 5 (in Mém. du Mus. d'hist. nat., vol. viii.).
1828.	*Sigillaria Brardii,*	Brongt., Prodrome, p. 65.
1836.	,, ,,	Brongt., Hist. d. végét. foss., p. 430, pl. clviii., fig. 4.
1845.	,, ,,	Germar, Vers. d. Steink. v. Wettin u. Löbejun., Heft. iii., p. 29, pl. xi., figs. 1 and 2.
1857.	,, ,,	Goldenberg, Flora Saræp. foss., Heft. ii., p. 25, pl. vii., figs. 7, 8 (? fig. 10).
1870.	,, ,,	Schimper, Traité d. paléont. végét., vol. ii., p. 102, pl. lxvii., figs. 10, 11.
1871.	,, ,,	Weiss, Fossile Flora d. jüngst. Stk. u. Rothl., Heft ii., p. 161, pls. xvi., fig. 1; xvii., figs. 7-9 (includes vars. *subquadrata* and *transversa*).
1880.	,, ,,	Zeiller, Végét. foss. terr. houil. de la France, p. 135, pl. clxxiv., fig. 1.
1881.	,, ,,	Renault, Cours d. botan. foss., vol. i., p. 129, pl. xvii., fig. 1.

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[1] *Sigillaria mammilaris*, Lx., Coal Flora, vol. iii., pl. cviii., 1884.

[2] *Sigillaria sauveuri*, Zeiller, Flore foss. Bassin houil. d. Valen., pl. lxxxiv., fig. 1, 1886. I possess a specimen of this plant from Staffordshire, showing a similar condition.

1881.	*Sigillaria Brardii,*	Feistmantel, Der Hangendflötzzug im Schlan-Rakonitzer Steink., p. 88, pl. v., figs. 1, 1*a*, and 2 (in Archiv. d. naturwiss. Landes. v. Böhmen, iv. Band, No. 6, Geol. Abth.).
1882.	,, ,,	Weiss, Aus d. Steinkohlenformation, 2nd ed., p. 7, fig. 22 (*not* fig. 21).
1888.	,, ,,	Weiss, Zeitsch. d. deut. geol. Gesell., p. 569, fig. 4.
1889.	,, ,,	Zeiller, Sur les variations de formes du *Sigillaria Brardi*, Brongt., Bull. Soc. Géol. d. France, 3^{e} sér., vol. xvii., p. 603, pl. xiv.
,,	,, ,,	Weiss, Zeitsch. d. deut. geol. Gesell., p. 376 (May).
1890.	,, ,,	Renault, Flore foss. Terr. houil. de Comentry, part ii., p. 539, pl. lxiii., fig. 1.
,,	,, ,,	Grand' Eury, Géol. et paléont. du Bassin houil. du Gard., p. 250, pl. xi., fig. 1 (? figs. 2, 3, 4).
1892.	,, ,,	Zeiller, Flore foss. Bassin houil. et perm de Brive, p. 83, pl. xiv., fig. 1.
1893.	,, ,,	Potonié, Flora d. Rothl. v. Thuringen, p. 190, pl. xxvii., fig. 2 (? fig. 1).
1826.	*Favularia Brardi,*	Sternb., Flore monde prim., fasc. iv., p. xiv.
1836.	*Sigillaria rhomboidea,*	Brongt., Hist. d. végét. foss., p. 425, pl. clvii., fig. 4.
1857.	,, ,,	Goldenberg, Flora Saræp. foss., Heft. ii., p. 22, pl. vi., fig. 6.
1880.	,, ,,	Zeiller, Végét. foss. d. terr. houil., p. 137, pl. clxxiv., fig. 2.
1836.	*Sigillaria Menardi,*	Brongt. (*in part*), Hist. d. végét. foss., p. 430, pl. clviii., fig. 6 (*not* fig. 5).
1857.	,, ,,	Goldenberg (*in part*), Flora Saræp. foss., Heft. ii., p. 24, pl. vii., fig. 2.
1870.	,, ,,	Schimper (*in part*), Traité d. paléont. végét., vol. ii., p. 103.
1885.	,, ,,	Renault, Comptes rendus, 7th Dec. 1885.
1886.	,, ,,	Weiss, Sitz. Bericht d. Gesell. naturforschender Freunde zu Berlin, No. 2, p. 8, woodcut 2.
1839.	*Sigillaria elegans,*	Brongt. (*not* of the Hist. d. végét. foss.), Observations sur la structure intérieure du *Sigillaria elegans* comparée à celle des Lepidodendron et de *Stigmaria* et à celle des végétaux vivants, Arch. du Museum d'hist. nat., vol. i., p. 405, pls. xxv.-xxviii.
1845.	,, ,,	Corda (*in part*), Flora d. Vorwelt, p. 24, pls. vii., viii. (not pl. ix., fig. 18).
1855.	,, ,,	Goldenberg, Flora Saræp. foss., Heft. i., p. 26; Heft. ii., p. 55, pl. v., figs. 6-13.
1881.	,, ,,	Renault, Cours d. botan. foss., 1 Année, p. 143, pl. xviii., figs. 7-10.
1885.	,, ,,	Renault, Comptes rendus, 7 Dec. 1885.
1886.	,, cf. *elegans,*	Weiss, Sitz.-Bericht d. Gesell. naturforschender Freunde zu Berlin, No. 2, p. 8, woodcut 1.

1848. *Sigillaria spinulosa,* Germar, Vers. d. Steink. v. Wettin u. Löbejun., Heft. v., p. 58, pl. xxv., figs. 1, 2.
1857. ,, ,, Goldenberg, Flora Saræp. foss., Heft. ii., p. 20, pl. x., fig. 5.
1870. ,, ,, Schimper, Traité d. paléont. végét., vol. ii., p. 120, pl. lxvii. fig. 12.
1875. ,, ,, Renault and Grand' Eury, Études sur le *Sigillaria spinulosa,* Mém. Acad. d. Sciences d. l'institute nat. de France, vol. xxii., No. 9, pl. i., figs. 2, 3.
1881. ,, ,, Renault, Cours d. botan. foss., vol. i., p. 130, pl. xvii., fig. 2.
1889. ,, ,, Weiss, Zeitsch. d. deut. geol. Gesell., p. 376 (May).
1864. *Sigillaria denudata,* Göppert, Foss. Flora d. Perm. Form, p. 200, pl. xxxiv., fig. 1.
1871. ,, ,, Weiss, Foss. Flora d. jüngst. Stk. u. Rothl., p. 159, pl. xvi., fig. 3.
1881. ,, ,, Feistmantel, Der Hangendflötzzug im Schlan-Rakonitzer Steink., p. 86, pl. v., figs. 3, 3*a*.
1882. ,, ,, Weiss, Aus der Steinkohlenformation, 2nd ed., p. 7, pl. iii., fig. 23.
1888. *Sigillaria Wettinensis,* Weiss, Zeitsch. d. deut. geol. Gesell., p. 569, fig. 3.
1893. *Sigillaria mutans,* Weiss, in Weiss and Sterzel, Die Sigillarien d. preuss. Steink.-u.-Rothl.-Gebiete (Abhandl. d. k. preuss. geol. Landesanstalt, Neue Folge, Heft. ii.), p. 88.

A. Leiodermarian Forms.

1893. *Sigillaria mutans,* Weiss, forma *denudata,* Göpp. sp., Weiss and Sterzel, *ibid.*, p. 92, pl. viii., fig. 39.
,, ,, ,, forma *denudata β,* var. *carbonica,* Sterzel, *ibid.*, p. 94.
,, ,, ,, forma *rectestriata,* Weiss, *ibid.*, p. 94, pl. ix., fig. 42.
,, ,, ,, forma *subrectestriata,* W. and Sterzel, *ibid.*, p. 96, pl. ix., figs. 44, 45.
,, ,, ,, forma *epulvinata,* Sterzel, *ibid.*, p. 97.
,, ,, ,, forma *subcurvistriata,* Weiss, *ibid.*, p. 98, pl. ix., fig. 43.
,, ,, ,, forma *undulata,* Weiss, *ibid.*, p. 100, pl. ix., fig. 46.
,, ,, ,, forma *latareolata,* Sterzel, *ibid.*, p. 102, woodcut 3.
,, ,, ,, forma *subspinulosa,* W. and Sterzel, *ibid.*, p. 105, pl. ix., figs. 51, 52.
,, ,, ,, forma *spinulosa,* W. and Sterzel, *ibid.*, p. 106, pls. x., fig. 50; xi., fig. 50A; x., fig. 47.
,, ,, ,, forma *Wettinensis-spinulosa,* W. and Sterzel, *ibid.*, pp. 108, 127.
,, ,, ,, forma *Lardinensis-Brardi,* Sterzel, *ibid.*, p. 110.
,, ,, ,, forma *pseudo-rhomboidea,* W. and Sterzel, *ibid.*, p. 112, pl. x., fig. 48.
,, ,, ,, forma *radicans,* Weiss, *ibid.*, p. 114, pl. x., fig. 49; pl. xi. fig. 49A, 49B.
,, ,, ,, forma *laciniata,* Weiss and Sterzel, *ibid.*, p. 116, pl. xi., fig. 53.

B. Sub-Leiodermarian or Sub-Clathrarian Forms.

1893. *Sigillaria mutans,* W., forma *rhomboidea,* Brongt. sp., W. and S., *ibid.,* p. 117.
,, ,, ,, forma *subrhomboidea,* W. and Sterzel, *ibid.,* p. 118, pl. xii., fig. 54.
,, ,, ,, forma *subleiodermaria,* W. and Sterzel, *idid.,* p. 120, pl. xix., fig. 72.

C. Clathrarian Forms.

1893. *Sigillaria mutans,* W., forma *Wettinensis,* Weiss, *ibid.,* p. 122, pls. viii., fig. 55*a*; xii., figs. 55, 56; xiii., figs. 57, 58.
,, ,, ,, forma *cancellata,* Weiss, *ibid.,* p. 128, pl. xv., fig. 62.
,, ,, ,, forma *urceolata,* W. and Sterzel, *ibid.,* p. 130, pl. xiv., fig. 59.
,, ,, ,, forma *Brardi,* W. and Sterzel, *ibid.,* p. 131.
,, ,, ,, forma *Brardi,* var. *typica,* Sterzel, *ibid.,* p. 133, pl. xv., fig. 60; pl. xx., fig. 82 (var. *ottendorfensis,* Sterzel on explanation to plate).
,, ,, ,, forma *Brardi,* var. *ottonis,* W. and Sterzel, *ibid.,* p. 138, pl. xvi., fig. 65.
,, ,, ,, forma *Brardi,* var. *sublaevis,* Sterzel, *ibid.,* p. 142, pl. xvi., fig. 63.
,, ,, ,, forma *Brardi,* var. *puncticulata,* Sterzel, *ibid.,* p. 143, pl. xvii., fig. 67.
,, ,, ,, forma *Brardi,* var. *ottendorfensis,* Sterzel, *ibid.,* p. 143, pl. xx., fig. 77.
,, ,, ,, forma *Brardi,* var. *Germari-variens,* Sterzel, *ibid.,* p. 145, pl. xv., fig. 61; pl. xvii., fig. 66.
,, ,, ,, forma *Brardi,* var. *subcancellata,* W. and Sterzel, *ibid.,* p. 154, pl. xix., fig. 73 (? pl. xxi. fig. 84).
,, ,, ,, forma *Menardi,* W. and Sterzel, *ibid.,* p. 156.
,, ,, ,, forma *Menardi,* var. *sub-Brardi,* Sterzel, *ibid.,* p. 158.
,, ,, ,, forma *Menardi,* var. *Autunensis,* Sterzel, *ibid.,* p. 159.
,, ,, ,, forma *Menardi,* var. *varians,* Sterzel, *ibid.,* p. 160, pl. xviii., figs. 68, 69, 71.
,, ,, ,, forma *Menardi,* var. *subquadrata,* Weiss, *ibid.,* p. 163, pl. xix., fig. 74.
,, ,, ,, forma *Menardi,* var. *Alsenziensis,* Sterzel, *ibid.,* p. 164, pl. xx., fig. 78.
,, ,, ,, forma *Menardi,* var. *minima,* Sterzel, *ibid.,* p. 165, pl. xx., fig. 80.
,, ,, ,, forma *favulina,* Weiss, *ibid.,* p. 168, pl. xviii., fig. 70.
,, ,, ,, forma *Heeri,* Sterzel, *ibid.,* p. 170, pl. xix., fig. 75.

1893. *Sigillaria ambigua,* Weiss and Sterzel, *ibid.*, p. 172, pl. xx., fig. 79.
1888. *Sigillaria,* Weiss, Zeitsch. d. deut. geol. Gesell., p. 568, figs. 1, 2.
1836. *Lepidodendron Ottonis,* Gopp., Syst. fil. foss., p. 462, pl. xlii. figs. 2, 3.
1860. *Lepidodendron sexangulare,* Eichw. (*not* Göpp.), Lethæa Rossica, vol. i., p. 114, pl. v., fig. 8 (? fig. 9).
1838. (?) *Aspidiaria Schlotheimiana,* Presl. in Sternb., Vers., ii., p. 181, pl. lviii., fig. 10 (excl. refs.).

Description.—Leaf-scar rhomboidal, as long as broad, but often broader than long; upper margin rounded, flattened, or notched, lower margin rounded, sides generally convex with sharp lateral angles. Cicatricules three, placed slightly above the centre of the leaf-scar, the central cicatricule transversely linear, generally concave, the two lateral oblique, frequently lunate, embracing the central cicatricule; above the leaf-scar there is frequently a small circular cicatricule.

Leaf-cushion. A definite limit of the cushion often absent (*Leiodermaria*), occasionally incomplete (*sub-Leiodermaria* or *sub-Cancellata*), or distinct (*Clathraria* or *Cancellata*). Leaf-cushion, when present, more or less elevated, generally rounded above and below, or subquadrate or spathulate with truncated base, and generally without any surface ornamentation. Leaf-scar usually on the upper portion of the cushion, central only in the young condition.

Cortex. On the Leiodermarian or sub-Leiodermarian forms, the outer surface of the bark, between the leaf-scars, is generally ornamented with a shagreen-like sculpturing of fine longitudinal ridges and delicate transverse striæ. The longitudinal lines are longer and coarser than the fine transverse striæ; under the leaf-scar the bark is frequently smooth,—above the leaf-scar it is generally smooth.

Immediately beneath the leaf-scar on certain Leiodermarian forms there sometimes occur one or two small circular scars.

Cortex thin—decorticated stem longitudinally striated.

The *cone-scars* form an irregular girdle round the stem. They are small, circular, oval, or subtriangular, and in the Clathrarian forms are placed on small cushions inserted between the leaf-scars, which, like the cone-scars, are usually more or less deformed by mutual pressure. In the Leiodermarian forms they possess no cushion, and are circular from the absence of all pressure.

Remarks.—Following Weiss and Sterzel in tracing the changes which take place in the external appearance of the bark of *Sigillaria Brardii*, Brongt., we may commence with those Leiodermarian forms which have been described as *Sigillaria spinulosa*, Germar, and *Sigillaria denudata*, Göpp., on which the leaf-scars are distinct, show no trace of a leaf-cushion, and whose bark is ornamented with the peculiar shagreen sculpturing already described. It is not necessary to consider at present whether these forms arise from a rapid growth of the stem in the young state, or by increase in girth of the trunk at a subsequent period.[1]

The next stage is that in which there are indications of a leaf-cushion, and such forms are described as *sub-Leiodermaria* or *sub-Clathraria*. To these corresponds the *Sigillaria rhomboidea*, Brongt. Here, also, the bark is usually ornamented with the shagreen sculpture.

In the succeeding progressive form the leaf-scar is placed on the upper part of a distinct and more or less elevated subspathulate cushion, whose upper margin is convex, the lateral concave, and the lower margin truncate. The plant has now assumed the Clathrarian form, and the shagreen ornamentation of the bark becomes less frequent. Of this type is the *Sigillaria Wettinensis*, Weiss.

In the last form, the distinct contiguous rhomboidal leaf-cushions are separated by well-defined dividing furrows. On the smaller branches the leaf-cushions are frequently transversely rhomboidal. The cushions are generally smooth and free from ornamentation. The *Sigillaria Brardii*, Brongt., corresponds with this condition of the plant.

The sequence of change just described is well seen on the small stem from the railway cutting at Florence Colliery, Longton, Staffordshire, which is shown natural size on Plate VII., Fig. 1. Commencing, however, in the reverse order to that given while tracing the variations through which

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[1] It should be remembered, however, that such Leiodermarian forms occur inserted between Clathrarian portions of the stem.

Sigillaria Brardii passes, we find on the upper portion of this example the typical form of *Sigillaria Brardii,* as figured by Brongniart in 1822 under the name of *Clathraria Brardii,* and which was subsequently reproduced in the "Histoire" under the name of *Sigillaria Brardii.* The leaf-cushion is elevated, transversely rhomboidal, the upper and lower margin rounded or slightly flattened, and the lateral angles are produced with a sharp point. Its surface bears a few irregular longitudinal lines. Somewhat near its upper margin is placed the rhomboidal leaf-scar, whose upper margin has a distinct notch with slightly convex sides; the lower margin is rounded, with concave sides; the lateral angles are prominent; cicatricules three, the central transversely elongate, and placed slightly above the middle of the scar, the two lateral, lunate, oblique (Fig. 1*a*).

Passing farther down the stem a very short space, the leaf-scars assume the condition of the *Sigillaria rhomboidea,* Brongt. (Fig. 1*b*). Here the cushion has no appreciable elevation, still its presence is indicated by a transverse furrow above the leaf-scar, from the extremities of which lines extend dividing the bark into faint hexagonal areas, somewhere in the upper portion of which is placed the leaf-scar. The surface of the bark in this form possesses the shagreen ornamentation, which is less pronounced in the neighbourhood of the leaf-scar. The lateral angles of the leaf-scar are slightly less prominent than in Fig. 1*a.*

The last form to which it is necessary to refer on this specimen is shown at Fig. 1*c.* Here all trace or indication of the leaf-cushion has disappeared, and the true Leiodermarian form of the plant is assumed, with the characteristic shagreen marking of the outer surface of the bark. This part of the specimen is the *Sigillaria denudata,* Göppert.[1]

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[1] Sterzel separates the Rothliegendes "*denudata*" from the Carboniferous "*denudata,*" which latter he distinguishes as var. *carbonica,* as there has been, according to this writer, no true *S. Brardii* found in the Permian. This does not appear to be sufficient reason for separating specimens which are otherwise the same. *S. Brardii* has, however, been figured from the Rothliegenden of Thuringia by Potonié.

Figure 2, Plate VII., shows the normal form of *Sigillaria Brardii,* and towards the base of this example portions of a verticel of cone-scars is seen. These form an irregular girdle round the stem. They are inserted without order between the leaf-cushions, which are generally, along with the leaf-scars, much deformed. The cone-scars vary much in contour. A small portion of the stem showing them, is enlarged at Fig. 2*b*. These little cone-scars are placed on cushions like the leaf-scars, and are formed of a circular or subtriangular ring, inside of which is a smaller circular ring. This latter probably represents the cicatrice of the vascular bundle.

One of the chief distinguishing characters of *Sigillaria spinulosa*, Germar, is the presence on the bark, generally immediately below the leaf-scar, of one or two small circular stigmaria-like scars. These were supposed by Germar to be the scars of deciduous spines, but Schimper and Renault think they are more probably the scars of ærial rootlets. Owing to all absence of lateral pressure, these little scars on *Sigillaria spinulosa* are always circular; but on the *Sigillaria Brardii* form of the plant these scars, being subject to the pressure of the leaf-cushions, are more or less irregular in outline. It appears to me from the specimens figured and described by Zeiller,[1] Renault,[2] and others, and by that given here on Plate VII., Fig. 2, that these little scars undoubtedly mark the point from which cones—and most probably stalked cones—have fallen.

Renault,[3] in describing a specimen of *Sigillaria Brardii,* to the cone-scars of which were still attached fragments of small branches 1 to 2 cm. long and 5 mm. in diameter, states that these spring perpendicularly from the stem, and bear small foliar cicatrices which are distant from each other instead of being contiguous, like those of the main stem. In this case, it is clear that the scars in question did not bear ærial rootlets, and the specimens figured by Zeiller and Renault, already referred to, and that given here by me, evidently represent a similar condition. It also seems to follow that the little

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[1] Végét. foss. terr. houil. de la France, pl. clxxiv., fig. 1.

[2] Cours d. botan. foss., 1881, pl. xvii., fig. 1.

[3] Flore foss. Bassin houil. d. Comentry, p. 540.

circular scars on the *Sigillaria spinulosa* form, are likewise cone-scars. Morphologically there appears to be nothing by which they can be distinguished from the corresponding scars on the *Sigillaria Brardii* condition of the species. Only in one they occur on the Clathrarian form, and in the other, on the Leiodermarian condition of the plant.

Weiss and Sterzel[1] suggest that *Palmacites quadrangulatus*, Schloth.,[2] might belong to their *Sigillaria mutans* forma *Wettinensis*, Weiss,[3] and Potonié[4] unites it with *Sigillaria Brardii*, and names the specimen figured by Zeiller as *Sigillaria quadrangulata*,[5] Schloth. sp., *Sigillaria Zeilleri*, Potonié.

The original figure of *Palmacites quadrangulatus*, Schloth., is very obscure, and devoid of the necessary characters for a right knowledge of his plant; and if the figure correctly represents the true condition of the fossil, it must have been in a most imperfect state of preservation. Under these circumstances, I do not see on what grounds a satisfactory identification of *Sigillaria Brardii* can be made with *Palmacites quadrangulatus*, Schloth. Such an identification must infer that Schlotheim's specimen possessed characters neither shown in the figure nor referred to in the text, and this course I am not prepared to follow. But whatever view may be taken of Schlotheim's *Palmacites quadrangulatus*, Zeiller's *Sigillaria quadrangulata* seems to be specifically distinct from *Sigillaria Brardii*, Brongt.

Sigillaria obliqua, Brongt.,[6] *Sigillaria venosa*, Brongt.,[7] and *Sigillaria lepidodendrifolia*, Brongt. (in part),[8] seem to have very close affinity with *Sigillaria Brardii*, if they are really specifically distinct; but an examination of the original specimens would almost be necessary before arriving at a satisfactory opinion on this point.

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[1] Die Sigillarien d. preuss. Steink.-u.-Rothl.-Gebiete, ii., pp. 127 and 237, 1893.

[2] Petrefactenkunde, p. 395, pl. xviii., fig. 1, 1820.

[3] *Ibid.*, pl. xii., fig. 55.

[4] Flora d. Rothl. v. Thüringen, p. 190, 1890.

[5] Bull. Soc. géol. d. France, 3e sér., vol. xiii., pl. ix., figs. 3, 4, 1884.

[6] Hist. d. végét. foss., p. 429, pl. clvii., figs. 1, 2.

[7] *Ibid.*, p. 424, pl. clvii., fig. 6.

[8] *Ibid.*, p. 426, pl. clxi., fig. 3 (not figs. 1, 2).

Sigillaria Brardii, Brongt., is very rare in Britain, and I am much indebted to Mr John Ward and Mr F. Barke for the specimens described in this paper.

UPPER COAL-MEASURES.

Locality.—Railway cutting, Florence Colliery, Longton, North Staffordshire (the Potteries Coal Field).

Horizon.—About 300 yards above Bassey Mine Ironstone, which is about 280 yards above the uppermost bed of the Middle Coal-Measures. Collected by Mr F. Barke. Reg. No. 818.

MIDDLE COAL-MEASURES.

Locality.—Cope's Marl Pit, Longton, North Staffordshire (the Potteries Coal Field).

Horizon.—Above the Peacock Coal. Collected by Mr John Ward. Reg. No. 817.

EXPLANATION OF PLATE.

Fig. 1. *Sigillaria Brardii*, Brongt., natural size, from railway cutting, Florence Colliery, Longton, North Staffordshire.

Fig. 1*a*. Leaf-scar and cushion from portion representing typical form of *Sigillaria Brardii*; × 3.

Fig. 1*b*. Leaf-scar from portion representing the *Sigillaria rhomboidea*, Brongt.; × 3.

Fig. 1*c*. Leaf-scar from portion representing the *Sigillaria denudata*, Göpp.; × 3.

Fig. 2. *Sigillaria Brardii*, Brongt., natural size, from Cope's Marl Pit, Longton, North Staffordshire.

Fig. 2*a*. Leaf-scar and cushion; × 2.

Fig. 2*b*. Portion of stem showing cone-scars; × 2.

XVIII. *A Preliminary Notice of a Parasitic Copepod from the vas deferens of* Nephrops norvegicus. By J. STUART THOMSON, Esq., Demonstrator of Zoology, New School of Medicine, Edinburgh.

(Read 15th April 1896.)

During the past session, while demonstrating the internal organs of *Nephrops norvegicus*, I noticed on the walls of the vas deferens a very conspicuous abnormality. This consisted of a swollen mass or hernia of a light burnt-sienna colour, extending over so considerable an area (40 millimetres in length by 10 millimetres in breadth) as quite to alter the ordinary appearance of the latero-posterior aspect of the thoracic cavity. On closer observation, the deformity was seen to be produced by a somewhat worm-like animal, whose head was attached to the walls of the vas deferens. This parasite, evidently a female, was accompanied by a small male of a very dissimilar form, which lay towards its posterior margin. I removed these dimorphic parasites from their host, and placed them in methylated spirit for future examination. On a later inspection of these animals, I recognised that neither of these were as well preserved as I would have desired, and therefore I set myself the task of finding further specimens, and of endeavouring to obtain data as to the frequency of their occurrence. For this purpose, all the specimens supplied to us for class dissection were carefully examined, and, in addition to this, I looked over a number of Norway lobsters at a well-known fish-dealer's in town. After an examination of about five hundred specimens, I had only procured two more parasites—a male and a female—and these not occurring on the same host; but in addition to these two actual specimens, in two other cases I noticed a degeneration of the vas deferens, possibly produced by a recent attack of this parasite. Thus it appears that during the winter season this parasite is by no means a frequent guest in *Nephrops norvegicus,* probably only one animal in a hundred being infected by this parasitic Copepod. In 1884 Mr J. T. Cunningham showed that the Norway lobster is attacked by a parasitic Trematode, which he named *Stichocotyle nephropis,* which lives in the rectum of its host; and it is interesting to note that these Trematodes are much more frequent in occurrence than is the case with these Copepod parasites, for Cunningham says, "Usually out of a dozen opened, three or four are infected." On the other hand, my percentage is the same as that given by Nickerson for the infestation of another host—the American lobster—by the same Trematode, *Stichocotyle nephropis.* The more general haunts of parasitic Copepoda are the skin, scales, muscles, fins, gills, eyes, lips, tongue, nasal cavity, and palate, and thus we notice that the habitat of the Copepod under discussion is exceptional in two ways—firstly, in being more endoparasitic than is usually the case in this order; and secondly, in being situated on the male reproductive duct, a fact which is to be compared with that of certain Cryptoniscidæ among the Isopoda, as Giard and others have shown, which seriously affect the male reproductive organs of their hosts.

The connection between this Copepod and the vas deferens of its host is an extremely close and intimate one; so much is this the case, that it is difficult to fix their respective limits. I have had some difficulty in preserving these parasites—a difficulty which has been experienced, but not overcome, by previous workers at this family of Copepoda. I find that methylated spirit is preferable to formalin; but the former must be added in a very gradual percentage.

The Area affected by Parasitism.—In one case the area affected by the attacks of this parasite was slightly over 40 millimetres in length by 10 millimetres in breadth. In another case the area affected was not nearly so extensive; but in the latter case the vas deferens appeared to have been ruptured; this rupturing might partly be the result of rough treatment in the trawl, or during carriage, as specimens are not infrequently mangled in this way. In this second case, the area affected only extended over 15 millimetres in length by 5 millimetres in breadth.

Size of the Animal.—In one case the length of the female appeared to be slightly less than 8 millimetres, while the length of the male was approximately 5 millimetres; but the measurements of the female were not very exact, as it was difficult to fix the exact limits of the animal. We may notice, however, that there is not so marked a difference in size between the male and female of this species as in a number of other dimorphic Copepoda.

Description of the Female.—The female of the older specimen was evidently so much altered in form by its endoparasitic habit, as to afford little or no clue as to the original shape of the animal. The younger stage, however, showed that this is one of those bizarre species deformed by warty outgrowths of the body. Some of these outgrowths are so definite in form as to lead one to mistake them for true appendages. The shape of the body in the female resembles, in quite a marked degree, that of *Anchorella triglæ,* Claus, a species belonging to the family Lernæopodidæ; but on the other hand, the head shows a similarity to that of *Cestopoda amplectans,* a member of the same family. The head, as in these two species, is fairly distinct from the thorax; but, probably on account of the intricate connection with the vas deferens, I was unable to make out a distinction between thorax and abdomen. As regards appendages, I experienced considerable difficulty in their dissection and in understanding their arrangement, on account of their being so thickly crowded together; the situation of the head, as in the Lernæopodidæ, being such that the appendages lie close together on the ventral surface.

The same difficulty has been experienced by others who have studied the Lernæopodidæ. In this female the only appendages which I made out at all distinctly were the first three pairs, presumably the two pairs of antennæ and the mandibles. The first pair of antennæ is much smaller and not nearly so prominent as the second pair. They show a trace of segmentation; but this is by no means so distinct, nor are the segments so numerous, as those of the second pair. The second antennæ possess a main joint, from whose ends two branches project. They extend farther forward, and tend to conceal the first pair. At the anterior head extremity of the older specimen I noticed a sucking organ, which is provided with a ventral and a dorsal fixing process. The female further shows a very slight niching on the dorsal surface of the head, and this is noteworthy, because, in the male, we find a much more prominent and extended niching of the dorsal surface. The female showed little or no trace of segmentation.

Description of the Male.—I obtained only two of these male parasites at different stages, and these possessed rather dissimilar characters. In both, however, there exists a very distinctive niching on the dorsal surface. This dorsal niching has an appearance not unlike that seen in the same position in *Canthocamptus minuticornis* and other species. The better preserved of the two specimens showed a division of the body into cephalothorax and abdomen; but in neither of these two specimens was segmentation at all distinct throughout the length of the body. In one of these males, I made out the ordinary appendages of the cephalothorax, namely, two pairs of antennæ, one pair of mandibles, one pair of maxillæ, and the rudiments of three pairs of maxillipedes. The posterior end of the abdomen had a shape which reminded one of that seen in some other species of the family Lernæopodidæ.

Generic Position.—Having found only a few specimens, and these exceedingly difficult to investigate, I have been unable to satisfy myself as to the generic position of this parasite, though I have evidence, which I hope to strengthen, that it belongs to the family Lernæopodidæ. A comparison with previously recorded forms inclines me to believe that here we have to deal with a new species, and that it will furnish fresh links between the several members of this family of Copepoda. This family, the Lernæopodidæ, is regarded by Kurz as one of the most natural among the Copepoda; but partly on account of the difficulty in determining the arrangement and structure of the mouth parts, and partly on account of the difficulty of preservation, the more aberrant forms of this family have been somewhat neglected.

So far the life-history of this parasite is unknown, or how it comes to occupy its peculiar position on the walls of the vas deferens. It is possible that it entered the male reproductive duct as a larval form.

In conclusion, I would here express my indebtedness to a fellow of this Society, Mr Lewis Beesly, who assisted me in making drawings and in looking over a number of specimens in search of these parasites.

BIBLIOGRAPHY.

BASSETT-SMITH, P. W., List of the Parasitic Copepoda of Fish obtained at Plymouth (with a good bibliography), *Journal of Marine Biological Association*, vol. iv., pt. 2, Feb. 1896.

KURZ, W., Studien über die Familie der Lernæopodiden, *Zeit. wiss. Zool.*, vol. xxix., pp. 380-428.

CUNNINGHAM, J. T., On *Stichocotyle nephropis*, a new Trematode, *Trans. Roy. Soc. Edin.*, vol. xxxii., pt. ii., 1884.

XIX. *Obituary Notice of the late Mr John Gunn, Secretary to the Society.* By R. H. TRAQUAIR, M.D., LL.D., F.R.S.

(Read 15th January 1896.)

John Gunn, eldest son of the late Mr Alexander Gunn, an extensive farmer in Caithness, was born at Dale, about five miles south of Halkirk, in that county, on the 7th September 1853. His education, begun at the country school of Westerdale, near his father's house, was afterwards entrusted to a private tutor, and finished at the Royal Academy at Tain, where he conspicuously distinguished himself as a pupil.

In 1874 he entered an accountant's office in Glasgow, but his health, which from childhood had been somewhat delicate, suffered from the close confinement which is inseparable from such an occupation, so that before two years had passed he was obliged to throw it up, and to proceed to the Continent for several months to recover his strength.

On returning to his native land, he spent some years at home in Caithness, busying himself mainly in local archæological investigations, until, in April 1886, he proceeded to Edinburgh to occupy a post in the "Challenger" office, under Dr John Murray, F.R.S. At the close of the Challenger Commission, Mr Gunn occupied himself with literary work, at first for Messrs Bartholomew of the Geographical Institute, afterwards for Cassels & Co., of London. During his life in Edinburgh, he also occupied much of his time with the duties of Librarian to the Royal Geographical Society, and, as we shall presently see, with those appertaining to the secretaryship of our own Society.

Mr Gunn joined the Royal Physical Society in February 1887, and in December of the same year he, to the gratification of the Council and of the Society generally, allowed himself to be nominated as Assistant Secretary in succession to the late Mr John Gibson. In December 1892, when the ill-health of our then Secretary, Mr William Evans, necessitated his taking a prolonged rest from work of the sort, Mr Gunn was appointed Acting Secretary for a year, at the close of which, on Mr Evan's definite resignation, the Society was glad to entrust the conduct of its affairs to him as permanent Secretary.

No doubt the removal from their posts within so short a time of two admirable secretaries—Mr Robert Gray, by death in 1887; Mr William Evans, by resignation in 1893—constituted severe losses to the Society, but in Mr Gunn we had chosen a man eminently fitted to make good these losses. The habits of exactitude which his work in Glasgow had developed, his experience in the Challenger Office, joined to an instinctive painstaking tendency, exactly suited him for undertaking the duties of secretary from the business point of view, while his scientific leanings, along with his remarkably amiable disposition, secured him the hearty co-operation of many friends in providing material for the work of the Society.

From his boyhood he displayed a decided scientific bent of mind, the branches of knowledge which specially attracted him being history, archæology, and geography, though at the same time he had wide sympathies as regards all the subjects which ordinarily come before us under the designation of Natural History. But though, as a Society, we lament the loss of a thorough man of business, who devoted himself in the most zealous and painstaking manner to the good of the Society, it is those who had the pleasure of knowing him personally who feel that loss most keenly. Utterly unselfish, as well as utterly unassuming, he seemed to consider working for the benefit of others to be the great object of his life, and those who enjoyed his friendship know well how sincerely devoted and faithful a friend he was in every case. They also know well the geniality of manner which shed a bright ray of happiness over an hour or two spent in his company, and the charm of his conversation, enlivened by a profusion of anecdote and supported by a groundwork of genuine kindly disposition and sound common sense. He was indeed what few of us can boast of being, a "man of many friends and no enemies."

In the month of March of last year, after the intense cold of January and February had given way, the country was visited by a severe epidemic of influenza, and one of the victims of this epidemic was our dear friend and secretary, John Gunn. Though he had indeed recovered from the ordinary symptoms of the disease, a weakness of the heart seemed to have come on as a sequela, and this was doubtless the cause of his death. On the morning of the 27th of April last he was found sitting placidly in his chair, but no longer alive.

We, who survive, will bear him in affectionate memory till our turn also arrives.

XX. *Obituary Notice of Dr Robert Brown.* By J. G. GOODCHILD, F.Z.S., F.G.S.

(Read 15th January 1896.)

The recent death of one of the former Presidents of the Royal Physical Society calls for at least a short notice in the pages of the Society's Journal, even though the subject of the notice had been absent from our midst for nearly twenty years.

Robert Brown was born at Campster, in Caithness, in the year 1842. He left that place early for Coldstream, where he received the earlier part of his education, and then came to Edinburgh, where in due time he graduated as Master of Arts. Then for some time he devoted himself to the study of medicine, and thereby received the scientific training which formed the basis of so much of his after work. It seems that, after studying some time in Edinburgh, he went successively to Leyden, Copenhagen, and Rostock, at which latter place he received the degree of Doctor of Philosophy.

In 1861 he entered as surgeon on board a whaler, and in that capacity visited Spitzbergen, Greenland, and Baffin's Bay, collecting in the meanwhile much information of value in regard to the geology and biology of the Arctic regions. Three years later he was appointed Botanist to the British Columbia Expedition, and then commander of the Vancouver

Island Exploring Expedition. He contributed a series of papers on the results of these expeditions to the *American Journal of Science* and other magazines. On another occasion he revisited Greenland—this time in the company of Edward Whymper—and subsequently wrote several other papers bearing more or less upon glacial physics.

After his return from this latter expedition, he was appointed Lecturer on Geology, Zoology, and Botany at the Watt Institution, Edinburgh, and at the Mechanics Institute, Glasgow.

He took a prominent part in the management of the Edinburgh Field Naturalists' Club, and was appointed the first President of that body. In 1872 he was elected President of the Royal Physical Society, and subsequently fulfilled the duties of Secretary to the same Society during the years 1874-76.

Amongst his published works are some few on Natural Science subjects contributed to our *Proceedings.* He is better known, however, amongst geologists in general, in connection with his paper "On the Physical Structure of Greenland," published in the papers for the Arctic Expedition of 1875, as well as for others on kindred subjects which appeared in the *Quarterly Journal of the Geological Society of London* and elsewhere.

In addition to his original contributions to scientific literature, Dr Brown was the author of a large number of compilations, most of them dealing in a popular manner with various branches of Natural Science.

Of late years he had devoted himself mainly to purely journalistic work in connection with the *Scotsman*, the *Echo*, the *Standard*, and others.

He died at Streatham on the 26th of October 1895.

XXI. *On the Discovery in Orkney of the John o' Groat's Horizon of the Old Red Sandstone.* By JOHN S. FLETT, M.B., B.Sc., Assistant to the Professor of Geology in Edinburgh University.

(Read 19th February 1896.)

It is now four or five years since I discovered in a quarry in Deerness, in the East Mainland of Orkney, specimens of *Dipterus macropterus* (Traquair), a fish hitherto recorded only from the John o' Groat's beds in the north-east of Caithness. Last summer, when visiting the same quarry in the hope of obtaining additional specimens, I was struck by the presence of a small Asterolepid, which greatly resembled *Microbrachius Dicki* (Peach), another of the fishes hitherto peculiar to the above-mentioned horizon in Caithness. The specimens were not well preserved, but careful examination confirmed my first impression, and when I returned to Edinburgh I submitted them to Dr Traquair, who assured me of their identity. During a short holiday at Christmas I was enabled to revisit the locality and collect additional specimens of the fishes which occurred in it, as well as to make some examination of the strata of the district. Having shown the entire collection to Dr Traquair, he at once identified several of the specimens as belonging to *Trichistopterus alatus* (Egerton), making three species in all which have been yielded by the beds exposed in this quarry.

What is worthy of note is that these three species, now for the first time recorded from Orkney, are precisely those which are characteristic of the John o' Groat's beds in Caithness. The quarry is a small one, about 400 yards north of the Deerness Parish School. The rock is a dark grey, thin bedded, very calcareous and brittle flagstone. It dips E.S.E. at a low angle, and in many places shows a curious curving and contortion of the beds. In this quarry no other description of rock is to be seen. The fossils are exceedingly abundant, *Dipterus macropterus* greatly predominating in numbers. When I visited the quarry, the layer then being lifted showed on its exposed face quite a number of *Microbrachii,* but from careful examination I feel convinced that this species is practically confined to one or two of the beds worked at present. Beside these fishes, no other fossils occur except drifted and broken fragments of plants, from a few inches to 2 feet or more in length, and sometimes 3 inches in breadth. These fragments are common in the Orkney flagstones generally, and are mostly undecipherable. I visited two other quarries in adjoining fields, one being somewhat above, the other somewhat below the level of the *Microbrachius* quarry. Both yielded a similar rock to that described, the upper containing also a few thin shaly beds, under which are some beds of sandstone, each 6 to 8 inches thick. Both quarries yield *D. macropterus* in abundance, but badly preserved and readily decomposing on exposure, and plant remains. In neither did I find *Microbrachius.* The dip is the same as in the first-mentioned quarry.

To ascertain the nature of the rocks at this particular horizon, I made an examination of the coast section exposed in the cliffs at the south side of Deerness parish. The narrow neck which joins the peninsula of Deerness to the mainland of Orkney is crossed by a fault which runs in a northerly direction out the bay. The downthrow is probably to the east. The first beds met with on the Deerness shore are yellow, somewhat coarse sandstones, in beds 4 to 8 inches or more thick, dipping E.S.E. at a low angle. Followed along the shore, they are succeeded by reddish sandstones, with red clay beds and thin layers of grey shales. At the Mermaid's Rocks, these are cut by a trap dyke running nearly north and south, and, as seen in the shore, about 25 feet broad. A little farther on, they are overlain by beds of red clay, with here and there sandstones, and over these a series of thin brittle calcareous flags, alternating with grey shales and layers of yellow sandstone. These are well exposed on the western shores of Newark Bay, and their dip varies a little, but is generally S.E. and E., at angles of 4 or 5 degrees. From their character and their strike there can be no doubt that they are the beds which yield *Microbrachius* in the quarry a mile or so inland. They are succeeded by soft dark brown sandstones and shales, abundantly ripple-marked and suncracked, which form a gentle syncline, and crop out again on the east side of the bay, beyond which point the dip rolls over again to the east; and a series of red and brown sandstones, with frequent yellow sandstones, red shales, and thin bedded grey flags, forms the coast up to the Point of Ayre. The whole thickness of this series, from Dingyshowe to the Point of Ayre, a distance of three and a half miles, is about 1200 feet.

Although quarries are few, owing to the unsuitable nature of the rocks for building or road-making purposes, I have no doubt that the succession, as traced in the shore, holds good for the inland structure of the district; for, traced along the strike in Deer Sound, there is no evidence of any important dislocation; and again, the beds are cut by two massive trap dykes, one already mentioned running north and south from the Mermaid's Castle, the other emerging at the Point of Ayre, and running north-west and south-east. Both of these I traced in several places inland, and found that they continued in straight lines—one actually passing within a short distance of the quarry in which the fossils were found.

Apart altogether from their characteristic fossil contents, the lithological character of the rocks of this horizon is worthy of notice. They distinctly resemble the Huna beds of the Caithness coast, and I have little doubt subsequent examination will show that they form a considerable part of the East Mainland of Orkney, as rocks having these characteristics, and containing *D. macropterus* in abundance, occur in several distinct localities in the district. On the other hand, in the district west of the great fault, which runs from Howquay Head to Kirkwall Bay, rocks of this facies do not occur, and from these beds none of the characteristic John o' Groat's fishes have been recorded.

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OF THE

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SESSION 1896-97.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXVI.

Wednesday, 18*th November* 1896.—Professor J. Struthers, M.D., LL.D., President, in the Chair.

Mr J. G. Goodchild, H.M. Geological Survey, F.G.S., F.Z.S., M.B.O.U., retiring Vice-President, delivered the following opening address, entitled "Some Geological Evidence regarding the Age of the Earth":—

Introduction.—Geologists from time to time have attempted many estimates regarding the Age of the Earth, and especially that portion of the Earth's history represented by the interval between to-day and the period when the oldest strata containing fossils were laid down. All who have made the attempt have realised that it is impossible, with our present knowledge, to state the antiquity of the rocks in question in terms of centuries, thousands of years, or even in millions. All we can feel sure of is that the records of the rocks fully justify us in claiming for the earth an antiquity so vast as to be far beyond the power of the human intellect to grasp. When a geologist wishes to form even some faint conception of what this antiquity implies, he turns to astronomy, and, after having formed in his mind some conception of what is meant by astronomical distance, he is able, in some measure, to transfer his conception of those vast intervals of space to the conception of the equally vast intervals of time with which it is his own special province to deal.[1]

"Vague, indefinite, but unquestionably vast beyond conception" is a phrase that must recur to the minds of most geologists when referring to the subject of Geological Time. Yet, indefinite though it must long remain, it seems to me that almost every attempt that has been made at reasoning out an answer to the question, "What is meant by Geological Time?" has contributed something that has helped to make our ideas upon the subject more and more definite. Speculation is not without its uses in science; and even when it may be based more or less upon error, the correction of that error may at least help to guide others into the track which, sooner or later, will lead them up to the truth.

In dealing with this subject of the Age of the Earth, the fundamental idea which a geologist steadily keeps in mind is that all the changes, physical and biological, which the records of the rocks inform us have taken place upon the Earth in the Past, can only be understood and properly interpreted by reference to changes of the same nature which are known to be in progress during the Present. This, of course, does not imply absolute uniformitarianism (as this is commonly understood), but it allows for catastrophism in certain exceptional cases, along with normal uniformity of action in the rest. The geologist obtains abundant confirmation of the justice of this view in the fact that, throughout the whole series of rocks, and even throughout those strata which are older than the most ancient yet known to contain records of life, the manifestations of Nature's forces show no sign of any action different, in either degree or kind, from those which are known to be at work at the present day. Rain fell in those early days much as it falls now. Wind blew then with apparently no greater force than it does to-day. The tides and currents of those early periods appear to have obeyed exactly the same laws that they do now, and in no

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[1] The astronomical models in the Museum of Practical Geology, and the more extended set placed in the Gallery of Scottish Geology and Mineralogy in the Edinburgh Museum of Science and Art, were set out with the express object here referred to.

case do they show any sign of having acted with greater energy than they do at the present day. In short, even as far back as the commencement of the Cambrian Period, the two great geological factors, solar energy and gravitation, appear to have operated then very much as they do now. To a geologist this merely indicates that the close of what has been termed the Astronomical History of the Earth terminated many millions of years prior to the Cambrian Period, and that the Earth must have been in a condition suitable for life through a long period of the time when the Archæan rocks were in process of formation.

Turning to the records supplied by fossils, we find that the life-conditions during Lower Cambrian times were in no respect yet discovered different from what such conditions are to-day. Organisms then, as now, changed under the influence of varying environment and other biological factors at, apparently, at least as slow a rate as now. Hence biologists concur with geologists in claiming, as requisite for the development of the existing forms of life, an interval of time fully as vast as that required to account for the physical changes which are known to have taken place upon the earth.

It is true that some there were, and perhaps there may be some still, who, taking note of these facts relating to the Earth's history, declared that they could perceive no vestige of a beginning, and no prospect of an end. It was only natural that a reaction should set in against views so directly opposed to all that we know through the researches of the astronomer. Mathematicians and physicists of eminence took up the question, and discussed it from their own standpoints, basing their conclusions upon what, at the time, appeared to be well-established facts. The conclusions referred to were by no means identical with those to which geologists had been led. Lord Kelvin, for example, boldly stated his opinion that all geological history showing continuity of life must be limited within some such period as 100,000,000 of years; and Professor Tait was disposed to allow even very much less than that. Lord Kelvin has lately considerably modified the view here referred to,[1] but

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[1] "Nature," vol. li., 1895, p. 257.

even yet geologists in general do not feel satisfied with the concession.

It certainly requires that a geologist should feel that he can place considerable reliance upon the value of his own set of facts and inferences before he can venture to call in question the validity of the conclusions arrived at by men of undoubted eminence in their own subjects, such as Lord Kelvin and Professor Tait are. Nevertheless, geologists still shake their heads, and repeat with approval Professor Huxley's well-known saying that "Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and as the finest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data." In the following pages I shall confine my attention to the purely geological side of the question, leaving the physicists to take up the discussion and deal with it in the light of new facts and views. The results at which they will eventually arrive will not, I feel confident, prove so discordant with geological evidence as those to which reference has just been made.

I propose in the following pages to pass in review certain changes which are known to have taken place in the past, beginning with the latest periods and working backward. I shall therefore commence with the Glacial Period.

Time required for the Physical Changes that have taken place during the Tertiary Period.—One of the best regions in the British Islands for the study of the changes which have taken place since the commencement of the Tertiary Period is to be found in the Inner Hebrides. It is true that, in regard to the sequence of glacial events, these islands do not afford us evidence quite as satisfactory as do other regions to the east. This, I think, is probably owing to the fact that the influence of the complex conditions known as the "Gulf Stream" (whether in the bodily transfer of warm water, or in the northward transfer of aqueous vapour, which, by its condensation into rain, warms the air—matters not in the present connection), was maintained close to the edge of the present 100-fathom line west of Europe all through the

Glacial Period. Consequently, from the West of Ireland to the Lofoten Isles, or farther north still, the evidence of glaciation is mainly confined to the low ground. Be that as it may, there must have been an excessively heavy rainfall there, if there was not much snow; and although the low ground, in, for example, Loch Coruisk in Skye, underwent considerable erosion through the action of simple glaciers of large size, the high ground there, as in the Lofoten Islands, was probably never overridden by an ice-sheet for any lengthy period, if it was so overridden at all. I only refer to the matter here in order that some reference may be made to the time which has probably elapsed since the Climax of the Glacial Period. Taking into account the small extent of the physical changes which are known to have occurred since that period, I made a rough estimate in 1887[1] that this time was distant from our own not more than 20,000 years. Observations by others, at home and abroad, have helped to confirm that estimate. Twenty thousand years is, at any rate, well within the estimates commonly made.

How long the Glacial Period lasted is a question still not satisfactorily answered—it certainly must have been one of great length, if one may judge by the amount of erosion that was accomplished on the *eastern* side of the Scottish watershed, where the precipitation from first to last mainly took the form of snow. But we do know that, although the valleys in the west were both deepened and widened by the ice, yet, as valleys, they existed long prior to the Glacial Period.

The time required for the excavation of these valleys by the joint agency of subaerial erosion and ice has next to be taken into account. We have no need to attempt an estimate of the thickness of rock removed during the Glacial Period itself—and almost none has been removed since. It will suffice if we take the average rate of lowering of the surface in general at 1 foot in 3000 years instead of 1 foot in 6000 years as is usually done, and then, in this case,

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[1] "Ice-Work in Edenside," Trans. Cumberland and Westmorland Association, No. xi., p. 167.

assume that under the conditions most likely to have obtained in Pliocene and Pleistocene times, that denudation went on more rapidly than is usually the case. Bearing this in mind, we will assume that an estimated 1 foot in 2000 years for the erosion accomplished would be one certainly on the safe side. From the summit level of the Cuchullin Hills to the sea-level is now over 3100 feet. These hills consist of a kind of gabbro, a plutonic rock that, whatever its nature and origin, could not possibly have been formed within a short distance of the surface. One would be almost justified in regarding it as a rock of deep-seated origin, for even if it be, as I have suggested in the *Geological Magazine*, that this gabbro represents basaltic lavas recrystallised by later intrusions, the metamorphism would still require that a considerable thickness of over-lying rock should have once covered it, and have since been removed. There are no exact means of arriving at an estimate of what that thickness was. But assuming that the Skye Volcano was of the same nature as, and had slopes as low as occur in, the volcanic mass of Hawaii, that alone would give us an elevation of its central portions of, at least, 8000 feet. In the period since the old volcano died out it has been trenched by rain, rivers, and ice to its very core. If this denudation has gone on at the moderate rate of only 1 foot in 2000 years, this rate gives us 16,000,000 as the time required for the formation of the valleys. The quantity of rock that has been removed since the close of the volcanic period can be shown by other examples to be enormous. Sir Archibald Geikie, in his well-known "Scenery of Scotland," refers especially to the excavation since that period of the great valley in which lies Loch Scridain in Mull; also to the extensive removal of volcanic material implied by the shaping of the Sound of Mull; and, further, to the evidence afforded by the dykes. For instance, referring to the dyke that crosses Loch Lomond and rises to near the summit of Ben Voirlich—and assuming that the particular dyke in question is of the same age as the volcanic rocks of Skye, Rum, Mull, etc.—he points out that, if the great valley in which Loch Lomond is situated was actually in existence at the time the volcanic matter was being erupted, the dyke would have filled the valley instead of taking its present form. Hence, he points out, the valley must have been excavated since. Inferentially, therefore, any, or all, of the largest valleys that traverses the Highland plateaux may well have been formed since. No geologist fully cognisant of the vast and important physical and biological changes which can be shown to have taken place on the Continent and elsewhere since the close of the Miocene Period here referred to, can hesitate to regard the estimate of 16,000,000 of years as being well within the mark.

We have next to consider the time required for the building up of a volcano of the dimensions above referred to. Sir Charles Lyell many years ago pointed out that the rate of growth of a modern volcano would appear to be very much slower than has commonly been supposed. There are several reasons why this is the case. (1) The eruptions are intermittent, and are often separated by long periods of repose, during which the ordinary agents of denudation tend to transport much of the newly formed volcanic material in the direction of the sea. (2) Violent explosive outbursts occur, perhaps several times, in the life-history of most volcanoes. These result in the shattering of much of the rock material previously accumulated, and aid in its transfer by the action of the winds to areas many hundred times the area of the parent masses (3) The lavas resulting from effusive eruptions usually take the form of narrow streaks, which are radial in respect to their crateral starting-points; other lava streams following these from the same crater rarely or never overflow the ridge formed by their immediate predecessors, but usually follow the line of lowest ground, which generally lies in another direction. Hence the lavas flowing from a summit crater take the form of radial streaks. To complete the circuit of the cone may require, in the case of a volcano of the form of Etna or Hawaii, many thousands of years. Hence the average thickness deposited in a century, taking the volcano all round, must actually be very small. Professor Lloyd Morgan, writing upon the subject of Geological Time (*Geological Magazine*, 1878, p. 204), regards

1 foot in 300 years as a fair average rate at which the growth of a volcano may be computed to have grown. No one who has carefully considered all the facts will regard this estimate as erring on the side of excess. We will therefore assume that the Skye Volcano, 8000 feet high over its central portion, grew at the rate of 1 foot in 300 years. Even at this comparatively rapid rate, and supposing that its growth went on without cessation, the volcano must have required 2,400,000 years for its completion. It is well known, however, that the growth of the volcanoes of that part was interrupted more than once or twice by long periods of quiescence, and we are therefore well within the truth in fixing the time at the rate just given.

For the purpose in view in the present address, it will be taken for granted that the Skye Volcano began to erupt some time in the Oligocene Period—many would think we should be quite justified in assigning a later date even than that to the commencement of the great volcanic episode. Prior to the Oligocene Period there was formed on the Continent several thousands of feet of the marine Nummulitic Limestone. Near Biarritz this rock is more than 3000 feet in thickness. The evidence for the whole of this being of later date than the Chalk, and of older date than the Oligocene strata, is admitted on all hands. Prior, therefore, to the first outbreaks of the Skye Volcano, and posterior in date to the Upper Cretaceous Rocks, occurred the marine episode referred to.

In dealing with the question of the rate at which rocks of sedimentary origin are being formed at the present day, we find ourselves at once face to face with the principal difficulty with which we meet in attempting to estimate the Age of the Earth. Of the rate of formation of terrigenous deposits we know as yet but very little. All one can say with tolerable certainty regarding the subject in general is that, as the greater part of the materials employed in their formation is carried seawards from the land by the agency of rivers, at a rate which is now (thanks to the labours of Tylor, Lyell, Croll, Geikie, and others) fairly well known, the rate of formation of a marine deposit of terrigenous origin over a given area cannot much exceed the rate at which that material was wasted by subaerial agencies from an equal area of land. But when it comes to particulars, we are confronted with so many difficulties that it seems impossible, with the knowledge we can at present command, to make any statement regarding the rate of formation of any kind of terrigenous deposit, which can be regarded as much more than a speculation. Even if, in the case of any given river-discharge, we knew the rate at which the various sea currents were flowing, and we were sure of their direction in all cases, we should still have to take into account the fact that all delta-areas are areas of subsidence, and, further, that both the rate of subsidence and the rate at which the downward phase of terrestrial undulation which it represents is progressing, are factors of the utmost importance in working out a question of the kind before us. It is only, it seems to me, in the case of marine deposits of organico-chemical origin that we have any data which appear to be at all trustworthy in this respect. These, at any rate, are not now so much affected by local causes, and probably have not been so in the past. Moreover, the influence of diffusion throughout the whole oceanic area tends rapidly to equalise the percentage of mineral substances held in solution. Hence, for example, if a river draining a limestone district where there is a heavy rainfall, carries into the ocean at one part exceptionally large quantities of lime-salts, that quantity is soon equalised throughout the whole area of the ocean. In like manner, if, as in the case of the Pacific and Indian Oceans, the growth of coral reefs locally drains the surrounding water of its lime-salts at an exceptionally rapid rate, the balance is soon made good by supplies carried into the ocean from points hundreds or may be thousands of miles distant. Hence, ignoring coral-reefs as a form of limestone which is confined to the Post-Miocene Periods of the Earth's history, marine limestones appear to afford us the most satisfactory data upon which we can base our conclusions; as such, in the remainder of this address, I propose to employ them.

Mode of Formation and Rate of Growth of Marine Lime-

stones.—To be brief, one may say that the limestones of marine origin are formed almost entirely by the direct and indirect agency of animal and vegetable organisms, living and dead. These, as Irvine has shown, extract their carbonate of lime chiefly from the sulphate of lime present in sea-water, from which, ultimately, they convert it into the carbonate.

It will probably be generally admitted that all lime compounds in solution, both river-water and sea-water, were derived, primarily, from the silicates in eruptive rocks. From these they have been liberated by "weathering," and have been carried seaward in solution as bicarbonate. Probably nearly all limestones, except, perhaps, those associated with highly metamorphosed rocks of eruptive origin, are, so to speak, secondary products—the primary or initial stage of calcium being that of combination with silica in eruptive rocks. From both primary and secondary sources lime-salts are being carried seawards from the land by rivers at a rate which for the whole world is now fairly well known.

It has to be remembered that it is mainly from this source that marine organisms obtain the supply whence the hard part of their calcareous structure is built up. Supposing, for the moment, that this lime secreted by marine organisms is wholly derived from the supply furnished by rivers, let us see what the quantity possible to obtain per annum upon the sea-bottom would be. For this purpose we must first review Dr John Murray's figures relating to the relative areas concerned. Taking these from his latest papers, we have—

Total Area of the Globe, . . .	196,940,700	square miles.
Total Area of the Land, . . .	55,697,400	,, ,,
Total Area of Inland Drainage, . .	11,486,350	,, ,,
Total Area of Ocean Drainage, . .	44,211,050	,, ,,

Area of Ocean Drainage to Area of entire Ocean, as 1 to 3·194.
Area of Ocean Drainage to Area of Calcareous Deposits, 1 to 1·173.
Area of Ocean Drainage to Area of Terrigenous Deposits, 1·62 to 1.

Aver. percent.	of $CaCO_3$ in	27,899,300	sq. miles of	Terrigenous Deposits,	19·
,,	,,	50,000,000	,,	Deep Sea Clays,	6·7
,,	,,	2,790,400	,,	,, Oozes,	4·
,,	,,	10,420,600	,,	Diatom Oozes,	22·96.

We have next to consider what evidence we have regarding the rate at which lime-salts are being supplied to the sea through the agency of rivers. Dr John Murray, in his "Total Annual Rainfall of the Land of the Globe, and the Relation of Rainfall to the Annual Discharge of Rivers," *Royal Scottish Geographical Magazine*, iii., pp. 65-77, gives a mass of data of the highest possible value in this respect. From Dr Murray's tables, Mr C. D. Walcott, in his "Address to Section E of the American Association for the Advancement of Science" (August 1893), has computed "113 tons as the total amount of matter in solution discharged into the Atlantic basin per annum from each square mile of area drained into it. Of this, 49 tons consist of carbonate of lime and 5·5 tons of sulphate and phosphate of lime." In a footnote Mr Walcott gives an abstract of Dr Murray's figures as follows:—"Total amount removed in solution per annum by rivers, 762,587 tons per cubic mile of river-water. Total discharge of river-water per annum into the Atlantic, 3947 cubic miles. Area drained, 26,400,000 square miles. Amount of carbonate of lime per annum, 326,710 tons per cubic mile of river-water; of sulphate of lime and phosphate of lime, 37,274 tons." Dr Murray's Table VII., *op. cit.*, p. 76, gives the proportion of the two latter salts as $Ca_3P_2O_8$, 2913 tons, and $CaSO_4$, 34,361 tons per cubic mile. Mr Wilbert Goodchild has computed for me the total quantity which these would represent if converted into $CaCO_3$. This comes to 4·143 tons from the phosphate and sulphate, which, added to the 49 tons of carbonate of lime, gives as the total 53·143 tons of carbonate of lime from each square mile of land surface per annum. The figures, it will be noted, are less than those given by Mellard Reade in his "Chemical Denudation in Relation to Geological Time," *Proc. Liverpool Geol. Soc.*, vol. iii., pp. 212-235 (1877). Further computation shows that, if we assume that 12·5 cubic feet of limestone go to the ton, this total quantity represents 664·3 cubic feet, which, if distributed over an area equal to that whence it has been derived, would, at the present rate of delivery by rivers, require 41,985 years for the accumulation of a thickness of a single foot.

The entire ocean area is to the area of ocean drainage as 3·194 to 1. If, therefore, the quantity of lime-salts carried by rivers into the ocean is converted into the solid form and left over the entire ocean area, the formation of a thickness of one foot of limestone would require more than 133,000 years.

There are, however, several causes which materially modify this result. One arises from the fact that the pressure of ocean water tends to dissolve calcareous organisms, beginning, as Professor Kendall has shown, with those which consist of aragonite, which are entirely dissolved before they descend from the surface-waters to a depth of 1500 fathoms, and dissolving those which consist of calcite as the depth increases, so that below 2900 fathoms hardly any reaches the bottom. This redissolved lime again enters into circulation, and becomes diffused through the areas adjoining The area where this dissolution takes place, therefore, must be left out of account. It may be roughly estimated to form about one-third of the entire ocean floor. There are other areas of the ocean, again, where the low temperature of the surface-water is unfavourable to the growth of large numbers of the pelagic lime-secreting organisms. Over this area, therefore, the supply of lime-salts in the sea-water is but little drawn upon. Then, again, although coral-reefs do undoubtedly represent a drain of a large quantity of the ocean lime-salts over an area perhaps extending even thousands of miles around, yet the solution of the limestone so formed goes on both at the surface and at some depths below, so that a fairly large proportion must find its way again into diffusion soon after it is fixed. Littoral shell banks, again, although they do represent so much solid material abstracted from the sea-water, yet undergo solution to some extent. Add to these sources the percentage of lime-salts dissolved by the ocean waters from the coast-line itself, delivery from submarine springs, and the lime dissolved out of basic tuff which happens to fall into the sea, and we seem to have taken into account every possible source whence lime-salts can find their way into the ocean.

If we assume for the present purpose that the quantity of lime-salts carried seaward annually by rivers is left in the solid form over one-third of the entire ocean area, and that the supply from the rivers is largely augmented by supplies derived from the possible sources mentioned, we still leave a large margin for the deposition of carbonate of lime from other—entirely unknown—sources, if, instead of 1 foot in 41,985 years, we regard it as accumulating now, and as having accumulated on the whole in the past, at 1 foot in 25,000 years.

If we estimate the thickness of the foraminiferal Nummulitic Limestone at only 3000 feet, this alone would require an interval of no less than 75,000,000 of years for its completion.

It is right to observe at this point that if there is any truth in the speculation that the atmosphere at past periods of the Earth's history contained even a slightly higher percentage of carbon-dioxide than it has now, the formation of limestone must have proceeded at even a slower rate than this. Also, if the ocean (as is supposed by many persons) formerly had a larger area relative to the land than it has now, the formation of limestone at the bottom of the sea in past times, so far from being more rapid than it is now, must have gone on at even a slower rate still. I shall therefore assume throughout this paper that 1 foot in 25,000 years is a fair rate to allow for the formation of marine limestones other than coral-reefs, with which geologists are but little concerned.

Summarising these figures, we have therefore for the duration of the Tertiary Period:—Time since the Glacial Period, 20,000 years; time for the excavation of the present land surface of the Western Island volcanic areas, 16,000,000 years; growth of the Skye Volcano, 2,400,000 years; time required for the formation of the Nummulitic Limestone, 75,000,000—total since the commencement of the Tertiary Period, 93,420,000 years.

Ninety-three millions of years may seem to those who are not fully acquainted with the succession of events that has taken place since the commencement of the Tertiary Period to be too extravagant an estimate to be for a moment seriously considered. With both geologists and biologists, however, the case will be different. Each will be only too fully aware of the difficulty that is encountered in attempting to explain the vast and important changes in both the organic and the inorganic worlds during the period in question. If we may judge of the rate of changes in the organic world by the rate at which, on the whole, those changes have proceeded since the dawn of the Historical Period, then the time required for the evolution of the various forms of life that have peopled the globe since the commencement of the Tertiary Period must be vast almost beyond conception.

Again, if, as geologists, we have to interpret the changes in the inorganic world that have taken place in the past, we are bound to do so by reference to the changes that are going on at present, and this is especially true when we are dealing with the geological history of a period so comparatively recent as that just noticed. Not to interpret the recent past by the actual present would be to reject one of the surest and best principles of geological reasoning. Those who, considering all these points, may still be in doubt regarding the chronological importance of the Tertiary Period, may be reminded that in the Mediterranean basin alone an aggregate thickness of over 23,000 feet of strata, largely composed of marine limestones, was formed in this period, and that the very materials out of which much of our largest mountain chains have been shaped had not come into existence in the form of rocks until a late period of Tertiary times.

Finally, if it can be shown, on sufficiently good grounds, that the changes that have taken place in a period so recent as the Tertiary Period require for their accomplishment a measure of time so much in excess of that which, on mathematical grounds, we are told is all that can be allowed for the time since it was first possible for life to exist upon the earth, then, I would respectfully submit, there must be some serious error in the data upon which those computations were founded. I venture to think that such must be the case, and in the concluding portion of this address I shall make bold to point out where it seems to me that some part of the error may possibly have crept in. In the meantime, geologists will probably agree with me in thinking that we may disregard the view I have referred to regarding the Age of the Earth. We may again advance, though most of my fellow-thinkers will agree with me in taking the lesson we have learned seriously to heart, so that when we do again advance, we may do so with much more cautious steps than many of us took before Lord Kelvin appeared at our head and gave us the order to countermarch.

Relation of the Tertiary Rocks to those of the Cretaceous Age.—In the Mediterranean region, and in the adjoining parts of Asia, no line can be drawn between the limestones of Eocene age and those referred to the Cretaceous Period. But in Western Europe the difference between the Eocene fauna and that of the Chalk is generally regarded as so great as to imply that a long interval of time elapsed between the formation of the two deposits. I shall endeavour to show that this difference is by no means as great as has been generally assumed. Moreover, an examination of almost every known section where the Lower Eocene Thanet Sands lie upon the Chalk, convinced me, over thirty years ago, that there is no trace whatever of any physical break between the two, or, at any rate, no more than might be expected to accompany a change of conditions from the warm surface-currents and the deep water of the Chalk sea to the colder surface-water and lesser depths of the sea in which the Thanet Sands were deposited. I therefore think it safer not to take into account, in the present connection, any interval of time which may possibly have elapsed between the close of the Chalk Period and the commencement of that during which the Eocene Thanet Sands were formed. The commencement of the period when the Nummulitic Limestone was formed immediately followed the close of the Cretaceous Period, and was not separated from this by any break.

Time required for the Formation of the Chalk.—The true measure of time required for the formation of the rock of any given geological period should be estimated with reference to the *maximum* thickness known to occur between an upper well-defined stage, characterised by life-zones whose contemporaneity over a larger area has been well put to the test by many observers, and a lower stage equally well characterised by its fossils. I would refer to the relation of the Moffat Terrane, with its graptolite zones, to their chronological equivalents in North Wales; or to the Lias, with its Ammonite zones, in illustration of what is meant here. If possible in making comparisons, sedimentary rocks of one petrographical type—such as there is reason to believe must have been formed at nearly the same rate through all geological periods—should be uniformly employed. Marine limestones are certainly the best for this purpose, except where, as in the case of some few rocks formed since Eocene times, these may happen to consist of true coral-reefs. The Chalk appears to me to be a typical deposit of this kind, as it was certainly formed in deep water, and at a rate sufficiently slow to admit of its including records of a long succession of changes of life—longer, I should think, than the whole of the period that has elapsed since its formation ceased on this part of the earth's surface.

In the neighbourhood of Southampton, and again near Norwich, the Chalk exceeds 1100 feet in thickness. On the east side of the North Sea it is even thicker than that. From bottom to top, it is almost entirely free from admixture with rock material of purely terrigenous origin, and its general petrographical character is that of a deposit formed under much the same conditions as the foraminiferal oozes of the ocean of the present day.

If we assume, as was done in the case of the Nummulitic Limestone, that 1 foot in 25,000 years fairly represents the rate at which limestones are now being (and have always been) formed, then, not taking into account any interruption of deposit, a thickness of 1100 feet of Chalk requires 27,500,000 years.

If this is the case, we need hardly marvel at the gradual disappearance of the Cephalopoda of the Chalk, nor at that of the great reptiles. According to the view here set forth, the Ammonites and Belemnites died out almost entirely within the Cretaceous Period itself. Only one Ammonite is known to survive to the period represented by the topmost bed of the Chalk, and the great reptiles appear, one by one, to have vanished from the face of the earth at an earlier period even than that. As for the lower Invertebrata, it cannot be too strongly insisted upon, as I pointed out many years ago, that the Gasteropoda and Lamellibranchiata of the beds next below the Chalk are very closely related to those which reappear in the Lower Eocenes, and especially in the Thanet Sands. Need I repeat that the same is substantially true of both the fishes and the plants?

Upper Greensand and Gault.—The base of the Chalk graduates downward in places into a glauconitic sand similar to that which is now being slowly accumulated in deep water off the east coast of Africa. This, in turn, graduates downward into the fine-textured marine clay, the Gault. The numerous biological changes to which the fossils in these rocks testify, necessarily denote long intervals of time. In the absence of any reliable data, we may perhaps assume that these rocks, as a whole, were formed at the rate of 1 foot in 5000 years. The Gault is 300 feet in thickness (or more), which, at the hypothetical rate suggested, gives us an interval of 1,500,000 years.

An important unconformity occurs at the base of the Cretaceous Series—one which implies so vast a lapse of time that it would appear to be desirable here to consider, first of all in general terms, to what conclusion phenomena of this kind are likely to conduct us.

Chronological Value of Unconformities.—There exists amongst geologists a considerable diversity of opinion regarding the time-value which should be put upon unconformities. On the one hand, there are those geologists who regard every unconformity as representing an interval of time which, in every case, is proportional to the thickness of strata missing, which interval of time they think should be added to the time required for the deposition of the quantity of rock removed. On the other hand are those who are disposed to regard all unconformities in the light of mere local, and purely accidental, phenomena, to which, in estimating the Age of the Earth, no importance whatever need be attached. There are others again, who, in spite of perfectly clear field-evidence, will persist in either inserting hypothetical unconformities between two adjoining groups of strata whose fossils happen to differ materially (as, for example, between the Chalk and the Thanet Sands, or between the Dyas and the Trias), or, otherwise, will ignore with equal persistence the time-value of an extensive unconformity such as that between the Lower New Red or Dyas and the Carboniferous and other rocks beneath, merely because a few fossils of low biological grade happen to have a sufficiently wide range in time to extend across the unconformity.

That unconformities have very different time-values in different cases, no field-geologist would be prepared to deny. All he would say regarding the general question is that each case must be judged entirely on its own merits, and that due regard must be paid in each case to both the physical and the biological aspects of the question. All unconformities must necessarily be, in one sense, local phenomena, and there must be, in every case, strata of some kind or other which have been formed in one part during the interval when waste and destruction were going on in another. This is only another way of stating the fact that the deposition of strata must have gone on continuously, and absolutely without break, over one part or another of the earth's surface, from the very beginning of its geological history down to the present day. It is only that the areas of deposit have gradually changed their positions, and that areas which at one time have been areas undergoing depression, have gradually changed phase and have become for a time areas of upheaval. There are many geologists who are of opinion that movements of these kinds have at one time or another affected every part of the earth's crust—in the course of long ages changing continental areas into oceans, or oceanic areas into land. However much geologists may differ upon this particular point, they are all agreed that earth-movements take the form of undulations. They would probably also mostly agree that these undulations differ widely in different cases in their amplitude, in their wave-length, and in their frequency. If, bearing these points in mind, they would take into account the fact (to which fuller reference will be made further on) that these terrestrial undulations progress, and roll, like great terrestrial tide-waves, from one part of the earth's surface to another, in the course of long ages, much of the difficulty that has been experienced in dealing with the subject of unconformities would no longer be felt. In each case, where it is possible to do so, we have to determine the amplitude, the wave-length, the locus of each wave-crest or wave-sinus at any particular time, the frequency of the undulation, and, finally, the direction of propagation. Geological evidence in a few cases supplies us with information upon one or more of these points, sometimes to an extent sufficient to warrant us in coming to fairly definite conclusions regarding the chronological value of particular unconformities. In other cases the information is very scanty, and we can only form our conclusions upon this point after studying a considerable number of collateral facts.

In pursuing the study of unconformities, there are many pitfalls into which the unwary inquirer may readily slip, and in this matter perhaps more than in most other geological subjects it is necessary to proceed with the greatest possible caution. In the case of one unconformity which will be considered in some detail presently, a particular stratum can be shown to lie across, or overstep, the edges of various strata whose collective thickness amounts to several miles. In a case of this kind we have to be quite sure (1) that the collective thickness referred to actually represents the thickness of strata which are known to have covered the lowest stratum overstepped at some time prior to the deposition of the overstepping stratum. (2) We have to assure ourselves that the unconformity in question is not wholly or in part contemporaneous, *i.e.*, whether in the case referred to the denudation of the strata did not commence at one part, while the deposition of the higher and newer strata of the same series went on in another—the areas of denudation and deposition lying within the area now overstepped by the unconformable bed. (3) We have further to assure ourselves that the unconformity in question belongs wholly to the period following the close of the formation of the highest bed overstepped, or whether it may with more probability be distributed over more than the one period. (4) And finally, we have to take into account both the nature of the denuding agency and the relative destructibility of the strata removed. If we are sure upon all these points, we may make our calculations with more or less confidence. As an illustration of what is meant, it may be mentioned here that the Upper Cretaceous Rocks of Britain (and of Western Europe in general) lie upon the upturned and denuded edges of strata, extending from the summit of the Neocomians across the whole of the Jurassic Rocks, the New Red, the Carboniferous, the Devonian, and even on to rocks in Scotland which are almost certainly of Pre-Cambrian Age. Over all these strata, collectively many thousands of feet in thickness, the Upper Cretaceous Rocks lie with an evenness of base which is little short of marvellous.[1] Yet we must be on our guard against supposing that the whole thickness of these strata was actually removed by denudation at this period. All that can confidently be stated is that the edges of the strata were planed to their present even form just before the Cretaceous strata were laid down. The total thickness of rock that can safely be regarded as having been removed by denudation which followed the Jurassic-Wealden Period and preceded the Neocomian and Cretaceous, is the aggregate thickness of the strata extending downward from the top of the Wealden to the base of the Upper New Red. We can easily satisfy ourselves that, traced westward along the southern parts of England, the Upper Cretaceous strata overstep the edges of the whole of the strata which are enclosed between the summit of the Wealden Rocks and the base of the Inferior Oolite. The Cretaceous Rocks of course lie upon strata of Neozoic Age much older than that — but we can be quite sure that the thickness referred to did actually at one time exist, and was removed by denudation prior to the deposition of the strata that succeed. The total thick-

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[1] I have long taught in my lectures that the peneplain of the Highland mountains, and of the mountain tops in the North of England, is the "modified descendant" of this Pre-Cretaceous plain, upheaved, and re-exposed by subsequent denudation of the Cretaceous Rocks.

ness of strata referred to consists of 2000 feet of the Wealden and 2400 feet of the Jurassics. This estimate does not take into account the thickness of the Lias (1340 feet) nor that of the New Red (fully 2500 feet), because there would appear to be some evidence that these strata were contemporaneously denuded during the formation of the later-formed rocks. To these rocks so removed we might well add the thickness of the Lower Greensand; but as there appears to be still some doubt in the minds of a few geologists regarding the physical relationship of these rocks to the strata above and below, I have thought it better in this connection to leave them out of account.

Now if we are to go upon the principle that we must, as far as possible, interpret the past by the present, we are justified in assuming that after the Wealden strata were formed, and before the Gault was laid down, strata to a thickness of 4400 feet were tilted and denuded. If this denudation went on at the rate of 1 foot in 3000 years, this implies an interval of time of 13,200,000 years. Further investigation may, possibly, lead to this estimate being somewhat modified; but, in the meantime, what other estimate can be made? If we abandon the principle of interpreting the past by the present, we shall be ignoring one of the foremost principles upon which all modern geological reasoning is based. I would much prefer to state my conclusions arrived at after due consideration, let them be in accordance with the beliefs at present in fashion or not, rather than make any departure from moderately uniformitarian principles.

We now retrace our steps, and consider here the *Time required for the Formation of the Lower Greensand.*—Strata of this age occur between the Wealden and the Upper Cretaceous Rocks in the south-east of England. They consist largely of glauconitic sands of undoubted marine origin, together with marine clays, and beds of chert, which are largely composed of sponge spicules. Whether regarded from a physical or from a biological point of view, these strata must have taken a long time to form. But in the absence of reliable estimates, I shall be content to assume that they were formed at the rate of 1 foot in 3000 years. This, at a thickness of 800 feet, gives 2,400,000 years, an estimate, again, which palæontologists, taking the life-history of the period into account, will probably regard as far too small.

Wealden-Jurassic Series.—Prior to the great Pre-Cretaceous unconformity, there was formed in the south of England more than 5700 feet of strata without any break—to wit, Wealden 2000, Oolites and Lias 3700. These largely consist of limestones, which show every sign of having been very slowly formed. It has been said that some of the limestones are simply old coral-reefs, and on that account it has been assumed that their rate of formation has been comparatively rapid. But the important fact seems to have been overlooked that the Jurassic Limestones do not occur as great upstanding masses which end off all round with great abruptness, but, on the contrary, they are distinctly well-stratified deposits, showing every sign of having been laid down upon the sea-bottom in precisely the same manner as the majority of other limestones; and, like these, are remarkably persistent over large areas. Corals occur in them in abundance; but there is an important difference between a limestone full of corals and a coral-reef. It may well be doubted whether the reef-building habit amongst corals can be traced back in time farther than the Miocene Period at the farthest.

Taking the Jurassic-Wealden series as a whole (and including the *marine* Wealden of the south of France), more than one-third of the entire thickness (or 2000 feet) consists of limestone. Assuming, as before, that each foot of this marine limestone took 25,000 years to form, the time required for this alone amounts to 50,000,000 years. We have to add to that the time required for the marine clays (which may be regarded as constituting another 2000 feet), 1 foot in 3000 years, to put it at the highest rate, another 6,000,000 years. To these add the time required for the formation of 1700 feet of sandstones. These Jurassic Sandstones I should be disposed to regard as having been formed at the rate of 1 foot in 2000 years, which makes an additional 3,400,000 years. This, in all, makes the period required for the evolution of the many successive changes of animal and plant life, which are so conspicuous a feature in the geology of the Jurassic-Wealden period, 59,400,000 years.

The New Red Rocks (Dyas and Trias).—At several localities in Britain, as is well known, a considerable thickness of rock, formed mainly under desert conditions, underlies the Jurassic Rocks proper. Their upper limit is marked by the (Marine) Rhætic Rocks, which contain a very well-defined fauna, and which graduate upward into the base of the Jurassic Rocks. Their lower limits are extremely variable—perhaps on account of their having been formed under terrestrial conditions—perhaps partly on account of more-than-usually-local flexures of the subjacent surface arising through differential subsidence. The aggregate maximum thickness may be fully 4000 feet; yet the higher members overlap in succession every one of the lower in one part or the other of Britain. Wherever the series exists, it is practically one conformable series from the top to the bottom. On the other hand, the base lies in one part or another with a violent unconformity upon every rock older than itself.

Low down in the series occurs, in places, a band of Magnesian Limestone, whose fossils, and especially the Invertebrata, show a certain affinity with those of the Carboniferous. This affinity, however, is by no means as close as was believed up to a few years ago, as many fossils supposed to have come from the Dyas really came from stained rocks of Carboniferous age. The fossils of the Magnesian Limestone, whatever their affinities may be, are sufficiently marked in character to enable one to trace the English Magnesian Limestone, by the aid of its fossil contents, far to the east of the British Isles. On the Continent, therefore, we can trace the upper limit of the New Red by means of the Rhætic strata into central Europe, and we can follow the Magnesian Limestone by the same clue almost as far. Important changes in the nature of the beds between these two platforms set in; and in place of a series of desert-formed rocks we find, in the Tyrol, thick masses of Marine Limestone. I have before suggested that we should employ as far as possible a uniform system in comparing strata of different ages, and should take everywhere as our type-deposit a marine limestone, and name the rocks in question from the locality where the marine calcareous type is best seen and most fully developed. I propose, therefore, that we should employ the name TYROLIAN for the Trias, just as we use DEVONIAN as the type form of the strata that were deposited while the Old Red Sandstone was being laid down. I should like to go further in this same direction. The Lower New Red (Dyas, or so-called "Permian") also takes on a marine facies in the Mediterranean region, being represented there by a considerable thickness of marine limestone, which in Sicily, near Palermo—the *Panormus* of the ancients—has yielded a most interesting and extensive set of fossils, including many Ammonites. I would suggest that the name PANORMIAN might fittingly be applied to this, the type-deposit of the same age as the Lower New Red, Dyas, or "Permian." So far as we are concerned in the present inquiry, the chief point of interest and importance is that the New Red Series is represented on the Continent by a thick series of marine limestones (the Tyrolian and Panormian Rocks), which fill up the *later* part of the vast chronological hiatus between the Carboniferous Rocks and those of Jurassic age. The abundance and variety of Ammonites in the Panormian, shows that we are dealing with the upper part of the intermediate series; but as there is just a possibility that the Panormian Rocks may represent not only our own Lower New Red or Dyas, but also represent in time part of the gap to be presently referred to, I propose for the present purpose to leave it out of account, and to compute the time with reference only to the marine limestone of the Rhætic and Tyrolian series. These are said to be "several thousands of feet" in thickness; but beyond this vague estimate there appears to be well-authenticated measurements of more than 3500 feet of marine limestone, largely made up of marine lime-secreting algæ. Taking the same figures as before, 3500 feet of limestone at 1 foot in 25,000 years, gives us 87,000,000 years. Again would I remind the reader of the enormous biological changes which took place in the interval —the development of the Anomodont reptiles from the

Amphibia, the evolution of the Ammonites, in short, the incoming of the new order of life, which is so marked a feature of the palæontology of these rocks, and which has led systematists to make the great dividing line between the Deuterozoic Rocks and those of Neozoic age coincide with the base of our New Red.

It is, of course, obvious that whatever time was required for the formation of Tyrolian Rocks, the same time must be required also for their British equivalents, the thin marine Rhætic Rocks and the 2500 feet of desert rocks which form the Upper New Red or Trias. Regarding the Panormian and its British equivalent, the Lower New Red or Dyas, I can offer no estimate; but as the sandstones of the Lower New Red were evidently formed under the same conditions as those of the Upper, we have to add on some unknown figure to the above. This, in the present state of our knowledge, we may here leave out.

Unconformity below the New Red in Britain.—There can be no reasonable doubt that the base of the Upper New Red in Britain is contemporaneous with the base of the Upper New Red—and therefore of the Tyrolian—on the Continent. We have next to consider the relation of this base to the older rocks in Britain. Briefly, it may be stated to be one of considerable and extensive unconformity. Not only were the older rocks folded, contorted, and faulted, but they were afterwards subjected to enormous denudation. This certainly happened in the interval following the close of the Upper Carboniferous Period, and preceded the deposition of the New Red itself. In the Bristol area the Upper New Red oversteps the denuded edges of the faulted and highly-disturbed rocks of Carboniferous age, as well as the whole of the Upper Old Red. There can be no question in this case of either non-deposition or of contemporaneous upheaval and denudation, as the Carboniferous strata are repeated on either limb of several anticlinals, and their strike is perfectly independent of that of the New Red. In this case, therefore, we have clear evidence of the removal by denudation of 15,000 feet of strata after the formation of the Upper Carboniferous Rocks, and before the deposition of the

Upper New Red. The evidence afforded by the Bristol area does not stand alone in this respect, but is abundantly confirmed by the relation of these rocks to each other in many different areas.

More than that, in Devonshire the New Red Rocks overstep not the whole of the Carboniferous, but most, if not the whole, of the Devonian Rocks as well. Possibly this latter feature may be attributable to an unconformity between the Upper Old Red and the Devonian Rocks, similar to that in Ireland between the Upper Old Red and the Glengariff Grits, and in Scotland between the Upper Old Red and all the rocks older than itself, including the Orcadian Old Red and the Caledonian Old Red.

If we assume that this unconformity in the Bristol area represents the removal of 15,000 feet of strata at the rate of 1 foot in 3000 years, that adds 45,000,000 years to our chronology.

Time required for the Formation of the Carboniferous Rocks.—Speaking in very general terms, the Carboniferous Rocks of England and Wales may be said to be divisible into two sections—Upper Carboniferous, which in Britain is certainly a terrigenous deposit, formed at no great distance from the land, probably as part of a delta; and Lower Carboniferous, which in England, Wales, and Ireland, is certainly in the main a marine deposit formed in moderately deep water in the southern parts of the kingdom, and in shallower water in Scotland. In some districts where fossils have not yet given the clue, there exists a little uncertainty as to where the dividing-line between the Upper and the Lower division should be drawn. In other districts, both physical and palæontological evidence point to the existence of an unconformity between them, as there is a very marked discrepancy between the vertebrate faunæ of the two divisions,[1] and the discrepancy between the fossil floras is not less pronounced.[2] For the present purpose, it will suffice to regard the rocks of the Severn basin as fairly typical of the whole series, and to base our estimates upon the facts we can glean from a study

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[1] Traquair, Proc. Roy. Soc. Edin., vol. xviii. (1890), p. 387; Geol. Mag., Dec. iii., vol. i., pp. 115–121.

[2] Kidston, Proc. Roy. Phys. Soc., 1894.

of the Carboniferous Rocks of that part. In the area referred to, the Upper Carboniferous Rocks (including under that term, for the present purpose, all the rocks from the highest remaining Coal-Measures to the top bed of the Carboniferous Limestone) are estimated to be fully 12,000 feet in thickness. These consist of alternate beds of sandstone, shale, fireclay, and coal. In dealing with these strata, we are forced to confess that we have not, and probably may not obtain yet for many years, any reliable estimate of the several rates at which delta deposits are at present being laid down. The most that can be done in the present state of our knowledge is to form an estimate from the "Challenger" maps of the ratio between the superficial area occupied by the purely terrigenous deposits now in process of formation, to compare this area with the area of the land whence drainage finds its way seaward, and then on this basis compute the proportion between the area of deposit and the proportion of material mechanically carried seaward by rivers. In the case of lime-salts, a question of this kind is simplified by the fact that, owing to rapid diffusion of matter carried in solution, especially lime-salts, an excess of these poured into the ocean by the rivers of one area is rapidly equalised by diffusion over the entire ocean area. An average rate, computed from observation made upon several rivers in different parts of the globe, therefore holds good for the whole. With terrigenous deposits the case is widely different. No diffusion worth considering appears to take place. On the contrary, each river has its own rate of deposit, which again, unlike the rate of diffusion of solutions, may be very different now from what it was at the same spot in former times, when different conditions obtained. Further, the matter is complicated by oscillations of level of the land, and by the fact that, unlike calcareous deposits of marine origin, marine terrigenous deposits tend to be more or less lenticular in form.

A rough estimate, however, based upon a comparison of ocean-drainage areas to the area of the terrigenous deposits in each case (the volume being yet unknown), gives us the following:—In the Indo-Chinese area the superficial area of the terrigenous deposits is to the drainage area about as two-thirds to one. In the Eurasian Atlantic drainage area the extent of the terrigenous deposits is to that of the oceanic drainage area also as two-thirds to one. On the other hand, the North American Atlantic drainage area gives rise to a much smaller fringe of terrigenous deposits, which form certainly less than half the area from which their materials are derived. In the South American Atlantic drainage area the terrigenous deposits occupy not more than one-third of the area of the land. In this case, as in the case of Africa, the proportion appears to be smaller than it really is, because the terrigenous deposits fall rapidly into deep water, and their superficial extent is therefore less in proportion to the thickness than it might otherwise be. As pointed out above, we can have no definite estimates of the rate of formation of delta deposits (not, at any rate, in terms of feet per century) until we know the amount and nature of the material transported, the rate of subsidence, and the strength and direction of the marine currents outside the delta. What we require to know is not so much the *area* alone which is formed in a given delta in a given time, as the *thickness* which is deposited in that time.

Dr John Murray's figures and maps give us as the total area of ocean drainage 44,211,050 square miles, and 27,899,300 square miles as the approximate area of terrigenous deposits. This is in the proportion of rather more than one and a half of drainage area, or area of denudation, to one of the ocean area over which terrigenous deposits are being laid down. This would seem at first sight to imply that the deposition of strata goes on half as fast again as denudation, and that a foot and a half of strata is laid down upon the sea-bed in the same time that is required to strip one foot of rock from the general surface of the land. That this is far from being the case will be evident when we consider that a large part of the sand and loam transported seawards from the land finds a resting-place close to the land itself. It is readily conceivable that loam (which is a mixture of fine sand with a small percentage of clay) should be laid down at the rate, say, of 1 foot in 2000 years. The finer clay, however, drifts far and wide before it subsides, and we should probably not greatly err in estimating the rate of formation of the clays and shales of the Upper Carboniferous Rocks if we set that rate at 1 foot in 3000 years. Now, the Upper Carboniferous Rocks of the South Wales Coal-field are said to be 14,000 feet in thickness. Of these, about half the thickness may be set down as sandstones, and the remainder of clays of one kind or another, together with coal-seams. Seven thousand feet of sandstone, if formed at the rate of 1 foot in 1500 years, give us 10,500,000 years; while 7000 feet of clays, at 1 foot in 3000 years, give an additional 21,000,000. To this we have to add the time required for the formation of the 105 feet of coal, which is said to be the aggregate thickness found in the Upper Carboniferous Rocks around Manchester.

In regard to these one may remark, it may be possible to "hurry up" in estimating the rate at which sandstones and a few other deposits have been formed, but when we are asked to do this in connection with either limestones or coals, the case appears to me to be very different. One has to remember that all vegetation derives its fixed carbon from the atmosphere alone, and that it does this under the combined influence of solar energy and its own vital force. The proportion of carbon-dioxide at present existing in the atmosphere is very small, ranging from an average of ·04 % to a maximum of ·10 %. A larger percentage than this latter is said to be detrimental, rather than conducive, to the growth of vegetable life. The supply of carbon-dioxide, which balances the demand made by the formation of limestones (in every cubic foot of which 16,000 cubic feet of carbon-dioxide are locked up) and of coals (of which carbon constitutes from 60 to 90 %), is met partly by the products of animal respiration, partly by the products of the decomposition of organisms, both vegetable and animal, but mainly from exhalations from volcanic sources. In the formation of eruptive rocks, a large quantity of carbonates of lime and other bases must be constantly passing back into their initial stage, that of combination in the various silicates. In this process carbon-dioxide is now, as it must always have been, liberated in considerable volumes. Bischoff estimates that 1,855,000,000 cubic feet of this gas rise annually from the vicinity of the lake of Laach alone, and it is almost certain that quantities equally large are given off from many other volcanic areas, both active and quiescent, elsewhere. This is mentioned here as an answer to one objection which has been often advanced against basing an estimate of the Age of the Earth upon the rate of denudation now taking place; the ground upon which the objection was founded being that the quantity of carbon now locked up in our coals and limestones must formerly have existed in the atmosphere over and above the percentage which is now present. This excess (if present) would, as has been very rightly pointed out, most materially accelerate at least the chemical disintegration of rocks, and thereby indirectly increase also the rate of deposit. But for the reasons given here and above, I agree with those who think that we are not justified in assuming the existence of any such excess above the percentage just given, *i.e.*, an average of ·04 %, ranging to a maximum of ·10 %.

Many coal-seams are known to consist largely of spores and spore-cases of Lepidodendroid origin—the actual plants themselves constituting but a small percentage of the mass. This is not the place to enter into a discussion of the precise conditions under which the majority of coal-seams were formed,[1] but on any view of their origin this fact is one of the many that points to their extremely slow growth. Mr Kidston, in his Address to this Society in 1894, has shown us in the clearest possible manner that it is very far from being the truth that the same species of plants existed all through the Carboniferous Period, and therefore gave rise to the various coal-seams that occur from the middle of the Lower Carboniferous Rocks up to the highest coal-bearing horizon. There was, on the contrary, a gradual replacement of one species by another, which, as the physical conditions remained the same throughout all the subdivisions of the periods when coal-seams were being formed, points in the most unmistakable manner to the lapse of enormous intervals of time. What the actual time required for the formation

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[1] "Some of the Modes of Formation of Coal-Seams," J. G. Goodchild, Proceedings Royal Physical Society, vol. x., p. 97.

of a foot of coal may be has been variously estimated—no two persons agreeing even approximately. Professor Huxley ("Formation of Coal," *Contemporary Review*, 1870, p. 627) suggests a possibility of it being about 1 foot in 500 years. Boussingault estimates (*Smithsonian Report for* 1857, p. 138) that luxuriant vegetation at the present day takes from the atmosphere about half a ton of carbon per acre annually, or 50 tons carbon in 100 years. Fifty tons of carbon of the specific gravity of coal (about 1·5) spread over an acre would make a layer about $\frac{1}{3}$ inch (1 inch in 300 years, 1 foot in 3600 years). Professor Phillips "Life on the Earth," p. 133, calculating from the amount of carbon taken from the atmosphere, as determined by Liebig, considers that if it were converted into coal, with about 75 % of carbon, it would yield 1 inch in 127·5 years, or 1 foot in 1530 years. Humboldt's estimate is 1 foot in 1800 years. Croll estimates it at 1 foot in 1600 years.

These figures are given on the assumption that coal is a purely subaerial deposit. In studying the mode of occurrence of coal-seams in the field, I have, however, come to the conclusion that a fairly large percentage of coal-seams of Lower Carboniferous age represent the mean term of a series of rocks which have marine shale at one end and marine limestone at the other. I should infer from these facts that the rate of formation of the coals in question was intermediate in age as the seams are intermediate in geological position—between that of finely laminated marine clays on the one hand and marine limestones on the other. These Lower Carboniferous coals of submarine origin are marvellously persistent in both lithological character and geographical extent, and I fail to see any reason why they should not be fair representatives of the great majority of coal-seams of all other ages.

Whether many will agree with me or not in these conclusions is not very material, but the facts as they appear to me warrant us in assuming that the rate of growth of coal-seams went on at the rate of somewhere between 1 foot in 3000 years and 1 foot in 6000. If we take the rate at the lower of the two estimates, 105 feet of coal, which is the aggregate thickness of the coal-seams in the Upper Carboniferous Rocks near Manchester, gives us 315,000 years. This takes no account of any intermittent action during the formation of these coals, nor does it take into account the fact that north of Yorkshire all the Upper Carboniferous Coals belong chiefly to the Millstone Grit, or at the very highest to the Lower Coal-Measures of the Manchester and Bristol section. An additional 40 feet of coal would therefore need to be taken into account.

Recapitulating these figures, we have—time required for the formation of 7000 feet of sandstone, at 1 foot in 1500 years,	10,500,000
7000 feet of argillaceous beds, at 1 foot in 3000 years,	21,000,000
105 feet of coal, at 1 foot in 3000 years,	315,000
Total, Upper Carboniferous,	31,815,000

Possible Unconformity at the Base of the Upper Carboniferous Rocks.—When I joined the Geological Survey in 1867, the present Woodwardian Professor (then Mr T. M'K. Hughes) instructed me, while mapping the Carboniferous Rocks of north-west Yorkshire, to keep a look-out for evidence of unconformity at the base of the Millstone Grit, *i.e.*, at the base of the Upper Carboniferous Rocks. After a few years field-work at these rocks, evidence began to be apparent; and I am now convinced that, in the dales of north-west Yorkshire, and in the area extending thence towards Craven, the Ingleboro Grit (the bottom bed of the Upper Carboniferous Rocks) does lie across, or overstep, the higher beds of the Yoredale Rocks, which form the uppermost member of the Lower Carboniferous Rocks. Many facts, which seem to me otherwise difficult of explanation, are easily accounted for on the supposition that this unconformity extends over a wider area still. Palæontological evidence is not wanting in confirmation of this view. Dr Traquair has repeatedly emphasised the fact that the fish fauna of the Upper Carboniferous Rocks has hardly any species in common with that occurring in the Lower Carboniferous. This becomes a striking and significant fact when it is realised that the physical conditions under which most of the Lower Carboniferous Rocks of Scotland were formed were identical with those under which the Upper Carboniferous Rocks of the same part of the British Isles were accumulated. Mr Robert Kidston is equally emphatic upon this point in regard to the plants.[1] We cannot leave this unconformity out of account, and yet there are no means of forming even an approximate estimate of its duration.

Lower Carboniferous Rocks.—In dealing with these, I shall adhere, as before, to the plan of estimating the time by that required for the deposition of the maximum thickness of marine limestone found during the period—partly because we should, I think, take the marine limestones of each period on the typical or standard deposit; partly because we may safely assume that when we are dealing with marine deposits of organico-chemical origin like these, the rate of growth must have been the same (or nearly the same) in the case of at least all the limestones that have been formed from those of the Cambrian Period down to the Foraminiferal ooze of to-day.

The Lower Carboniferous Rocks of the Bristol and other areas consist of 2500 feet of marine limestone. This, at the rate of 1 foot in 25,000 years, would require 62,500,000 years.

Omitting any reference to the Lower Limestone Shales—which may be represented in Edinburgh by the greater part of the 2000 feet of the red and green beds below the volcanic rocks of Arthur's Seat, we have as a grand total for the Carboniferous Period, Upper and Lower, 94,315,000 years.

It has to be borne in mind that the top of the Coal-Measures is probably not left anywhere in Britain. Possibly it may be represented on the Continent by some of the beds called Permian in Bohemia.

Upper Old Red.—In places the Lower Carboniferous Rocks graduate downward into the true Upper Old Red—the Lower Limestone Shales forming the passage beds from the one to the other. This is the case, for instance, near Sedbergh in

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[1] See the Vice-Presidential Address before the Royal Physical Society in 1894.

Yorkshire, near Bristol, at various localities in Ireland, at Copeth ("Cockburnspath") on the Berwickshire coast, and, lastly, in the city of Edinburgh. In other places it appears to me that there is evidence of a certain amount of unconformity between the two formations—not on palæontological grounds alone, but also on physical. The Lower Carboniferous Rocks of Cumberland, for example, of East Fife, probably also of the Pentlands, appear to me to lie trangressively across the denuded ends of the older rocks, including the Upper Old Red, in a manner suggestive of something more than contemporaneous erosion. Messrs Lapworth and Watts ("Geology of South Shropshire," p. 331) refer to facts of much the same kind in that district. Although the unconformity may not appear to be great, it certainly coincides with the final disappearance of the very remarkable groups of fishes which characterise the Old Red. Personally, I doubt whether the geographical change from that of desert conditions and inland lakes to marine conditions affords altogether a satisfactory explanation of the phenomena. Lapse of time is a factor of equal importance, and all the evidence to the contrary in this particular case has completely broken down with advance of knowledge.

From the Upper Old Red Sandstone, petrographically considered, we can draw no conclusions of any value respecting the time implied in the formation of these rocks. But the researches of Dr Traquair have made known to us the fact that palæontological zones exist in the Upper Old Red as in other formations.[1] It is difficult to see how this could arise unless the formation of the rocks in question occupied a very long time.

In the absence of definite data, I am reluctantly compelled to omit this from the calculation. But, as will be seen presently, the marine Devonian of the Continent is probably contemporaneous with not only the lower parts of the Old Red series, but with the Upper Old Red as well, so that we shall count it in another connection.

[1] "Extinct Vertebrata of the Moray Firth Area," in Harvie-Brown and Buckley's "Vertebrate Fauna of the Moray Basin," vol. ii. Edinburgh, 1896.

Unconformity at the Base of the Upper Old Red.—In the English Lake District the Upper Old Red lies across, or oversteps, the ends of strata fully as much as five miles in thickness.[1] In Scotland it lies unconformably across all the strata older than itself. At the Old Man of Hoy, for example, the Upper Old Red forming the "Old Man" lies in a nearly horizontal position on the ends of beds very high up in the Orcadians, which are tilted, Dr Heddle tells me, at angles of 30° to 35°. Within a short distance the same Upper Old Red oversteps fully 7000 feet of the Orcadian Rocks there. I very strongly suspect, as already hinted above when discussing the New Red, that this same unconformity of the Upper Old Red upon the older rocks will be found, on closer examination, to extend into the areas occupied by the Devonian Rocks of Cornwall and Devon as well. In Scotland, as already noticed, it lies across not only the Orcadians, but across every member of the Caledonian Old Red in Perth and Forfar, and also in the Pentlands. In Ireland the same striking fact has been described by many observers. For reasons given below, however, I am disposed to leave this unconformity out of account.

Orcadian Old Red.—The Old Red Sandstone rocks of the Moray Firth, Caithness, Orkney, Shetland, and some other areas in the north-east of Scotland, are regarded by Sir Archibald Geikie as having been laid down in a different basin of deposit from those south of the Grampians. He has proposed for this basin the name of Lake Orcadie, a name which has suggested to other geologists the very suitable adjective Orcadian, which of late years has been much used in referring to these rocks. The Orcadians consist of a vast thickness, possibly many thousands of feet, of strata, which in the main have evidently been very quietly and slowly laid down in an area of inland drainage. Dr Traquair's researches upon the fish fauna render it certain that the formation of these rocks must have occupied a very long interval of time. To the consideration of this formation we shall return presently. It will suffice to repeat the statement here,

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[1] Silurian Rocks, 14,000 feet; Coniston Limestone and Borradale Volcanic Series, 12,000; Skidda Slates, 12,000 +.

that where it is covered by the Upper Old Red the relationship between the two is that of a strong unconformability.

Caledonian Old Red.—To the south of the Grampians, and perhaps also to the west, occurs another area of Old Red of considerable interest and importance. These rocks are in the main also of inland lake origin, and they include as well an important group of eruptive rocks. Sir Archibald Geikie, in his important memoir "On the Old Red Sandstone of Western Europe" above referred to, regards the greater part of these as having been deposited in a lake separate from Lake Orcadie, and for which he has proposed the name Lake Caledonia. I have found it very convenient, in describing these rocks, to convert this name into an adjective, and to speak of the rocks in question as the Caledonian Old Red. The precise stratigraphical relations of the Caledonian Old Red to the Orcadian cannot be made out by field-evidence alone. But the fish fauna of the Caledonian Old Red, Dr Traquair informs us, is of a decidedly older type than that of the Orcadian — and this appears to be the case even where fish from strata high up in the Caledonians are compared with the fish from the lower horizon of the Orcadians, as if the Orcadians, as a whole, were newer than the Caledonian Old Red. In the present connection this question is one of considerable importance, for if the two are of different ages, it is quite clear that one must have been formed before the other, and we have to take the sum total of the time required for the formation of both.

Lanarkian Old Red.—In the Pentland area the Upper Old Red lies with a strong unconformity across the Caledonian Old Red Rocks, which form the mass of the Pentlands, while these, in their turn, lie with a violent unconformity upon yet another series of Red Sandstones, whose close connection with the true Silurian rocks was clearly pointed out by Sir Archibald Geikie as far back as 1860 (*Quart. Jour. Geol. Soc.*, xvi., p. 312). The interrelations of the three Old Reds in the Pentland area are admirably summed up by the same author in "Siluria," 4th ed. (1867), p. 250, in these words: "It thus appears that, between the Grampians and the Cheviot Hills, what has been called 'Old Red Sandstone' consists of three zones—a *Lower*, graduating down into the Upper Silurian shales; a *Middle*, bounded both above and below by an unconformable junction; and an *Upper*, which shades up into the Carboniferous Rocks." This relationship is most clearly and accurately shown upon the "Horizontal" Section of the "Geological Survey of Scotland," Sheet 3, of which Sir Roderick Murchison gives a condensed diagram-section in "Siluria," 4th ed., p. 249.

Chronological Value of the Old Red Unconformities.—It appears to me that the complicated relationships existing between these several groups of strata do not warrant us in assuming, in this case at any rate, that we should be right in adding on to the time required for the actual formation of each subdivision of the Old Red other intervals of time which the unconformities would seem to imply. We are quite justified in taking it for granted that Sir Archibald Geikie's suggestions upon this point offer us a satisfactory explanation of some of the chief difficulties. According to this view, deposition and upheaval went on simultaneously in *closely adjacent* areas, so that older rocks were folded upward, and underwent denudation along one zone of the surface; while along a parallel zone, not many miles away, a downward phase of the terrestrial undulations gave rise to the conditions suitable for deposition. I have endeavoured to show elsewhere[1] that this was probably also the case in later Ordovician times in the north-west of England, where at one part there appears to be a perfectly unbroken succession from Lower Ordovician into Upper, while along another zone rocks of Bala age were deposited upon the upturned edges of the Lower Skidda Slates (? Upper Cambrian).

In the case of the unconformities connected with the various Old Reds, it appears to me that the facts warrant us in going further than this, and in assuming that the undulations to which Sir Archibald refers were not simple up-and-down movements confined to particular localities, but that they actually progressed in course of ages from one part to another. Early in the Silurian Period, according

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[1] "On the Stratigraphical Relations of the Skidda Slates," Proc. Geol. Assoc., vol. ix., No. 7.

to this view, an upward phase of undulation was established along a line nearly coincident with the structural axes of the present Southern Uplands of Scotland, the septum lying parallel to that, perhaps only a few miles to the north, and the main axis of depression farther north still. The effect of a gradual upheaval of that kind would eventually be to cut off, by slow degrees, the marine area in which the normal Upper Ludlow Rocks were in process of deposition, from the area to the north, which eventually passed into a lagoon. In this latter was deposited the material derived from the waste of the uprising area to the south, which went to form the red sandstones, whose remains are so well seen in Lanarkshire, and again in the heart of the Pentlands. In dealing with these several Old Reds, I have long found it convenient to distinguish this lowest member of the series from the others by some special name. As the rocks are best seen in Lanarkshire, where their true relations were first made out by Sir Archibald Geikie, I have ventured to term the whole of this lowest Old Red series the LANARKIAN Series. Probably most people will recognise the similarity of their stratigraphical relations to those of the Glengariff Grits, on the one hand, and to the Foreland Sandstones, or Lower Devonian Rocks, on the other; and as with these, some doubt may be entertained by many as to whether they should be classed as Ludlow or as a lower member of the Devonian series. What the full thickness of the Lanarkian Rocks was when complete we have no means of knowing; but I ventured to suggest during the Edinburgh Meeting of the British Association that the missing higher members of the series may at one time have included a band of marine limestone. Numerous blocks of such a limestone, containing an assemblage of fossils remarkably like those of the Devonian Limestone of Plymouth, occur in the conglomerate which unconformably overlies the Silurian and Lanarkian Rocks. Its Brachiopoda were at one time identified as Devonian by Davidson, and many of its numerous corals are certainly, to say the least of it, closely allied to those of the Devonian Rocks. On the other hand, it is unlike any Silurian Limestone yet discovered in Scotland.

Whether this represents a true Devonian Limestone in Scottish areas is, of course, open to question; but whether it does or not is immaterial for our present purpose. I conceive that a downward phase of undulation slowly advancing northward, went on concurrently with the northward advance of the axis of upheaval that originated to the south. Eventually this axis of upheaval reached the area where the Lanarkian Rocks had been deposited, and then they, in their turn, underwent denudation as they were carried upward by the advancing wave, and the products of their denudation, in turn, supplied materials for the Caledonian Rocks, which were then in process of deposition farther north. The upheaval referred to must have been considerable, for the Lanarkian Rocks are very greatly disturbed and crumpled—all of which implies *time;* for I presume that no geologist is prepared to maintain that any disturbances sufficiently intense to throw rocks into the vertical position, or even to invert them, could well take place anywhere near what was the surface for the time being. After a considerable denudation, a downward phase of undulation, which had been slowly travelling northward, reached the spot where the Lanarkian Rocks now lay, and then they were covered by the conglomerates which lie at the base of the Caledonian Old Red in the Pentlands, and eventually by the great volcanic series itself.

If the reader can conceive of a succession of such undulations travelling from the south northward, depressing one area after another in its progress from south to north, he will have little difficulty in realising the nature of the changes to which the various Old Reds, from the Lanarkian to the top of the Upper Old Red, are due. This view will explain how it happens that the Orcadian Rocks nearly, but not quite, pass upward conformably into the Upper Old Red; and, as Mr Peach has remarked, if we could trace the Orcadians perhaps only a short distance beyond the northern limit of the British Isles, we should probably be able to discover a perfect passage from these into the true Upper Old Red.

In dealing with this part of the subject, therefore, I am disposed to assign a comparatively small chronological value to the Old Red unconformities, as they appear to be due to undulations of much smaller wave-length, greater amplitude, and higher frequency, than we have reason to believe prevailed during many other periods. The nearest parallel case in progress at the present day seems to me to be the zone of country which embraces the Nile Valley and the borders of the Red Sea, where, apparently, terrestrial undulations of the same nature are throwing the earth's surface into close alternations of upland area and area of depression.

According to the view here taken, the time required for the formation of the Lanarkian Rocks, and their probable chronological equivalents the Glengariff Grits, is counted partly with that occupied by the formation of the Ludlow Rocks, partly with that of the lowermost part of the Caledonian Old Red; while to the time represented by the formation of the Caledonian Old Red (20,000 feet or more) will probably have to be added that represented by at least the upper half of the Orcadian Rocks, of the full thickness of which perhaps not more than two-thirds at present remain.

The true measure of time represented by the rocks at present referred to could be estimated probably with the nearest possible approximation to accuracy, if we knew the maximum thickness of marine limestone formed in the interval between the close of the Ludlow Period and the commencement of the Carboniferous. All we can say upon this point is that in the Continent at least 20,000 feet of marine strata of various kinds are referred to this horizon, and of these at least 5000 feet consist of marine limestone. There does not appear yet to be any precise figures in relation to this; but assuming that only 5000 feet of marine limestone were formed during the period when so many physical and biological changes went on in other parts, that alone gives us for the Devonian Period a time interval of 125,000,000 years. It may be remarked here that, where the Devonian Limestone attains this exceptional thickness, no unconformity can be traced between the Silurian Rocks and the Carboniferous. I have therefore taken no account of the unconformities in Britain, vast and otherwise important as they undoubtedly are. Biologists taking note of the many and important changes in life that took place during the Devonian Period will probably all agree that this interval, vast as it seems, is yet not more than sufficient to account for the biological phenomena observed.

Silurian (*Salopian*) *Rocks.*—In the English Lake District the Salopian Rocks, stated in ascending order, consist of (1) a conglomerate lying in places unconformably upon the Ordovician Rocks; (2) Graptolitic Mudstone, which, although rarely exceeding 50 feet in thickness, yet shows by both its lithological character and the organic changes recorded by its fossils, that its deposition must represent an interval of time of enormous length. This is almost certainly a deep-sea deposit, one probably formed on the very outer verge of the zone of terrigenous deposits of its time. Above this lies the Pale Slates, a rock whose lithological character also suggests that it had a deep-sea origin, and therefore that it also accumulated at a very slow rate. The aggregate thickness of these two is rarely more than 600 feet. Judging by the organic changes which took place in the interval between the commencement of the Graptolitic Mudstones and the close of the formation of the Pale Slates, the time implied must far exceed that required for the formation of the 12,000 feet of terrigenous deposits which make up (No. 3) the remainder of the Salopian Rocks of Westmorland.

About one-third of No. 3 consists of fine-grained greywackes, which contain a high percentage of quartz particles, and which, therefore, have probably been laid down as a fringe not very far from the margin of the old land, and, in consequence, at a comparatively rapid rate. The remaining two-thirds are of a more argillaceous character. Perhaps it would be safe to regard these rocks as consisting of two-thirds of rocks which were originally loams, and one-third which may be regarded as clays. The whole, of course, is of marine origin. From top to bottom this vast pile of rocks shows evidence of quiet deposition—a view of their mode of origin which receives further support from their uniformity of lithological character over large areas, and the fineness and evenness of their lamination. Their fossils, again, point to much the same conclusion.

We certainly have no reliable data on which to found an estimate of the time required for the formation of this enormous accumulation of marine deposits. The greywackes *may* have been formed at the rate of 1 foot in 2000 years; which, as their estimated thickness is 8000 feet, gives us 16,000,000 years for the whole of this section. The more argillaceous portion, which may be set down as about one-third of the entire thickness, *i.e.*, 4000 feet, must have been formed at a slower rate. If we set this rate at probably 1 foot in 3000 years, we shall be within the mark. This gives us an additional 12,000,000 years; making a total of 28,000,000 years for the Middle and Upper Salopians.

As for the time required for the accumulation of the deep-water graptolitiferous beds and the deep-sea clays which now form the Pale Slates, we can only judge by analogy. If the rate of palæontological change may be taken as a guide, then these two subdivisions of the Lower Salopian must have taken longer to form than the whole of the overlying 12,000 feet of greywackes and argillites. This view will, I am sure, commend itself to all palæontologists, and to the majority of the geologists who have studied these rocks in the field. I shall therefore add another 28,000,000 years for the formation of the rocks in question.

Unconformity at the Base of the Salopian Rocks in Shropshire and elsewhere.—Near Moffat, and at one or two other localities in Scotland, there is no clear evidence of any great physical break between the Salopian Rocks and the Ordovicians — probably because deep-sea conditions persisted there throughout the whole period from Arenig times to near the end of the Lower Salopian. In Ayrshire the break between the two is more marked. In Craven, as Professor Hughes showed many years ago, a well-marked unconformity exists—one to which I am myself disposed to attach much greater importance even than he did. In South Wales the unconformity between the Salopian and Ordovician Rocks is very pronounced. But it is in Shropshire, and especially in the Longmynd area, that the evidence of a break of enormous extent is most clearly to be seen. There the May-Hill, Llandovery, or Lower Salopian, beds are seen to overstep the edges of every member of the Ordovician Rocks, themselves 15,000 feet in thickness—the whole of the Cambrians, 3000 feet or more—and, finally, they overstep the edges of the older Longmyndian Rocks, whose thickness cannot be less than 8000 feet, and may well be between twice and three times that thickness. Taking the lowest estimate, this gives us for the total thickness of rock overstepped by the Salopians in the Longmynd area 26,000 feet (or possibly half as much more than that).

There can be no question here of *overlap* to any appreciable extent, as the Pentamerus Beds are present over nearly the whole area, which shows that we are not dealing with a case either of deposition of marine strata on the flanks of an old island, or of deposition in an area of very unequal subsidence. Nothing can be clearer than the evidence that the whole of the unconformity is pre-Salopian. But, on the other hand, there is abundant internal evidence to show that the whole of this vast hiatus cannot be referred to denudation following the close of the Ordovician Period. On the eastern side of the Longmynd area, at Caer Caradoc, the Bala Rocks repose directly upon rocks of Tremadoc age—the intermediate rocks of Lower Ordovician age, fully 10,000 feet in thickness within a short distance of this spot, being here entirely absent. Mr Watts informs me in a letter that in places the Salopian Rocks lie even upon the rocks of Longmyndian Age. Part, therefore, of the enormous gap occurring at the base of the Salopian in the Longmynd area is referable to an unconformity of pre-Bala age. I have mentioned above that the equally vast unconformity at the base of the Upper Old Red in the English Lake District is referable, in like manner, to the cumulative effect of several unconformities of widely different ages. The unconformity at the base of the Upper Ordovician

Rocks has a much wider extension than appears hitherto to have been recognised.

Returning to the Longmynd unconformities: we find the Cambrian Rocks themselves, in their turn, overstepping the edges of the old Pre-Cambrian Rocks of the Longmynd, and they are known to lie even upon the edges of a series of eruptive rocks—the Uriconians—which many competent geologists regard as unconformable below the Longmyndians themselves.

Ignoring these older unconformities, therefore, we need at this point only take into account the thickness of strata which there is reason to believe was removed by denudation after the close of the Ordovician Period, and prior to the deposition of the Lower Salopian Rocks. Taking this amount at 4000 feet, as shown by the Survey sections, this, at the average rate of denudation here employed, gives us an additional 12,000,000 years.

Time required for the Formation of the Upper Ordovician Rocks.—Confining our attention for the present to the Upper Ordovician Rocks of the Longmynd area, we find, from a measurement of the Geological Survey "Horizontal" Sections, that these rocks are fully 4000 feet in thickness, and consist mainly of marine sediments, together with some volcanic rocks. The general character of the series as a whole is suggestive of quiet deposition, while the changes in the faunas as the rocks are traced from below upward, point unmistakably to a great length of time. If we assume that, as a whole, this series was formed at no greater rate than that of 1 foot in 3000 years (which in this case, as in others of the same nature, seems to me to be a rate far too rapid), 4000 feet would require 12,000,000 years.

Unconformity at the Base of the Bala Series.—Considering that the Longmynd district has been repeatedly the centre of axes of upheaval, and considering, further, that volcanic action was rife throughout the older period there, it seems to me advisable to regard the unconformity which brings the Bala Rocks into direct contact with the Tremadoc strata on the east side of Caer Caradoc, as probably due to contemporaneous disturbances and upheavals of the same nature as those originally described by Sir Archibald Geikie in connection with the Lanarkian and Caledonian Old Reds; and, still more to the point, of the same nature as those I described in my paper "On the Stratigraphical Relations of the Skidda Slates,"[1] in which rocks of Bala age have been made to lie upon the upturned edges of the Tremadoc and older rocks of the northern side of the English Lake District; and, again, in the case of the Bala Rocks in Ireland, which repose upon the upturned ends of the Cambrians. I do not therefore consider that we are fully justified in counting the unconformity specially under notice, as it is probably, in part at least, contemporaneous in time with the Bala Rocks themselves.

Time required for the Formation of the Older Ordovician Rocks.—Still confining our attention to the Ordovician Rocks of the Longmynd area, we find that the collective thickness of the Llandeilo[2] and Arenig Rocks there is, according to the Survey "Horizontal" Section, fully 16,000 feet. Here again the rocks consist largely of marine strata, amongst which graptolitiferous mudstones bulk largely. This is especially true of the upper part of the series. The lower part, still marine, includes a large percentage of volcanic material, and, moreover, contains quartz-particles in abundance. But if we consider that the more rapid formation of the lower strata is compensated, or more than compensated, by the slow rate of accumulation of the upper, as evidenced by both its mineral character and the biological changes of which its fossils present a record, we should be well within the mark if we estimate that the formation of these Lower Ordovician Rocks, as a whole, went on at the average rate here assumed, *i.e.*, 1 foot in 3000 years. At this computation these rocks add 33,000,000 years to our roll.

Time implied by the Cambrian Period.—In general, the Lower Ordovician Rocks pass down conformably into the underlying Cambrians. In North Wales, near Harlech,

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[1] Proc. Geol. Assoc.

[2] I employ the term Llandeilo for those strata which occur below the pre-Bala unconformity, and which conformably succeed the rocks of Arenig age.

the Cambrian Rocks, properly so-called, are certainly not less than 13,000 feet in thickness. The Harlech and Llanberis Rocks, measured up to the base of the Menevians, are, according to my calculation on the ground, a little over 6000 feet. To this we have to add 200 feet for the Menevians, 5150 feet for the Lingula Flags, and 2000 feet for the Tremadoc Rocks. This gives a total thickness for the Cambrians of 13,350 feet, which is, if anything, below, rather than above, the mark. The Harlech beds are largely quartzitic, and may have been formed at a somewhat more rapid rate than that generally taken into computation here. On the other hand, the remaining strata consist largely of what must originally have been fine marine loam, mud, and clay, which were slowly and quietly deposited at some distance from the land. In dealing with these Cambrian Rocks, I should be disposed to modify the figures used generally in the foregoing computation, and to allow a somewhat higher rate for the formation of the Harlech and Barmouth Rocks, seeing that these consist largely of a coarse greywacke. If we set their rate of accumulation at 1 foot in 1000 years, this would probably be a fair average, seeing that these rocks include argillaceous bands in the proportion of about one-fifth of the whole. Taking their collective thickness at 6000 feet, this gives us 6,000,000 years.

The overlying Menevian strata contain a widespread, if thin, deposit of manganese ore (which, by the way, is a true bed, and not a vein), whose general aspect lends additional confirmation to the view suggested by its fossils that in this case we are dealing with a deep-sea deposit. It has already been stated that the petrographical nature of both the succeeding Lingula Flags and Tremadoc Rocks is also suggestive of quiet and slow deposition—a view equally well borne out by the fossils which occur in these rocks. I was so much impressed by these features when studying these rocks in North Wales a few years ago, that I should feel quite justified in setting their rate of formation at 1 foot in 5000 years. Their aggregate thickness in North Wales is 7350 feet, which, at the rate suggested, gives us a period of 36,000,000 years.

The Durness Limestone.—It happens in the case of the rocks of Middle and Upper Cambrian age that we are able to a certain extent to check the computation regarding their age by figures obtained from another source. In the north-west of Scotland the rocks containing *Olenellus* and a Lower Cambrian fauna (which correspond in time with the upper part of the Harlech Rocks) are overlaid by a thick mass of marine limestone—the Durness Limestone—whose higher beds yield fossils with a Tremadoc facies. This limestone would therefore seem to be the equivalent in time of all the North Wales strata from the base of the Menevian to the top of the Tremadocs. Mr Peach tells me it may be from 1500 to 2000 feet in thickness or even more, as its top is not known for certain. Relying upon these lower estimates, it would seem that the 7350 feet of argillaceous beds in North Wales are chronologically equivalent to 1500 feet of limestone in the north-west of Scotland, which is in the proportion of about four and a half of fine marine mud to one of limestone—a proportion which seems to hold good in other cases than this. If we take the time requisite for the formation of the Durness Limestone at 1 foot in 25,000 years, this gives us 37,500,000 years, which is an estimate not very different from that arrived at in connection with the Cambrian Rocks of North Wales.

Adding to this estimate the time required for the formation of the Lower Cambrian Rocks of Wales, we get for the whole Cambrian Period 42,000,000 years.

Summary regarding the Age of the Lower Cambrian Rocks :—

	Time in Years.
From the Commencement of the Tertiary Period to the Present Day, ...	93,420,000
Time represented by the Formation of the Chalk, Upper Greensand, Gault, and Lower Greensand, ...	31,400,000
Pre-Cretaceous Unconformity in Britain, ...	13,200,000
Time required for the Deposition of the Jurassic-Wealden Series,	59,400,000
Time represented by the Tyrolian and Panormian Rocks, . .	87,500,000
Unconformity at the Base of the Lower New Red in Britain, .	45,000,000
Duration of the Upper Carboniferous Period in Britain, . .	31,815,000
Carry forward, .	361,735,000

	Time in Years.
Brought foward,	361,735,000
Time required for the Formation of 2500 feet of Carboniferous Limestone,	62,500,000
Time represented by the Continental Devonian Limestones,	125,000,000
Duration of the Period represented by the Salopian (Silurian) Rocks,	56,000,000
Chronological Value of the Unconformity at the Base of the above,	12,000,000
Time required for the Accumulation of the Upper Ordovician Rocks,	12,000,000
Lower Ordovician Time,	33,000,000
Upper and Middle Cambrian Period,	36,000,000
Lower Cambrian Period,	6,000,000
Total since the Commencement of the Cambrian Period,	704,235,000

Concluding Remarks.—Seven hundred millions of years back from the present to the commencement of the Cambrian Period may seem to many persons far too extravagant an estimate to be for a moment seriously considered. Every one of the data upon which this estimate is founded will probably be regarded as absolutely untrustworthy, on the ground that they are avowedly based almost as much upon speculation as upon fact, and also upon the ground that I myself do not put these conclusions forward as a final answer to a very difficult question, and one which probably never will be answered with more than a very rough approximation to the real truth. If the estimate prove wrong in any particular, then the very rectification of the error in question will bring us a step nearer to the truth, and no one will rejoice more than I shall at finding what I feel is little else than a speculation, based as yet upon imperfectly-known data, replaced by facts and inferences therefrom which are of a more trustworthy character. Hypotheses have their use in Geology as much as in other branches of Science.

For my own part, I am quite prepared to find that, as our knowledge of Geology and Biology advances, we shall feel it necessary to extend rather than to abbreviate the estimate I have put forward.

Seven hundred millions of years carry us back to the

Commencement of the Cambrian Period, but not to the Commencement of Life upon the Earth. We have long known, thanks to the labours of fellow-geologists in Britain and in America, that the Lower Cambrian fauna contains representatives of all the chief forms of Invertebrate Life, and these are in most cases by no means of low zoological grade. No one who fully realises the import of Evolution as now understood can for a moment doubt that this fact points in a manner that is unmistakable to the inference that the Beginning of Life upon the Earth must be vastly more remote—perhaps as much farther back from Cambrian times as they are removed from our own. To me, to whom Geology is of interest chiefly as throwing light upon the past history of Life upon the Earth, this early appearance of highly-organised forms of Invertebrata suggests remarks sufficient to double the already considerable length of this Address. I must content myself, however, with referring the reader to the very thoughtful and suggestive address on this aspect of our inquiry which Professor Poulton delivered at the 1896 meeting of the British Association.

In regard to the physical and mathematical aspect of this question of the Age of the Earth, I, as neither a physicist nor a mathematician, can have but little to say. But, so far as I can judge, the late Dr Croll's "Stellar Evolution" supplied an answer to one of the main objections to any high estimate of the Earth's Age. Professor Perry, Mr O. Fisher, and others have done equally good work in the same direction, and have earned the thanks of all geologists for their labours in a good cause.

On my own part, I have only two suggestions to make, neither of which, I am told, is new, but of which both seem to me to have an important bearing upon the physical aspect of the present question. Each shall take the form of a query.

1. Is it certain that the whole of the downward increment of heat within the Earth is due to any vestige of the Earth's original heat? If not, why may not part of it be due to the conversion of the energy of motion arising from terrestrial

undulations (set up mainly by luni-solar gravitational energy) into the energy of heat?

2. Is it certain that radiant energy in general differs from gravitational energy in operating only between two solid bodies? If radiant energy acts only between any two material bodies, how do we know that the radiant energy of the sun, or the heat of the earth, is being dissipated into space at anything like the rate which is generally assumed to be the case?

XXII. *Some Additions to the List of Spiders collected in the Neighbourhood of Edinburgh.* By GEORGE H. CARPENTER, B.Sc., and WILLIAM EVANS, F.R.S.E.

(Read 15th April 1896, and revised for publication 1st October.)

Since the publication of our list of Edinburgh Spiders about two years ago (*Proceedings Royal Physical Society*, xii., pp. 527-590), we have—though not paying special attention to the group—obtained a few species not hitherto known to occur in the district, besides discovering additional localities for some of the less common kinds already recorded: these it may be well to place on record now.[1] There are also some changes in nomenclature to notice;[2] and we regret that through an error in identification one species (*Walckenaëra obtusa*, Bl.) must, for the present at any rate, be withdrawn.

The additional species, which for convenience we shall enumerate first, are five in number, making—with the 175 in our original list, less the one now cancelled—a total of 179 recorded for the neighbourhood of Edinburgh up to the present time. The names of the five are:—*Cnephalocotes interjectus*, Cambr., *Epeira cornuta* (Clk.), *Epeira umbratica* (Clk.), *Tibellus oblongus* (Wlk.), and *Ælurops insignita* (Clk.), the first and last being new to Scotland: indeed, the

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[1] As before, the field-work has been done entirely by Mr Evans.

[2] We confine ourselves at present to a few generally accepted changes in specific names.

Cnephalocotes has only once before been taken in Britain, namely, at Hoddesden, Herts; while the *Ælurops* has hitherto been noticed only in Dorsetshire and Hampshire.

I. ADDITIONS TO FORMER LIST.

Cnephalocotes interjectus, Cambr.

Among a number of small spiders obtained from under a stone in the lane behind Morningside Park, Edinburgh, on 26th September 1895, the Rev. O. P. Cambridge, who kindly looked them over for us, detected an adult male of this rare species. This is but the second British record. The species was described by Mr Cambridge in 1888 from a male taken at Hoddesden, Herts, and he has since received it from Holland.

Epeira cornuta (Clk.).

Epeira apoclisa, Bl. Spid. Great Brit. and Irel.

An adult male, a number of adult females in their nests, and many young examples were detected on marsh plants growing in a ditch on Luffness Links, Aberlady, on 27th August 1896. Having drawn attention, in the introductory part of our paper, to the absence of this fine spider from the list, we are the more pleased to be able to add it now.

Epeira umbratica (Clk.).

We are also pleased to be able to add this large though plain-looking *Epeira* to our list. In September 1894 a colony was discovered on some dead Scots firs standing on the edge of the wood skirting the north side of the Tyne estuary at Tyninghame, in East Lothian; and on 10th July 1895 a similar, though smaller, colony was found on dead poplars in a plantation opposite Luffness House in the same county. All the specimens examined (over a dozen) were females, mostly adult; but not wishing to destroy the habitats, we removed small portions only of the loose bark under which the spiders were concealed. Their large and somewhat untidy webs first attracted attention. Previously recorded Scottish localities are Braemar and Aviemore.

Tibellus oblongus (Walck.).

Philodromus oblongus, Bl. Spid. Great Brit. and Irel.

During September 1894 immature males and females were common on brackens at Hedderwick Hill Links, on the south side of Tyne estuary, East Lothian; and also on long grass on the salt-marshes at the upper end of the estuary. On 13th May 1895, two adult females were found on a wooden fence by the roadside at Glencorse Reservoir in the Pentland Hills; and in July 1895 an immature example was obtained off grass at Ormiston, East Lothian. Lastly, in September 1896, one was got off a young fir at Gosford. Dr Hardy has taken it in Berwickshire.

Ælurops insignita (Clk.).

Ælurops v-insignitus, Cambr. Spid. Dorset.

This fine spider was common on and at the base of the railway embankment between Burntisland and Pettycur, Fife, on 7th May 1895. The rapidity with which they hopped from stone to stone and disappeared in the crevices rendered the capture of a dozen males and half as many females (all, with one exception, adult) no easy matter. Heaths in Dorsetshire and Hampshire are, so far as we are aware, the only previously known British localities for it.

II. CHANGES IN NOMENCLATURE.

In view of recent investigations by the Rev. O. P. Cambridge and his nephew, Mr Fred. O. P. Cambridge, the results of which will be found recorded or referred to in the *Proceedings of the Dorset Natural History and Antiquarian Field Club* (vol. xvi., pp. 92-128, 1895) and in the *Annals and Magazine of Natural History* (ser. 6, vol. xv., pp. 25-41, 1895), it becomes necessary to alter the specific names under which several spiders appear in our original list.

Drassus cupreus, Bl.

Drassus lapidicolens, Cambr. Spid. Dorset (in part), *non* Blackwall, Spid. Great Brit. and Irel.
Drassus lapidosus, Carpenter and Evans, List Spid. Edin., p. 538.

The common *Drassus* of the district, which stands in our list under the older of Walckenaër's names—*lapidosus*—is, it would now seem, referable to the form to which Blackwall gave the name of *D. cupreus.* At any rate, a number of specimens (including adult males and females taken on Blackford Hill in May 1895) sent to the Rev. O. P. Cambridge since the publication of our list in 1894 have all been referred by him to this form; and he tells us he has only recently come to discriminate between it and the true *D. lapidicolens* (= *lapidosus*) of Walckenaër, and that he much doubts if he has yet seen the latter from Scotland.

Leptyphantes terricola (C. L. Koch).

Linyphia alacris, Bl. Spid. Great Brit. and Irel.; Cambr. Spid. Dorset.
Leptyphantes alacris, C. and E. List Spid. Edin., p. 555.

The Messrs Cambridge have come to the conclusion that Blackwall's *L. alacris* is identical with C. L. Koch's *L. terricola,* which, being the older name, has therefore priority over the other.

Leptyphantes blackwallii, Kulcz.

Linyphia terricola, Bl. Spid. Great Brit. and Irel.; *L. zebrina,* Cambr. Spid. Dorset, but apparently not of Menge; *Leptyphantes zebrinus,* C. and E. List Spid. Edin., p. 556.

Blackwall's *L. terricola,* being a different spider from that to which C. L. Koch had previously given that name, and being also different, it would seem, from Menge's *L. zebrina,* has had to be renamed. This has been done by Professor Kulczynski, who has recently ("Araneæ Hungariæ," tom. ii., pars i., p. 70, 1894) named it *Leptyphantes blackwallii,* which has therefore to be substituted for *L. zebrinus* in our list.

Leptyphantes tenuis (Bl.).

Linyphia tenuis, Bl. Spid. Great Brit. and Irel.; *L. tenebricola*, Cambr. Spid. Dorset, but not of Wider; *Leptyphantes tenebricolus*, C. and E. List Spid. Edin., p. 557.

Another result of the recent investigations above referred to has been to show that the *L. tenebricola* of Cambridge's "Spiders of Dorset" is not the *L. tenebricola* of Wider, but must be restricted to the *L. tenuis* of Blackwall. The latter name has, therefore, to be substituted for the other in our list. Mr Cambridge has specimens of the true *L. tenebricola* of Wider from "Scotland" (exact locality not known), so that it will probably be found in our district in time. All the specimens we have recently sent to the Messrs Cambridge have, however, been referred by them to *L. tenuis* (Bl.).

Tetragnatha solandrii, Scop.

Tetragnatha extensa, Bl. Spid. Great Brit. and Irel. (in part); Cambr. Spid. Dorset (in part); C. and E. List Spid. Edin., p. 578.

Since the publication of our list, Mr Fred. O. P. Cambridge has examined a large number of specimens (including ours) of *Tetragnathæ* from England, Scotland, and Ireland, and has found no less than four species besides the true *Aranea* (*Tetragnatha*) *extensa*, Linn. (the name hitherto applied to all British examples), represented. Those from the localities given in our paper he refers to *T. solandrii*, Scop. Specimens taken in May 1894 on a moor about two miles south of Callander he refers to *T. extensa* (L.), and this is the nearest locality from which we have as yet had it authenticated.

III. ADDITIONAL LOCALITY-RECORDS, Etc.

Drassus blackwallii, Thor.—This is one of the four species included in our list which we had not ourselves detected in the district. To the locality mentioned by Mr Cambridge (Arthur's Seat), we are now, however, able to add another, namely, houses in Aberlady, where, in August 1896, we obtained an adult male (which Mr Cambridge has seen) and two females.

Clubiona reclusa, Cb.—Up to the time our paper went to press, we had not detected an adult male of this species in the district. In July 1894, however, we found one, which we submitted to Mr Cambridge, among heather, etc., in a wood near Kirknewton.

Amaurobius ferox (Wlk.).—In the spring of 1895 two adult females were brought to us from a stable in Blackford Road, Edinburgh; and, in September 1896, one was obtained in a house in Aberlady.

Theridion pallens, Bl.—Fairly common on fruit-trees on garden wall, Tynefield, East Lothian, August and September 1894; also a few in Yester grounds, September 1896.

Pedanostethus neglectus (Cb.).—An adult male, Gifford, 16th September 1896.

Linyphia montana (Clk.).—Common in garden at Tynefield, near Dunbar, August and September 1894.

Porrhomma pygmæum (Bl.).—A number of males and females off bushes near Kirknewton, 3rd May 1895.

Hilaira uncata (Cb.).—Female near Kirknewton, 3rd May 1895; male and female, Torduff Hill, Pentlands, 19th March 1896.

Tmeticus hardii (Bl.).—On 31st December 1895, eight or nine males and four females (all adult) were obtained under stones, etc., lying close to the shore on Dirleton Common, East Lothian—identification confirmed by Mr Cambridge. This is the first occasion on which the female has been found in the British Isles; it is being figured by Mr Cambridge in the *Proceedings Dorset Nat. Hist. and Antiq. Field Club.*[1]

Tmeticus abnormis (Bl.).—Pentlands to east of Bonaly, 5th February 1896, adult female.

Tmeticus rufus (Wid.).—Adult males and females (especially the former) abundant under stones at foot of North Berwick Law, 2nd January 1896.

Tmeticus reprobus (Cb.).—Adult males and females again

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[1] In a recent paper in *Proceedings Berwick Nat. Club* (vol. xv., p. 117), I stated that this spider had not been found in Britain, except in Berwickshire and East Lothian. Mr Cambridge, however, informs me that he has an adult male from Cambridgeshire, which was recorded in *Proceedings Cambr. Phil. Soc.*, vol. vi. (1888), p. 301.—W. E.

abundant under stones embedded in cast-up seaweed near Aberdour, 4th March 1896; male, Aberlady, September.

Gongylidium agreste (Bl.).—Adult male, neighbourhood of Edinburgh, October 1896—identification confirmed by Mr Cambridge.

Tiso vagans (Bl.).—Adult male, Winton, East Lothian, 4th July 1895.

Dicymbium nigrum (Bl.).—Adult male, near North Berwick, January 1896; another at Macbiehill, Peeblesshire, 2nd April 1896. Our previous records were all for autumn.

Dismodicus bifrons (Bl.).—Two adult males under stones on Pettycur Links, 7th May 1895.

Savignia frontata, Bl. = *Diplocephalus frontatus* (Bl.).—Curiously enough, the true female of this common spider has not yet, it seems, been described or figured. In the *Proceedings Dorset Nat. Hist. and Antiq. Field Club*, vol. xv. (1894), Mr Cambridge gave a description and figure of what he took to be the female, but he has since come to be of opinion that he was mistaken in so regarding it. On learning this, we were able, in November last, to send him a number of undoubted specimens, from which a fresh description and figure will be given in the Club's *Proceedings* for 1895.

Typhocrestus digitatus (Cb.).—Two adult males under stones on Dirleton Common, 31st December 1895.

Aræoncus humilis (Bl.).—A few adult males under stones in lane behind Morningside Park, Edinburgh, 26th September 1895.

Lophocarenum parallelum (Bl.).—Two males and one female, Longniddry, 28th February 1896; one male, Aberdour, 4th March 1896—shown to O. P. Cambridge.

Lophocarenum nemorale (Bl.).—Two adult males, North Berwick Law, January 1896, and another near Colinton, October.

Plæsiocræus permixtus (Cb.).—Adult male, among *sphagnum*, Pentlands above Bonaly, October 1896.

Plæsiocræus alpinus (Cb.).—Mortonhall, adult male among leaves, 2nd April 1895; North Berwick Law, two males and two females, January 1896; near Longniddry, adult male, 28th February; Kirknewton, adult male, 21st March.

Seems to be more generally distributed than we formerly supposed.

Caledonia evansii, Cb.—Since the publication of our list, Mr Cambridge has described and figured (*Proceedings Dorset Nat. Hist. and Antiq. Field Club*, 1894, vol. xv., p. 111), as the female of this species, a spider taken by us on the Pentland Hills in October 1893.

Wideria antica (Wid.).—Adult male, wood near Kirknewton, 15th April 1895; female, Torduff Hill, Pentlands, 19th March 1896.

Walckenaëra nudipalpis (Westr.).—In addition to Luffness fir wood (the only locality we gave for this species), we must add Pentlands (between Glencorse Reservoir and Currie Moor)—the male spider obtained there on 14th September 1893, and recorded as *W. obtusa*, having proved, on further examination, to be really a specimen of the closely allied *W. nudipalpis.*

Walckenaëra obtusa, Bl.—This must, in the meantime at any rate, be withdrawn from the list, the supposed specimen being, as above explained, an example of the previous species.

Prosopotheca monoceros (Wid.).—An adult male found under a stone on Dirleton Common, 31st December 1895—identification confirmed by Mr Cambridge.

Epeira cucurbitina (Clk.).—An adult female, off fir, Tyninghame, September 1894; and another on trunk of beech, Falkland, Fife, August 1895.

Epeira agalena, Wlk.—A good many (immature) beaten off pines on north side of Tyninghame Bay, September 1894.

Oxyptila atomaria (Panz.).—An adult male (our first from the district) under a stone by Braidburn path, 9th May 1895.

Euophrys erraticus (Wlk.).—Common in cocoons under stones on south side of North Berwick Law, January 1896—all immature; on stones, east end of Gosford Bay, August 1896, several, likewise immature.

Note.—On 6th March 1897 Messrs T. Scott, F.L.S., and J. Lindsay discovered *Argyroneta aquatica* in the small loch on the top of the Braid Hills (see *Annals Scot. Nat. Hist.*, 1897, p. 126).

XXIII. *The Origin of the Bituminoid Cement of the Caithness Flagstones.* By J. G. GOODCHILD, H.M. Geol. Survey, F.G.S., F.Z.S., M.B.O.U.

(Read 20th January 1897.)

It has long been known that the remarkable tenacity to which the Caithness Flagstones owe so much of their commercial value is largely due to the high percentage of bituminoid matter by which their constituents are cemented. It is this cement which enables cliffs of these rocks to withstand the action of the sea, which they do even in those cases where they are thinly bedded, and are at the same time traversed by well-marked joints cutting undeviatingly through a considerable thickness of rock. Analyses of the Caithness Flagstones show that some parts of these rocks contain as much as thirty per cent. of bituminoid matter. This permeates certain bands of the rock to such an extent, Dr Traquair tells me, that a microscopic examination of the organic tissues of the embedded fossils is often rendered next to impossible. In the field, too, the large quantity of bituminoid matter present causes this substance to exude from the rock-surfaces in a manner that reminds one of the resin given off from fir trees. A fact of this kind could hardly fail to attract attention from commercial men; and accordingly we find that it has more than once been seriously proposed to work these bituminiferous bands for the distillation of paraffin, or even for the manufacture of gas.

The organic origin of the substance under notice has long been recognised, and has probably never been called in question. By the great majority of geologists the source of the bituminoid has generally been supposed to be matter of animal origin—in great part due to the decomposition of the remains of the fossil fish which occur in these rocks. The object of the present note is to show that it is highly probable that substances of vegetable origin have had a large share in the formation of the hydrocarbon compound in question; and that, in some cases, it may be due to vegetable matter entirely.

In approaching an inquiry of this kind, probably no geologist would venture to propound an explanation of the facts in any form except that of a temporary working hypothesis, which he would regard more as a suggestion of what may be possible, rather than as a final answer to a question which, whenever it comes to be answered definitely, must be answered by a chemist. Up to the present no chemical geologist has even attempted a solution of the difficulty; in the mean time, and until someone does do so, we may endeavour to form some kind of idea for ourselves, by making the best we can of what evidence we can gather in the field. With this object in view, we need first to review the more salient petrographical characters of each of the larger divisions of the Old Reds, noting, especially, what characteristics accompany each type, alike in the cases where bituminoids are present and where they are absent.

It is now generally known amongst geologists that the Devonian Period in the northern parts of the kingdom was one during which continental instead of marine conditions obtained, and that it was here also a period characterised by important terrestrial disturbances. The general nature of these has been indicated in my Address on the "Age of the Earth," printed in the present volume. It will suffice here to summarise the general conclusions upon this point. Owing to the terrestrial undulations being of greater amplitude, shorter wave-length, and higher frequency, than is usual in such earth-movements, and owing also to the fact that these undulations progressed from south to north, important upheavals and denudations of the strata went on concurrently with depressions of the surface, and consequent deposition, in areas closely adjacent. The earliest formed Old Red (the Lanarkian) appears thus to have furnished materials for the succeeding (or Caledonian) Old Red. This in its turn, as the upward phase of undulation progressed northward, may have, in like manner, furnished materials for other subdivisions higher still: successively-newer strata thus being formed as the terrestrial movements progressed from south to north. Two important unconformities result from these complicated movements.

The stratigraphical relations of the subdivisions of the Old Red in the south of Scotland were admirably described by Mr (now Sir Archibald) Geikie in volume xvi. of the *Quarterly Journal of the Geological Society of London;* and again (and, if possible, better still), in an oft-quoted description of the facts in "Siluria," 4th edition, 1867, pp. 248-250. The Orcadian Rocks, specially referred to in the present paper, were described in detail in the same author's "Old Red Sandstone of Western Europe" (*Trans. Roy. Soc. Edin.*, vol. xxxviii.). For much of what we know respecting the palæontology of these rocks, and especially regarding the bearing of the evidence yielded by fossils upon the order of succession of the various subdivisions of the Old Red, we are indebted to the labours of Dr Traquair, whose beautiful and life-like restorations of the fish of the Devonian Period have now made the study of these fossils a pleasure to geologists, instead of a task of almost hopeless difficulty, as it has been hitherto.

For the purpose at present before us, we need only to summarise from the writings of these and other authors the main facts regarding the succession, and the chief petrographical characters of each group of the Scottish rocks of Devonian age.

At the bottom of the series occurs the Lanarkian "Old Red" already referred to, which consists largely of red sandstones, and which graduate downward into, and form part of, rocks of Ludlow Age. These Lanarkian Rocks, as I hope to be able to show presently, are distinctly not of marine origin, but were formed in either lagoons or inland lakes, principally under arid—if not under desert—conditions. They are coloured bright red by ferric oxide, they contain no traces of fossil plants, and no bituminoid matter. These Lanarkian Rocks have long been known in the Pentland area to be covered by the Caledonian Old Red, a violent unconformity marking the stratigraphical relations between the two sets of rocks. The Caledonian Old Red in its lower part, and where not of volcanic origin, differs from the Lanarkian Rocks in being coloured largely by ferric hydrate. The rocks on this horizon, therefore, are brown instead of red, as those are in which the colouring matter consists of ferric oxide. To this division belongs the volcanic rocks of the Ochils, Sidlaws, Pentlands, etc. Succeeding these volcanic rocks in the areas to the north of the Forth is a band of grey flagstones in which occur fossil fish (*Cephalaspis* and its allies, and some of the Acanthodians) and frequent remains of fossil plants. Bituminoid matter is present in these grey beds containing the organic remains, and ferric oxide is conspicuous by its absence. These grey, bituminiferous, and plant-bearing beds are succeeded by the sandstones and marls of Strathmore, which are, prevalently, red, with the pale green decoloration marks which so often accompany strata coloured by ferric oxide. Fossils of any kind are rare or absent entirely from these red beds, and bituminoids are equally conspicuous by their absence. The total aggregate thickness of the beds belonging to the Caledonian division of the Old Red must be close upon, if it does not exceed, 20,000 feet.

At the present day it is no longer possible to trace the connection between the highest or any other subdivision of the Caledonian Old Red and any part of the Old Red of the type occurring in the Moray Firth. These latter rocks present, in their lower portions especially, much the same petrographical characters as the Caledonian Old Red. Calcareous concretions, however, occur in the lower parts of these rocks, and these concretions have yielded numerous fish remains, which Dr Traquair regards as pertaining to a later stage of evolution than the fish remains from the Caledonian Old Red. In tracing the Old Red rocks of the Moray Firth northward, we find the members of the series there assuming a somewhat different type, which prevails throughout the greater part of Caithness, and extends northward into Orkney. The rocks of this type consist of flagstones, which, like the other sedimentary members of the Old Red, appear to have been formed either as torrential deposits on the land, or else as layers deposited under shallow-water conditions in inland lakes. But instead of being characterised by a coloration due (as the brown is) to ferric hydrate, or as the red coloration is, to ferric oxide, these strata are prevalently of a dark grey colour, which is due to the abundant diffusion of bituminoid matter. Bands tinted with ferric hydrate occur here and there, and there are also thin laminæ containing more or less carbonate of lime or else dolomite. Bands of calcareous nodules of concretionary origin also abound on certain horizons. With these various constituents of the rock occur remains of fish, and also traces of vegetation, sometimes converted into coaly matter.

Above the Orcadian Old Red lies unconformably the Upper Old Red, which, in one area or another, oversteps every rock older than itself. This rock again, though not red throughout, shows some red coloration, which is due, as in the other cases mentioned, to the presence of ferric oxide, which occurs as films coating the grains of sand composing the main part of the rock.

The whole of the rocks formed during the Devonian Period in Scotland of which remains *in situ* still exist, appear to me therefore to have been formed under continental conditions and in inland lakes. At the very most there may have been once or twice local subsidences of sufficient amount to admit of communication with the sea. But of even this it appears to me that there does not exist any unequivocal evidence. This view is, of course, the same as that advocated by Godwin Austen, and afterwards so ably supported by Sir Andrew Ramsay. This latter author considered that the Old Reds were formed under geographical conditions analogous to those now obtaining in the Aralo-Caspian area.

There is no need on the present occasion to go into full detail regarding the physical geography of the area of inland drainage referred to, as this has often been treated of by others. There are, however, one or two points connected with this part of the subject which are of importance to take into consideration in an inquiry like the present. One of these is that, under conditions of inland drainage, the whole of the water carried down by rivers is partly absorbed by the earth and the rest dissipated by evaporation. An important result, so far as the present subject is concerned, is that the various substances brought down by the rivers in solution, being only partially absorbed by the earth, and not at all carried off, as the water is, by evaporation, tend to accumulate in solution, and do so, until their several points of precipitation are reached, when, of course, each in its turn goes down in the solid form. Rock-salt is one of these. [In regard to this, I have once before stated before the Royal Physical Society my belief that the occurrence of this mineral is often due to the following sequence of events:—Firstly, it has been driven up from the ocean in the form of spray during storms, and in a state of minute crystals has been subsequently diffused by the agency of aerial currents through the atmosphere. Secondly, that these particles of chloride of sodium diffused through the air have formed nuclei around which aqueous vapour has been condensed. Thirdly, in the form of rain it has again descended to the earth, whence, under normal conditions of drainage, it has found its way back again to the sea. This part of its history has been made abundantly clear by the labours of Mr John Aitken of Darroch. In the case of areas of inland drainage, however, as I have pointed out, the cycle is not completed at once, for the chloride of sodium does not immediately return to the sea, but remains inland, where I believe that, in time, it forms one of the sources of beds of rock-salt.] Bicarbonate of lime is a second constituent carried in solution in river-waters, and sulphate of lime is a third. Both of these play an important part in connection with the Caithness Flags. Along with these two substances, most rivers contain in solution more or less ferrous carbonate and sulphate. The first of these is due to the action of the humus acids and their ultimate term carbonic acid, which have disengaged the iron, in the first instance, from its primary source, the iron-bearing minerals of eruptive rocks. Disregarding for the moment these substances in solution, we may pass on to notice the character of the substances of organic origin which are carried down in suspension.

In areas of inland drainage there is usually a rainfall below the average in amount. This may range from a maximum of say 20 inches to a minimum of 10 inches, or even less than that. The same district may, under changing geographical conditions, pass in course of time from one hygrometric extreme to the other. Under the maximum rainfall, and especially if this rainfall is fairly distributed throughout the year, vegetation will mostly flourish; and, with an abundant vegetation, will occur also more or less abundance of animal life. Rivers flowing into the lakes will (as the Jordan does into the Dead Sea, for example) transport more or less of this organic matter into the lake, where the concentration of salts is in progress. Under these conditions, as we shall presently see, results very different in their nature from those that obtain under more arid conditions will obtain. If, on the other hand, the nature of the precipitation is such that, if the maximum, it falls in large quantities at a time, and without regular recurrence, or if the rainfall is nearer the minimum above-mentioned, then vegetation (except of the scrubbiest kind) cannot maintain its existence. The soil becomes bare, and is frequently drifted from place to place by the wind, animals disappear, and the place becomes a desert. Under these circumstances, little or no organic matter finds its way into the lake, concentration goes on apace, and the chemical reactions arising from the deposition of the various salts carried in by rivers differ in most important respects from those in the alternative case just considered.

As bearing upon the nature of the changes that ensue under either set of conditions, I can hardly do better than abstract, as nearly as possible in the author's own words, the substance of an address to the Geologists' Association, by W. H. Hudleston, F.R.S., "On the Geological History of Iron Ores."[1] [Iron dissolved in the first instance from the rocks of the land by the action of the humic acids and their ultimate term carbonic acid, eventually become diffused through the waters of the rivers and lakes. Those parts of the solution which are near the surface of the water seize upon an additional molecule of oxygen, thereby losing their carbonic acid and becoming transformed into ferric oxide, which immediately combines with water to form ferric hydrate, in

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[1] Proc. Geol. Assoc., vol. xi., No. 3, pp. 104-144.

which state it at once sinks to the bottom. If at the bottom of the lake there exists any decomposing vegetable matter, this brings about a redissolution of the ferric hydrate, owing to the abstraction of the extra molecule of oxygen by the carbon of the decomposing vegetable matter. This extra molecule of oxygen helps to form one or other of the humus compounds, which, having a powerful affinity for iron, quickly dissolve it, and carry it back again into solution, where it goes through the same changes as before. Solution and precipitation thus follow each other indefinitely. In those cases where decomposing organic matter at the bottom of the lake is small, or is absent entirely, then the balance is in favour of precipitation—the iron ore taking the form of the nearly indestructible ferric oxide, which becomes diffused through all the permeable strata at the bottom of the lake; and the quantity of iron accumulating will be limited only by the two factors of the rate of supply and the duration of the conditions referred to. Where, on the other hand, decomposing organic matter in any quantity is present in the lake, the iron can never be precipitated as ferric oxide, but will be diffused through the strata in the form of the ferric hydrate, or, under particular circumstances, as ferric carbonate. Reduction renders iron soluble and locomotive: oxygenation arrests locomotion, and fixes the iron on the spot in the form of the ferric oxide.]

All this is in perfect accordance with the facts met with in the field. In all strata which are coloured red by ferric oxide at the time of their deposition, there is a conspicuous absence of vegetable matter in any form. Bituminoids, also, are absent in this case. But if, in connection with these Red Rocks (be their position in the geological scale what it may), there occurs a zone of strata in which the rocks are not coloured red by original ferric oxide, it is in that zone that organic remains may be expected to be met with. The grey beds of the Forfarshire Flags present us with a good illustration of this principle.

It may be remarked here that the infiltration of ferric oxide from the lake bottom into the strata beneath may proceed to a considerable depth. In the case of the Carboniferous sandstones underlying the New Red Rocks, for example, ferruginous stains from this source have been traced to a depth of 600 feet below the base of the stratum whence the colouring matter originally came. In this case, however, the abundant diffusion of matter of vegetable origin in the Carboniferous Rocks so affected has led to considerable modifications of the colouring effect, as might be expected to be the case on a consideration of the facts stated above.

If, now, we attempt to reason back from effects to causes, we seem to be perfectly justified in concluding that any extensive tract of strata which are coloured, originally, by ferric oxide, must have been formed in inland lakes, under conditions of aridity, if not actually under desert conditions. We must be quite prepared, in studying such rocks in the field, to find evidence of changes in climatal conditions as we trace the strata upwards in the order of deposition. A red stratum, indicating arid conditions during its formation, may overlie or may be succeeded by another stratum formed under climatal conditions of quite a different kind. Such beds as these, coloured usually with ferric hydrate, and therefore yellowish or brownish to begin with, may be affected afterwards by later infiltrations, which may considerably modify the original colouring. Mr George Maw, of Broseley, has given us much interesting information upon this head. A stratum, red from causes acting at the time of its deposition, can usually be distinguished with ease from one in which the colouring is of secondary origin.

These facts warrant us in coming to the conclusion that, under whatever conditions the Lanarkian Rocks, as a whole, were deposited, their red sandstones mark the result of desert conditions. The brown and grey beds of the Caledonian Old Red mark a change in climatal conditions. Like its older analogue, it was formed in inland lakes; but the wide diffusion of ferric hydrate, and the occasional occurrence of grey bands, show that the earlier part of the period was one during which the conditions ranged from sub-arid to sub-humid. On the platform where the grey, fossiliferous beds come in, we have, it seems to me, evidence of a temporary return to humid conditions, which were followed, when the Strathmore Sandstones were in course of formation, by arid conditions once more. Reasoning on the same lines, we may also conclude that the commencement of the period when the Orcadian rocks were formed was one in which arid and sub-arid climatal conditions prevailed. On the other hand, the bituminous nature of the cement of the Caithness Flagstones, properly so called, appears to me to warrant the belief that humid conditions, favourable for the growth of vegetation, followed the arid conditions by which the earlier part of the period was characterised. The red beds overlying the Caithness Flagstones suggest yet another return to conditions unfavourable to the development of vegetable life. These and other mutations of climate of a similar character finally gave way to those under which the varied and abundant flora of the Carboniferous Period was ushered in.

Reverting to the Caithness Flagstones, we find that some points of importance still remain to be considered. To understand these, we must now review some further chemical reactions arising from the peculiar combination of conditions that usually obtain in inland lakes. One of the most important of these relates to the presence in river-waters, and hence also in the lakes, of solutions of sulphate of lime. This, on coming into the presence of decomposing organic matter, and especially matter of vegetable origin, undergoes reduction, with, finally, the liberation of the lime in the form of carbonate, which may go down in such a form as to remain in a state of diffusion throughout the strata forming at the time, or else may, eventually, separate into concretions. Very few river-waters are free from some carbonate of magnesia, especially in the case of rivers draining areas in which rocks containing the ferro-magnesian silicates occur. Hence dolomite may be formed. The same may happen even where the disintegration of the ferro-magnesian silicates is effected by the alternate expansion and contraction due to great diurnal ranges of temperature, such as usually prevail where the percentage of aqueous vapour present in the atmosphere is below the average amount. Where vegetable matter is carried into the lakes in lesser quantity, changes of a different nature occur; but with these we are not at present specially concerned.

In regard to the effect of these concentrated solutions of sulphate of lime and other salts upon the vegetable matter itself, we have as yet no absolutely certain data upon which to base any satisfactory conclusions. But we are enabled, it seems to me, to form some general idea of the nature of the chemical processes which go on under these circumstances by studying the field evidence, and by noting the facts common to a large number of cases where deposits of gypsum occur. Briefly summarised, the facts gleaned from these sources of information are these:—There is a very common, one might almost say, universal, association of rock-salt and gypsum with two types of strata. In one of these the associated strata are coloured by ferric oxide, and in that case not a trace of any kind of vegetable matter, or of bituminoids derived from it, is to be found. In the other case, where the gypsum is associated with rocks which are not coloured with ferric oxide, traces of vegetable matter are occasionally, but rarely, present, and then in a more or less bituminised form; but the rocks themselves are often, so to speak, saturated with one or other of the hydrocarbon compounds, amongst which bituminoids usually occupy a conspicuous place. There appears to be some reason to believe that what happens in such cases is that a cross reaction takes place between the decomposing vegetable matter and the solutions of sulphate of lime. Precipitation of lime in the form of carbonate is one result, and the other would appear to be the rapid maceration of the fermenting vegetable matter, and the conversion of that macerated vegetable matter into one or other of the bituminoids, in which form it is diffused throughout the rocks forming at the time at the bottom of the lake. I am disposed to regard this as the origin of the bitumen found in the Dead Sea, and in so many other inland lakes into which vegetable matter is drifted. Even in the case of the Pitch Lake of Trinidad, it seems to me that the uprise of water containing sulphate of lime, which on its passage to the surface passes through beds of peat, is quite sufficient to account for the phenomena in question. The very common association of deposits of sulphur with those of these bituminoids points also to the same conclusion, as this would represent one of the ultimate products of decomposition of the sulphate of lime.

Given conditions of inland drainage where the nature of the rainfall within the drainage area permits of the growth of vegetable matter, it seems to me that all the rest follows as a necessary consequence. The sediments formed under such conditions would contain in a diffused form — (1) limonite (ferric hydrate); (2) calcareous or dolomitic matter; (3) bituminoids in quantity proportionate to that of the vegetation carried into the lake. They may contain in addition deposits of rock-salt and gypsum, together with any of the "abraum" salts commonly associated with these. But they will contain no iron in the form of ferric oxide.

I should therefore regard the red parts of the Old Red (whether in the Orcadians or other) as having been deposited in areas of inland drainage at a time when the climatal conditions here were in the main too arid to permit of the growth of almost any vegetation. On the other hand, such grey, bituminiferous beds as the plant-bearing beds of the Caledonian Old Red, and also the Caithness Flagstones proper, represent other parts of the Devonian Period when conditions of inland drainage still prevailed, but when the climate for the time being approached the normal, or humid type, and when, in consequence, vegetation flourished.

It is to the action of weak solutions of sulphate of lime upon the vascular tissues of such of this vegetable matter as was swept into the old inland lakes, that I am disposed to attribute the formation of the bituminoid cement of the Caithness Flags.

XXIV. *Results of Meteorological Observations taken in Edinburgh during* 1896. By R. C. Mossman, F.R.S.E., F.R.Met.Soc.

(Read 17th March 1897.)

During the past year the bi-diurnal observations have been taken, as in previous years, at 9 A.M. and 9 P.M. The instruments used are those described in former reports. No change has taken place in their exposure or position, and no additions have been made. The automatic instruments, which yield continuous records of pressure, temperature, humidity, rain, and sunshine, have worked without interruption throughout the year. As in past years, detailed weekly and monthly returns have been sent to the Scottish Meteorological Society, the Registrar-General for Scotland, the Meteorological Office, and to private individuals. The reduction of the accumulated mass of observations taken in Edinburgh from 1731 to 1736 and from 1764 to 1896, has been completed and communicated to the Royal Society of Edinburgh.[1] Full particulars are there given as to the data utilised in the calculation of the mean values contained in the annual returns hereto appended.

REMARKS ON THE METEOROLOGY OF 1896.

January.—The outstanding feature of the meteorology of the month was the phenomenal elevation of the barometer, which culminated at 9 A.M. on the 9th in the highest barometric reading ever taken in Edinburgh—viz., 31·072 inches. The next highest value observed during the last 127 years was 31·058 inches, on 9th January 1820. During the greater part of the month the weather was dry, sunny, and mild, the mean temperature being 4°·4 above the normal. The mean barometric pressure was the highest since 1880.

February.—The characteristic features of this month were a high mean temperature and barometric pressure, small rainfall, and a good deal of sunshine. The mean temperature was

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[1] The Meteorology of Edinburgh, part i.—Trans. Roy. Soc. Edin., vol. xxxviii., p. 681. Part ii. was communicated to the Society on 1st March 1897.

3°·2 above the average, the days being 2°·7, but the nights 3°·8 warmer than the normal. There was little appearance of winter throughout the month, except on the 26th, when snow showers fell.

March.—Low pressure prevailed throughout the greater part of the month, with a high mean temperature, a considerable percentage of sunshine, and a precipitation slightly below the normal. The weather, as a whole, was rough and unsettled—snow, hail, and rain being of frequent occurrence. The lowest pressure of the year occurred on the 3rd, when the corrected reading was 28·299 inches. A strong gale was experienced on the 2nd, and again on the 16th.

April.—Very fine weather prevailed during the greater part of the month, the mean temperature being 48°·8, or 4°·0 above the average. The only warmer Aprils back to 1764 were 1844, 1821, 1798, 1796, 1792, 1788, and 1785. The warmth was pretty equally partitioned between the day and the night, the maximum being 3°·7 and the minimum 4°·3 above the normal. The rainfall was less than an inch, and there was no heavy fall on any day.

May.—The weather was quite phenomenal, the month being the warmest May since 1848, the driest since 1859, and the sunniest since 1882, while the mean barometric pressure was the highest, with one exception—1836—since the record commenced in 1769. The warmer Mays since 1764 were those of 1784, 1804, 1833, and 1848. The mean temperature of April and May was 51°·8—being absolutely the highest for these two months from the records of the last 133 years. The mean temperature of the five months, January to May, was 45°·8, being only exceeded by the record year, 1779, when the mean for the period under review was 46°·0. The rainfall for this period was only 4·81 inches, the least since 1805, when it was 4·35. In 1771 the downfall for the first five months of the year was 4·56 inches.

June.—During the first half of the month the wind blew steadily from the east, with very little sunshine, and heavy rain. The hills around the city during most of the time were enveloped in mist, which sometimes descended to the level of the station. During the second half of the month the weather was on the whole fine, although a good deal of rain was recorded.

July.—Wet unsettled weather predominated, although pressure was above the normal. The mean temperature of the days was half a degree under, but the nights over a degree above the mean, the diminished range being due to cloudy skies. With the exception of a heavy fall of rain on the 8th, the meteorological conditions were featureless, most of the elements approximating closely to their averages.

August.—Although rather a cool month, the weather, as a whole, was much finer than in any August during recent years. The rainfall amounted to little more than half the average, and a good deal of sunshine was recorded, there being only one sunless day.

September.—Exceptionally dull weather prevailed during practically the whole month, only 60 hours bright sunshine being recorded, or only 16 per cent. of the possible. This was the smallest amount of sunshine registered in September since 1881, which had 58 hours. In the first fortnight there were eight sunless days, only 2½ hours sunshine being recorded. As the result of the sunless weather, the mean of the day temperatures was over two degrees below the average, while the night values were about a degree above the normal. Heavy rain fell on many days, the downfall for the month being a third greater than the mean. There was a great deal of mist during the prevalence of the easterly current, which continued till the 14th.

October.—The weather of October was very cold, the mean temperature being 4°·0 below the normal, and the lowest since 1817, when the depression of temperature amounted to 5°·2: the only other instance of such exceptional cold so early in the season was in 1778, when the October mean was 4°·6 below the normal. Sunshine was deficient, and heavy rainfalls were frequent, over seven-tenths of an inch falling on the 7th, 10th, 18th, and 19th. Snow fell on the 10th. The month's sunshine total of 58 hours was the lowest since 1886, which had 34 hours.

November.—Dry sunless weather prevailed throughout the month. Only 0·65 inch of rain fell—the lowest for

November since 1815. The sun shone on only 22 hours, the next lowest back to 1860 being the Novembers of 1887 and 1888, when 33 hours bright sunshine was recorded. The mean barometric pressure was 0·320 inch in excess of the normal, being the highest since 1879. The mean daily range of temperature, owing to the overcast skies, was very small.

December.—December was a most unsettled month, with only ten hours sunshine, being barely one-third of the average. In 1890 only seven hours sunshine was recorded, but, with this single exception, the month under review was the most sunless since the commencement of the record in 1860. No sunshine was recorded on 25 days, or 11 more than the average.

NOTEWORTHY PHENOMENA IN THE METEOROLOGY OF 1896.

Highest barometric reading 31·072 inches, on January 9th, at 9 A.M.

Lowest barometric reading 28·299 inches, on March 3rd, at 3 P.M.

Highest temperature in shade 78°·1, on May 11th.

Lowest temperature in shade 23°·8, on December 1st.

Greatest range of temperature 33°·2, on May 11th.

Least range of temperature 2°·2, on November 13th.

Highest temperature in sun's rays (black bulb thermometer in *vacuo*) 133°·9, on July 20th.

Greatest excess of sun maximum over shade maximum 62°·6, on July 1st.

Lowest temperature on grass 19°·9, on December 1st.

Greatest difference between minimum on grass and in shade 9°·4, on November 14th.

Sunniest days May 25th and 26th, with 14·6 hours bright sunshine, being 87 per cent. of the total possible.

Stormiest day October 8th, average velocity of wind 20·8 miles per hour.

Greatest daily rainfall 1·23 inch, on July 8th.

	Barometer at 32° and Mean Sea-Level.					Temperature in Shade 4 Feet above Grass.															
																Departure from Average 50 years.					
	Highest in Month.	Lowest in Month.	Monthly Range.	Mean Pressure.	Difference from Average 1770-1896.	Highest in Month.	Lowest in Month.	Range.	Mean Temperature.	Mean of all the Highest.	Mean of all the Lowest.	Mean Daily Range.	Greatest Daily Range.	Least Daily Range.	Mean Variability of Temperature.	Mean Max.	Mean Min.	Mean Daily Range.	Mean Temp.	Mean Variability of Temp	Diff. from Aver. 1764-1896, Mean Temp.
	Ins.	Ins.	Ins.	Ins.	Ins.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
January, . .	31·072	28·857	2·214	30·222	+ ·404	52·9	23·9	29·0	41·2	45·5	36·9	8·6	16·1	2·6	4·0	+ 2·8	+ 4·1	− 1·3	+ 3·4	+ 0·6	+ 4·4
February, . .	30·689	29·525	1·164	30·202	+ ·389	52·9	27·7	25·2	42·3	47·0	37·6	9·4	18·9	3·9	3·2	+ 2·7	+ 3·8	− 1·1	+ 3·2	+ 0·3	+ 3·7
March, . .	30·190	28·299	1·891	29·633	− ·231	56·1	29·4	26·7	42·4	48·8	36·0	12·8	18·8	7·1	3·0	+ 1·9	+ 1·6	+ 0·3	+ 1·8	+ 0·1	+ 2·1
April, . .	30·450	29·524	0·926	30·054	+ ·159	65·9	34·5	31·4	48·8	55·7	41·9	13·8	27·6	6·1	2·2	+ 3·7	+ 4·3	− 0·6	+ 4·0	− 0·5	+ 4·0
May, . . .	30·537	29·755	0·782	30·266	+ ·326	78·1	37·3	40·8	54·8	64·0	45·7	18·3	33·2	10·2	2·8	+ 6·4	+ 3·6	+ 2·8	+ 4·8	0·0	+ 4·9
June, . . .	30·170	29·399	0·771	29·908	− ·024	75·5	44·4	31·1	56·7	62·8	50·6	12·2	26·0	2·4	2·6	− 0·7	+ 2·8	− 3·6	+ 1·0	− 0·2	+ 1·0
July, . . .	30·325	29·510	0·815	29·972	− ·008	75·3	43·3	32·0	58·4	65·1	51·8	13·3	22·3	3·6	2·3	− 0·5	+ 1·2	− 1·8	+ 0·3	− 0·2	− 0·2
August, . .	30·327	29·551	0·676	29·984	+ ·110	73·1	43·7	29·4	56·8	63·8	49·8	14·0	22·9	6·3	2·8	− 1·2	− 0·5	− 0·7	− 0·8	− 0·2	− 1·0
September, .	30·362	28·821	1·541	29·672	− ·214	66·5	39·9	26·6	53·3	58·8	47·8	11·0	17·9	2·5	2·7	− 2·2	+ 0·8	− 3·0	− 0·7	+ 0·1	− 0·3
October, . .	30·543	28·900	1·643	29·709	− ·108	53·7	28·8	24·9	43·2	48·7	37·8	10·9	17·6	3·4	3·0	− 4·4	− 3·6	− 0·8	− 4·0	+ 0·1	− 4·0
November, .	30·644	29·081	1·563	30·140	+ ·320	53·7	26·3	27·4	42·0	46·0	38·1	7·9	14·9	2·2	3·1	− 0·8	+ 1·6	− 2·4	+ 0·3	0·0	+ 1·1
December, . .	30·395	28·731	1·664	29·683	− ·118	56·2	23·8	32·4	39·0	42·7	35·2	7·5	15·3	2·7	2·8	− 1·1	+ 1·1	− 2·2	0·0	− 0·4	+ 0·7
Year, . . .	31·072	28·299	2·772	29·954	+ ·084	78·1	23·8	54·3	48·2	54·1	42·4	11·7	33·2	2·2	2·9	+ 0·6	+ 1·7	− 1·1	+ 1·1	0·0	+ 1·4

	Rainfall.				Relative Humidity. Saturation = 100.			Vapour Pressure.			Solar and Terrestrial Radiation.							
	Total Fall.	Max. in 24 hours.	Diff. from Average 25 years.	No. of days on which ·01 in. or more fell.	At 9 A.M.	At 9 P.M.	Mean.	At 9 A.M.	At 9 P.M.	Mean.	Maximum in Sun.	Mean.	Greatest Excess over Shade Maximum.	Average Excess over Shade Maximum.	Minimum on Grass.	Mean.	Greatest Difference from Shade Min.	Mean Difference from Shade Min.
	Ins.	Ins.	Ins.		%	%	%	In.	In.	In.	°	°	°	°	°	°	°	°
January, ...	0·84	0·13	−1·59	17	86·0	86·1	86·0	·226	·218	·222	84·5	60·6	37·3	15·1	19·9	34·0	7·5	2·9
February, ...	0·85	0·26	−1·11	9	84·1	84·3	84·2	·228	·224	·226	96·4	73·2	47·0	26·2	23·9	34·4	6·5	2·5
March, ...	1·59	0·32	−0·38	20	77·5	81·5	79·5	·219	·212	·215	108·4	89·6	58·2	40·8	24·1	32·3	6·5	3·7
April, ...	0·96	0·13	−1·10	12	72·1	75·6	73·9	·253	·243	·248	116·3	104·7	61·6	49·0	28·7	38·1	7·0	3·8
May, ...	0·57	0·20	−1·52	6	69·1	79·2	74·2	·312	·303	·307	124·2	112·5	62·2	48·5	31·7	42·1	8·6	3·6
June, ...	3·57	0·84	+1·47	22	83·2	84·9	84·0	·387	·362	·374	126·5	106·1	57·7	43·3	40·3	49·0	5·0	1·6
July, ...	4·33	1·23	+0·97	19	78·2	84·2	81·2	·392	·382	·387	133·9	111·8	62·6	46·7	39·1	49·5	5·5	2·3
August, ...	1·79	0·49	−1·69	14	76·4	83·7	80·0	·358	·350	·354	126·2	111·8	58·1	48·0	39·0	46·8	5·5	3·0
September, ...	4·47	0·86	+1·55	21	84·7	87·7	86·2	·351	·342	·345	116·0	91·6	55·5	22·8	34·7	45·1	7·2	2·7
October, ...	4·14	0·79	+1·74	21	82·4	84·0	83·2	·230	·228	·229	105·7	75·9	49·5	27·2	23·9	33·9	7·4	3·9
November, ...	0·65	0·11	−1·99	12	85·7	85·3	85·5	·229	·227	·228	87·1	62·0	39·8	16·0	21·5	33·3	9·4	4·8
December, ...	3·35	0·49	+0·97	23	89·5	86·5	88·0	·212	·217	·214	69·5	50·3	23·0	7·6	19·9	30·8	9·0	4·4
Year, ...	27·11	1·23	−2·78	196	80·7	83·6	82·2	·283	·276	·280	133·9	87·5	62·6	33·4	19·9	39·1	9·4	3·3

	Bright Sunshine for Hour ending Greenwich Time.																Total.	Percentage of possible Duration.	Difference from Average 30 years.	Greatest in One Day.	Greatest Percentage of possible in 1 Day.	No. of Sunless Days.	Difference from Average 30 years.	Cloud 0–10.			Horizontal Air Movement.			
	A.M.								P.M.																					
	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8								9 A.M.	9 P.M.	Mean.	Total Movements.	Mean Velocity per hour.	Greatest in 24 hours.	Estimated Wind Force, 0–12.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	%	%	Hrs.	%						Mls.	Mls.	Mls.	
January, .	...	...	...	...	...	1·3	5·8	7·2	7·9	9·5	4·5	1·1	...	...	...	...	37·3	16	− 5	4·8	58	14	+ 3	7·3	6·4	6·8	5143	6·9	330	0·93
February, .	...	...	...	...	1·0	3·4	6·2	7·4	7·5	9·7	9·4	5·7	2·5	0·1	...	...	52·9	20	− 6	8·3	82	9	+ 4	8·4	5·8	7·1	4872	7·0	405	0·99
March, . .	...	...	1·0	5 5	10·0	12·6	12·6	10·6	11·7	11·5	12·5	10·8	8·0	2·7	...	...	109·5	30	0	9·9	83	4	− 3	7·1	5·3	6·2	5629	7·5	414	1·37
April, . .	...	0·8	5·2	8·7	12·1	14·8	13·7	16·3	13·5	11·2	12·8	13·5	13·0	9·4	1·2	...	146·2	34	+ 4	10·6	77	1	− 5	6·8	6·1	6·4	5326	7·4	395	1·22
May, . .	2·2	11·2	11·1	13·6	14·1	15·6	16·2	17·6	19·1	20·7	18·9	17·0	18·0	17·1	12·6	2·1	227·1	45	+13	14·6	87	1	− 3	6·2	5·2	5·7	3160	4·2	250	0·73
June, . .	3·0	6·6	9·0	7·8	7·9	11·8	9·2	10·1	10·8	10·4	10·9	12·4	10·2	10·1	5·7	1·4	137·3	27	− 1	13·0	75	6	+ 3	8·2	7·3	7·8	3579	5·0	251	0·81
July, . .	3·4	7·6	6·6	10·6	9·4	8·6	9·5	10·6	12·6	12·9	12·5	12·6	11·4	10·6	7·8	0·9	147·6	28	− 1	12·6	77	4	0	8·5	6·9	7·7	3464	4·7	248	0·58
August, .	0·6	4·0	8 8	9·1	10·8	12·0	10·4	10·6	10·2	10·3	13·0	12·8	14·7	12·2	4·4	...	143·9	31	+ 1	12·5	79	1	− 4	7·5	8·2	7·8	3902	5·2	420	0·92
September,	...	...	0 3	3·3	4·9	7·4	7·3	4·8	7·3	6·6	6·5	5·0	4·6	2·1	...	...	60·1	16	−15	9·1	71	10	+ 6	7·6	7·6	7·6	4165	5·8	350	0·82
October, .	...	...	...	...	3·6	8·6	9·9	10·4	7·3	5·8	5·9	4·7	1·7	...	...	...	57·9	18	−11	7·7	70	9	+ 2	7·4	7·5	7·4	4370	5·9	500	0·82
November,	...	...	...	...	...	0·7	5·6	6·8	4·4	2·7	1·9	0·2	...	...	...	...	22·3	9	−15	4·2	57	15	+ 6	7·4	6·3	6·8	3865	5·4	325	0·95
December,	...	...	...	...	...	...	1·4	4·0	3·0	1·8	...	...	...	...	...	...	10·2	5	−14	3·8	55	25	+11	7·9	7·0	7·4	2930	3·9	275	1·20
Year, . .	9·2	30·2	42·0	58·6	73·8	96·8	107·8	116·4	115·3	113·1	108·8	95·8	84·1	64·3	31·7	4·4	1052·3	26	− 1	14·6	87	99	+20	7·5	6·6	7·0	50,405	5·7	500	0·94

Wind from Observations made at 9 A.M. *and* 9 P.M. *Number of Days it blew from certain directions.*

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm or Variable.
January,	3	0	2	0	0	2	20	3	1
February,	0	0	3	2	3	3	15	2	1
March,	0	2	2	0	1	4	20	2	0
April,	1	1	2	0	0	1	17	8	0
May,	6	6	4	0	0	1	9	3	2
June,	3	3	10	1	1	1	9	2	0
July,	7	1	4	0	1	1	13	2	2
August,	6	3	3	0	0	0	15	3	1
September,	1	3	10	1	1	1	10	1	2
October,	7	2	2	1	0	2	11	5	1
November,	2	0	5	1	1	4	15	1	1
December,	1	3	6	2	1	7	6	4	1
Year,	37	24	53	8	9	27	160	36	12

Number of Times the Following Phenomena were observed.

	Gales.	Halos.	Rainbows.	Thunder-storms.	Lightning.	Aurora.	Snow.	Hail.	Frost in Shade.	Frost on Grass.	Mist or Fog.	Dew.	Hoar Frost.
January,	1	2	0	0	0	0	1	0	7	15	2	3	4
February,	0	3	0	0	0	0	1	0	7	11	0	1	4
March,	2	3	1	0	0	0	5	3	4	14	0	2	5
April,	0	6	1	1	1	0	0	3	0	5	0	0	3
May,	0	0	0	0	0	0	0	0	0	1	1	7	0
June,	0	2	0	2	0	0	0	0	0	0	5	1	0
July,	0	1	0	0	0	0	0	0	0	0	0	0	0
August,	2	3	0	1	0	0	0	1	0	0	0	2	0
September,	1	3	1	0	0	0	0	0	0	0	4	3	0
October,	1	5	0	0	0	1	1	2	4	12	0	2	2
November,	0	4	0	0	0	0	0	0	4	15	2	2	5
December,	1	0	0	0	1	0	2	0	12	21	0	2	4
Year,	8	32	3	4	2	1	10	9	38	94	14	25	27

	Earth Thermometers. Read Daily at 9 A.M.							
	Mean Temperature.				Variability of Temperature.			
	3 ins.	12 ins.	22 ins.	Air Temp. at 9 A.M.	3 ins.	12 ins.	22 ins.	Air Temp.
January, ...	38°·8	39°·7	39°·9	41°·0	2°·4	0°·8	0°·5	5°·2
February, ...	40·0	41·0	41·2	41·5	1·9	0·6	0·3	4·5
March, ...	40·2	40·2	41·4	43·3	2·0	0·6	0·3	4·4
April, ...	46·7	46·7	45·6	49·4	1·5	0·6	0·4	2·7
May, ...	55·0	53·8	51·8	56·1	1·9	0·6	0·4	4·2
June, ...	57·8	57·5	55·6	56·8	1·8	0·7	0·4	4·5
July, ...	59·4	59·0	57·7	59·2	2·1	0·6	0·4	4·7
August, ...	57·2	57·9	57·2	57·1	1·4	0·4	0·2	3·3
September, ...	53·2	54·5	54·4	53·5	1·7	0·3	0·3	3·3
October, ...	42·8	46·1	47·0	42·5	2·1	0·7	0·4	3·5
November, ...	40·5	42·2	42·6	41·6	2·3	0·6	0·4	4·8
December, ...	37·3	39·2	40·1	38·5	1·9	0·8	0·5	3·6
Year, ...	47·4	48·2	47·9	48·4	1·9	0·6	0·4	4·1

XXV. *Notes on the Mollusca of the Laminarian Zone at Leith.* By J. G. Goodchild, H.M. Geological Survey, F.Z.S., M.B.O.U.

(Read 17th March 1897.)

In studying the molluscan fauna of any marine area below tide-marks, the only means usually available for the purpose is by dredging. Much useful work can be done by such an instrument as the dredge, especially when it is in the hands of skilful and experienced operators; but at the best, one obtains by such means only a number of small samples of the material to be studied, which are gathered, so to speak, almost at random. The dredge is, therefore, by no means a perfect instrument of investigation when it is desired to study the molluscan (or other) fauna of any given marine area. It is only on very rare occasions that one has an opportunity of studying the mode of occurrence of such organisms *in situ* over an area of any considerable extent. One opportunity of doing so is now (March 1897) presented by the excavations being made in the Firth of Forth at Leith for the New Dock Extension works, by which some recent shell-bearing strata are being laid bare. Here an area of many acres in extent has been enclosed from the sea by an embankment, and has been drained partly by gravitation, partly by pumping, and is now in process of excavation to a depth of about 25 feet under the level of low water.

In the present notes upon the shell-bearing strata, the chief object kept in view is the origin of the marine molluscan fauna of the Firth of Forth, with especial reference to that contained in the shelly sands just referred to. To this end it will be best first briefly to pass in review the history of such of the later physical changes the district has undergone, so far as these have any bearing upon the chief points under consideration, or as the statement of these facts may enable the reader more easily to grasp the significance of both the facts themselves, and the conclusions to be drawn from their consideration.

Britain, prior to the Glacial Period, appears to have stood for a long time at a much higher elevation above the sea than it has at present. This difference in elevation may have amounted at one time to 600 feet, or even more. It was under these geographical conditions that the present River Forth and its tributaries, aided by the ordinary agencies of surface denudation, excavated the valley to something like its present form. Under such conditions the North Sea, at the time referred to, did not exist. Where that sea now is was then a broad plain, through which the Rhine, receiving as tributary streams all the rivers on the east of Britain, flowed northward, and discharged its waters into the Atlantic on the north-western side of Scotland. The margin of the Atlantic under these conditions coincided, or nearly so, with the present 100 fathom line off the west of Britain. We are concerned at present mainly with the fact that there was no sea-water where the North Sea is now; and, of course, equally so with the fact that there was no sea-water where is now the Firth of Forth. Off the west of Scotland the sea washed the margin of the land, and the causes which gave rise to the Gulf Stream then, as now, helped in the transfer of warm water, and of air charged with aqueous vapour, from the south-western regions of the Atlantic to the region lying far to the north-east.

While the land stood at the higher level referred to, and the sea was excluded from the North Sea area, the climatal conditions on the eastern side of Britain were decidedly colder than at present, as a direct consequence of that elevation, and the exclusion of the sea. Rapid condensation of the vapour-laden currents of air travelling north-eastward with the Gulf Stream resulted in consequence. On the west of Britain, and of Norway, this precipitation took the form of rain, while on the east of Britain and of Scandinavia, the same precipitation was congealed into the form of snow. The east of Scotland, therefore, experienced a colder climate than was found in the west. Rain fell on the one side, snow on the other. Hence arose glacial conditions. Snow once on the surface, the temperature of the superincumbent air could not rise above the freezing-point. So matters, so far as climate is concerned, went on from bad to worse, until in the end—the east of Scotland first, and eventually even the west, became enveloped in a thick mass of ice. This flowed outward from the principal areas of high ground over the low lands adjoining, modifying the surface features to an extent that is not yet fully appreciated even by northern students of glacial geology. Great quantities of detritus were transferred *within* the ice itself (possibly some even on it, and some beneath), and these eventually, when the movement of the ice ceased and it began to melt away, were left beneath the ice as a kind of sediment, which now forms the Till; while the material liberated near the surface was washed down the gradually-widening crevasses, and eventually left as Eskers or Kaims.[1]

When rain falls on the surface, most of it flows off under the influence of gravitation, and the load upon any given part of the earth's crust is not perceptibly increased. When snow forms and gives rise to glaciers, the load on the surface

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[1] This explanation, which is now well known under the title of the *englacial* theory of the origin of glacial deposits, was first put forward by the present writer in a paper "On Drift," Geological Magazine, November 1874.

is increased in proportion to the thickness and extent of the mass. In Scotland, the whole country was enswathed in ice at the climax of the Glacial Period, which ice could not have had a thickness less than 2000 feet around Edinburgh, and must have been even considerably thicker than that nearer its source.

Many physicists are of opinion that the earth's crust everywhere is always in a condition of unstable equilibrium, ready to rise if a load is eased off it at any part, equally ready to sink if a load is placed upon it. Hence the loading of this part of the earth's surface by a heavy mantle of ice may well have resulted in a slow and gradual subsidence. Whether the cause alluded to is or is not the correct one, is not very material for the present purpose. But it is certain that *after* the climax of the glacial conditions was reached, the land here began to subside. As I hold that the Gulf Stream was in operation all through the Glacial Period (and, indeed, was the primary source of the snow by which the glaciers and the ice-sheet were nourished), it follows that with each foot of subsidence an increasingly-larger area was covered by the sea, and a rapid amelioration of climate ensued in consequence. In the meantime, cold surface-waters still favoured the southward migration of the *fry* of Arctic Mollusca (and other marine invertebrates). Therefore, as the land subsided, and the sea gained admittance to the area now occupied by the German Ocean, communication was established with the Atlantic and the old valley of the Forth, into which the sea for the first time gained admittance, while the southern entrance to the German Ocean was barred by the chalk hills (since broken through) between Dover and Calais.

The first marine fauna of the North Sea, and therefore of the Firth and the estuary of the Forth, gained admittance as fry borne along by surface currents entering this area from the region between Scandinavia and Shetland. Such a fauna had necessarily an Arctic facies, and could not well include many Celtic or Lusitanian forms of Mollusca, such as held their own, perhaps through the whole of the Glacial Period, in the area to the west of Britain.

The progenitors of the present Invertebrata of the Forth were thus exclusively boreal and arctic in character, in which respect they differed materially from the contemporaneous fauna of the west of Scotland. The latter fauna included, in addition to the true northern forms that came in with the arctic conditions, many others whose constitution and previous history enabled them to adapt themselves to changed conditions, and to maintain their ground, more or less, alongside that held by the northern invaders.

It was near the close of the Glacial Period proper, and when the land stood one hundred, or perhaps two hundred, feet lower than it does at present, and while the waters of the Forth were muddy with the clay liberated from the melting of the floating ice drifted both down and up its channel, that the boulder clays of Leith Docks, Portobello, Elie, Errol, etc., were formed. And it was at this period that the parent stock of the present molluscan fauna of the Forth first gained admittance here. This fauna has long been known to have possessed an exceptionally arctic character, which is strikingly shown by the nature of the shells found at Elie.

No shells of any kind have rewarded a very careful and oft-repeated search in the boulder clay at Leith Docks. It may well be, as Mr Peach has suggested, that at the time this clay was being formed the quantity of mud in the water was so great, and the surface temperature so low, that even arctic Mollusca could not well establish themselves. That they lived near here, however, is abundantly proved by the shells in the deposit of the same age at Elie.

Under ordinary circumstances, and supposing that no important changes of level occurred, it might be expected that a colony of marine Mollusca established under these conditions would have lived on with but little modification, and with the disappearance of but few species, through the succeeding periods down to the present day. The changes of climate that have ensued since the Glacial Period embrace, it is true, some considerable oscillations of temperature; but then it has to be remembered that it is chiefly on the land, and to a very much lesser extent on the surface of the sea, that the influence of these climatal changes is made manifest.

There is no reason why, with the amelioration of the climate that has followed the Glacial Period as a consequence of the subsidence referred to, the Mollusca found at Leith, for example, should not closely correspond with those still found, under similar conditions of bottom and depth, off the north-west of Scandinavia. Or, if that were not the case, we might reasonably expect a transition in the character of the molluscan fauna as the strata representing the deposits of the successive periods are traced from those of the Glacial Period up to those lately found at Leith. This, however, is not the case. At Leith, instead of there being a transition in petrographical character from the deposits of glacial age up into those of later date, and a similar transition in the respective faunas, we find the sands which overlie the boulder clay there succeeding the boulder clay abruptly and without any signs of a passage, while the molluscan fauna of the sands referred to (which are from 12 to 15 feet in depth, according to the form of the surface upon which the sands lie) is from bottom to top virtually the same, and contains, in fact, exactly the same kinds of shells as those living on a sandy bottom from low-water mark to a depth of 3 or 4 fathoms in the Forth now.

What has happened is not difficult to explain. As the glacial conditions gradually died away, and deposits of the normal type began to be laid down upon those formed under arctic conditions, there has been a tendency for the land as a whole to rise towards the level it had in former times. With each uprise of the land the gradient of the bottom of the Forth has been increased proportionately with the difference of level established, and an increased flow has been imparted to the bottom-waters, with the result that one deposit after another, together, of course, with their included organic remains, has been swept seawards and rearranged. The formations contemporaneous with each of the newer raised beaches (which deposits might have been expected to contain records of the life of each of these periods) have been one after the other swept away. The boulder clay itself being probably very thick to begin with, and being, moreover, excessively tough and difficult of removal, has in great part survived these changes, and is now directly—one might almost say, unconformably—surmounted by a deposit of sand and loam, which, for aught one could determine to the contrary, may well have been laid down entirely since the days of the Romans.

We may now notice the shells as they actually occur. We find, as might be expected, more or less of a mixture of species here. There are some shells which have travelled downwards from the beach under the influence of gravitation; some again which have been washed up from lower laminarian zones during storms; some few which may have drifted down stream from muddy or rocky bottoms higher up the Forth. With these there is a fairly-large percentage of shells which lived on the spot. Looking at the assemblage as a whole, what must strike the observer is the small percentage of carnivorous Mollusca as compared with the abundance of both individuals and species of the forms that are vegetable feeders. Even though an abundant food supply would easily be obtained on the spot, the only indigenous siphonated gasteropods were a small number of *Purpura lapillus*, a fairly large percentage of small examples of *Nassa incrassata*, a few of *Trophon truncatus*, and three examples of *Murex erinaceus*. Not a single example of *Fusus antiquus*, and only some evidently-drifted shells of *Buccinum undatum*, were met with.

Of the holostomatous Gasteropoda there were seen examples of *Littorina littorea*, which may have rolled downward from the beach; some few of *L. obtusata* and *L. rudis;* one specimen of *Lacuna divaricata*, which may have drifted hither on seaweed. With these, and probably brought here in the same manner as the last, were several examples of *Rissoa striata* and *Hydrobia ulvæ*. As might have been expected, *Patella vulgata* occurs in more or less abundance, but as the deposit is mainly sandy, the examples met with are almost certain to be drifted. *Patina pellucida* probably came with floating seaweed, as may also the example of *Tectura testudinalis*. *Trochus cinerarius* is common. Two specimens of *Aporrhais pes-pelecani* were met with. No specimens of *Natica* were seen, although *N. catena* is known to occur on

Leith sands. The last gasteropod in the list is *Turritella terebra*, which is, of course, common.

The Lamellibranchiata are abundantly represented, all the forms that occur on the east of Scotland on sandy bottoms at a depth down to that of a few fathoms being more or less well represented. In the following list the species are stated in the order of the numerical abundance of the individuals; those which occur also in deposits of late glacial age being denoted by a prefixed asterisk:—

**Tellina balthica*, **Cardium edule;* **Mya arenaria*, of which a great number of shells, about one-third the size of the adult, occur in the position of growth; **Mya truncata*, **Artemis lincta*, **Tellina tenuis*, **Tapes decussatus*, *Tapes pullastra*, *Solen ensis* and *Solen siliqua*, **Venus striatula* (or *gallina*), **Mactra solida*, *Mactra stultorum*, *Mactra subtruncata*, *Venus fasciata*, **Pecten opercularis*, **Pecten pusio;* **Mytilus edulis*, mostly drifted; **Nucula nucleus*, **Corbula gibba*, **Astarte compressa*, **Leda minuta*, **Cardium echinatum*, **Cyprina islandica*, **Lutraria elliptica*, *Syndosmya alba*, *Thracia phaseolina*, **Donax vittatus*, **Psammobia ferroensis*, *Cryptodon flexuosus.*

Saxicava, *Pholas*, *Ostrea*, were hardly to be expected on a bottom of loose sand. *Anomia ephippium*, of which two small examples were met with, probably came with seaweed.

A glance at the list shows that, along with many shells that occur in the glacial deposits of Elie and Errol, there occur others that are not found in those places. Some few species common in deposits of late glacial age, and which have probably at one time lived here, are conspicuous by their absence. This is, of course, partly due to the conditions of bottom and depth under which the Mollusca found in the shelly sands at Leith have lived. But much of the difference arises from the numerous oscillations of level that have from time to time affected this part. This is almost as potent a factor in its relation to the well-being of the Mollusca that live in waters of no great depth as the amelioration of the climate. The other chief factor in bringing about the biological change referred to has been the gradual immigration of molluscan fry from the warmer surface-waters of the Atlantic by way of the channel between Scandinavia and Shetland, and perhaps to even a greater extent by way of the Straits of Dover, which, as a channel of communication between the Atlantic and the North Sea, has only recently been established. There is thus a certain amount of competition going on between the shallower-water Mollusca of boreal and arctic origin, and the forms proper to the same conditions which are finding their way in from Celtic or Lusitanian provinces. It is only in the deeper parts of the Firth of Forth, which have not been affected seriously by the changed conditions, that we have any reasonable hope of meeting with the descendants of the primal stock of the Mollusca occurring at Leith.

XXVI. *On the Postponement of the Germination of the Seeds of Aquatic Plants.* By H. B. Guppy, M.B., Pearl Harbour, Oahu, Hawaiian Islands.

(Read 17th March 1897.)

The postponement of the germinating process in the case of aquatic plants displayed itself in the course of a large number of experiments conducted near London between 1891 and 1896. That germination may be deferred to the third, fourth, and fifth years is sufficiently demonstrated in the appended Table of results; and from those experiments still in progress, it may be presumed that instances of a still greater delay will be in time afforded. This capacity is not necessarily connected with the hardness or with the impermeability of the seed-coverings, as is well shown by the behaviour of *Limnanthemum,* although the stony fruits of *Potamogeton* and *Sparganium* exhibited it to a more marked extent.

Unless otherwise indicated, the results given for aquatic plants in the Table were obtained from seeds and fruits never allowed to dry. A variety of other influences affected the experiments, such as those connected with the temperature, the amount of light, the employment either of water or of wet mud, influences, however, that would also greatly differ under natural conditions. A considerable number of special experiments were also made on the effects of light, of drying, of ice, of the removal of the seed-coverings, and of the influence of sea-water immersion. Their addition to the Table would not only have swelled it to twice its size, but would have obscured its principal purpose, that of exemplifying the postponement of germination. Their results, however, will be given in the text when dealing with the individual plants; but those relating to temperature will remain for future treatment, the errors likely to spring from this source being guarded against by preserving the same thermal conditions in all cases of special experiments.

With regard to the influences affecting the germination of *Nuphar luteum* and *Nymphæa alba*, which stand first on the list, it may be at the outset remarked that the seeds of the first plant are less liable to decay in water than those of the second. During the first two years of Experiment 2, only 2½ per cent. of the *Nuphar* seeds rotted. In Experiment 5, about 6 per cent. of the *Nymphæa* seeds decayed in less than twelve months. It will be observed in the Table that the seeds of *Nymphæa alba* germinated in much greater number in the first year than did those of *Nuphar luteum*, and that the last-named plant is better able to defer the germinating process over a series of years. Drying soon deprives the seeds of both plants of their germinating capacity. Various experiments on seeds that had been dried, in each case, for periods ranging from two to fifteen months gave no results, the seeds when examined being in all stages of decay. This is doubtless due to the circumstance that they readily lose their moisture. The seeds of *Nuphar* lost 30 per cent. of their weight in nine days and 50 per cent. in a month, the subsequent loss of weight after many months' drying being very slight.

The following experiment was made on *Nuphar luteum* with the view of determining the influence of different degrees of light on germination. A large number of seeds were divided equally, and placed, on December 9th, in four vessels of water. Two vessels were placed in a greenhouse and two in a room; whilst in each case the two vessels were set side by side so as to ensure the same thermal conditions, one being left exposed to diffused light, and the other being covered so as to be always in darkness. The experiment was prolonged to June 10th, and during this period 54 seeds germinated in the exposed vessel in the greenhouse and 21 in the covered vessel. In the room 186 seeds germinated in the exposed vessel and 56 in the covered vessel. The inference is that whilst these seeds will germinate in the dark, they will germinate in much greater numbers when exposed to diffused light.

In Experiments 1, 6, and 7, the seeds of *Nuphar* and *Nymphæa* germinated freely after being inclosed in frozen mud for two weeks without a thaw; the mud was throughout as hard as stone. Amongst the methods of promoting early germination of *Nuphar* seeds may be mentioned that of immersion in sea-water, as is indicated in Experiment 4. With *Nymphæa alba* the contrary is the case. Of seeds that had been lying six weeks in sea-water, only 4 per cent. germinated and the rest rotted.

The fruits of *Myriophyllum spicatum* germinated readily in most of my experiments in the year of their growth from September on to December. In this respect this plant differs from most of the aquatic plants named in the Table. Occasionally this does not happen, and the process, as indicated in Experiment 12, may then be deferred to the second year. Free germination occurred in the case of fruits of *M. spicatum* that had been kept dry for eighteen months, and of those of *M. alterniflorum* which had been kept dry for a year. Lying sunken in water, both in darkness and in bright diffused light, and under the same thermal conditions, the fruits of both these species germinated with equal readiness. An inclosure in ice for two weeks did not impair the germinating capacity.

The postponement of germination is well illustrated in the Table in the case of the seeds of *Limnanthemum nymphæoides.* These seeds are well able to withstand prolonged drying, and in the course of the experiments some germinated healthily in water after drying for thirty months. Inclosure in ice and in frozen mud for some weeks favours rather than hinders germination. In most of the experiments the seeds were frozen up during successive winters for continuous periods of from one to three weeks.

The fruits of *Ceratophyllum demersum* germinated but scantily in the first year, and freely in the second year, about one-fourth postponing the process to later years. Two months' drying promoted early germination. Their capacity in this direction was not further tested.

Sparganium ramosum is conspicuous even among aquatic plants for its capacity of postponing germination over a number of years. As a rule, germination is postponed altogether to the second year; or, in other words, of drupes grown in 1893, none would germinate until 1895. This inference applies to mature fruits gathered from the plant, and it is based not merely on Experiment 23, but on numerous indications displayed in other experiments not included in the Table. Experiments 20 to 22 were made on drupes found afloat in the seed-drift of the River Thames. A careful study of this matter showed that in an average collection of floating drupes obtained from the Thames drift in the spring, between 60 and 70 per cent. were of the previous year's growth, between 20 and 25 per cent. of the growth of the year before that, and between 5 and 10 per cent. of a still earlier year, which had been at least two and a half years in the water. These last were usually the first to germinate in the experiments.

Aquatic fowl, however, are important agents in promoting the early germination of these fruits. It has long been known that water-birds swallow the fruits of *Sparganium*,[1] which doubtless they sift out of the mud at the bottom of ponds and rivers. The stomachs and intestines of thirteen wild ducks purchased in the London market were examined by me, and in eight individuals occurred 166 stones of a *Sparganium*—to all appearance *S. ramosum*—the number in each bird varying from 3 to 65, and nearly all being entire and sound. Such fruits almost all germinated within three months when placed in water. In one case two germinated within five days of their removal from the bird's stomach.

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[1] *Vide* the English edition of the Systematic Botany of Le Maout and Decaisne.

In the stomach of a bird that had been dead at least a week, a germinating fruit was found.[1]

Early germination of the fruits may also be procured by baring with a knife the stones of fruits gathered from the plant. Of drupes thus treated, 40 per cent. germinated in the first year. The same end can be attained usually by immersion in sea-water. Fruits that floated forty and a hundred days in sea-water germinated in half the cases during the first year.

The drupes of *Sparganium ramosum* also withstand ice well. In the prolonged experiments, they germinated after being encased in ice during successive winters for continuous periods ranging from a week to seventeen days. Fruits that had been dried for three or four months subsequently germinated.

The drupes of *Sparganium simplex* exhibit little or no tendency to germinate in water during the first year, and may defer the process for years. Here, as with *S. ramosum*, aquatic fowl are very effective agents in directly promoting germination. Four out of thirteen wild ducks[2] examined by me contained in their stomachs 129 *Sparganium* "stones," evidently belonging to this species. After being kept a few weeks, fifteen were placed in water, and five of them germinated within a fortnight. As in the case of *S. ramosum*, sea-water immersion favours early germination, and the drupes are not injured either by being dried for three months or by being inclosed in ice for a fortnight.

The mature seeds of *Calla palustris* float in fresh-water until they germinate, and, in fact, never sink. They are able to put off the germinating process to the second year; or, in other words, seeds matured in the summer of 1893, and at once placed in water, would in some cases not germinate until the spring of 1895, when they would be still afloat. The capacity of postponing the process is influenced by various circumstances. Inclosure in ice favours early germination, as is exemplified in the Table. When never inclosed in ice

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[1] These facts were given in a paper by the author in Science Gossip, September 1894.

[2] *Ibid.*

—as in Experiment 27—none of the seeds germinated in the first year, and nearly all in the second year. In Experiments 28 and 29, the seeds were seventeen days in ice during the first winter; and in the one case about half, and in the other all of the seeds germinated during the first year. These seeds withstand a prolonged inclosure in ice better than the seeds and fruits of almost every other aquatic plant experimented on. The effect of drying for some months, and of prolonged flotation in sea-water, is to put off the germinating process to the second year.

Coming to the *Potamogetons,* it is not possible here to enter into any details relating to the somewhat complicated history of their fruits in our ponds and rivers. In such a case it would be necessary to distinguish those with buoyant fruits from those without, and to look into the habits of each species in so far as it bears on the history of the fruit. Here I will merely deal generally with the postponement of germination, and with some of the influences that favour or impede the process. That the delay of germination for years is a characteristic feature with these plants is strikingly illustrated in the Table. Whilst it is there demonstrated that these fruits can defer the process, when in wet mud, to the fifth year, and in water to the fourth year, an analysis of the results leads to the conclusion that in water the delay will be protracted on to the fifth, and even to the sixth year.

Here, however, as with the *Sparganiums,* the aquatic bird sometimes intervenes as an agent, and by swallowing the fruits and voiding them uninjured, it prepares them for early germination. The fruits of *Potamogetons* were found by the author in the stomachs of three out of thirteen wild ducks—the total number found being forty-one. Of these fruits, twelve were placed at once in wet mud, and in four months time all had germinated. A large number of the fruits of *Potamogeton natans* were mixed with the food of a domestic duck. They were found in the droppings in quantities unharmed, and of these 60 per cent. germinated in the following spring. Of those left in the vessel from which the duck had been fed, only 1 per cent. germinated in the next spring, and another year passed before any number of them germinated.[1] Fish, no doubt, similarly prepare these fruits for germination. Darwin, in his "Origin of Species," and other authors notice the occurrence of these fruits in the stomachs of fresh-water fish. They are voided by animals bared of their soft coats. My efforts in imitation of the process, by baring the "stones" with a knife, failed to induce early germination.

It is of importance to determine to what extent these fruits will withstand drying. Those of *Potamogeton natans* germinated freely after drying for four months, but all rotted after being dried for thirty months. Those of *P. densus* germinated after drying for eleven weeks, but all rotted after drying for seventeen and thirty months. On the other hand, the fruits of *P. crispus* germinated in numbers after drying for eighteen months. These facts are sufficient to justify the conclusion that *Potamogeton* fruits retain their powers of germination after drying for several months.

Having noticed that the fruits of *Potamogeton natans* germinated in water more readily in darkness than in diffused light, I made a special experiment with the object of testing this observation. A large number of the fruits were divided into four sets, and placed in four vessels of water, two being in darkness and the other two in diffused light. The seeds of *Nuphar luteum* were experimented on at the same time in these vessels, and the method of the experiment has been already described when treating of that plant. The results obtained for *Potamogeton natans* from December to June, when the experiment began and ended, were these:—In the greenhouse, 35 fruits germinated in bright diffused light and 61 in darkness. In the room, 226 germinated in diffused light and 217 in darkness; but the advantage at first was much on the side of the fruits in darkness, of which up to the end of March 150 had germinated, against 66 in diffused light. It appears, then, that neither light nor darkness is essential to germination, although darkness favours it most. The contrary inference, as regards the effect of darkness, was drawn for the seeds of *Nuphar luteum*, which were in the same vessels, the

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[1] These data were given in Science Gossip for September 1894.

experiment beginning and ending at the same time for both plants. It is noteworthy that with these two plants germination was more frequent in the room than in the greenhouse. This I attribute to the daily range of the water-temperature in the room being much less than that in the greenhouse; and in this respect the experiment in the room closely reproduced the conditions of ponds and rivers.[1]

Inclosure in ice and in frozen mud for continuous periods, varying from seven to seventeen days during successive winters, did not impair the germinating powers of the fruits. The effect of freezing on the general course of the experiments could rarely be appreciated. In Experiments 37 and 38 there was no freezing, whilst in Nos. 39, 40, and 41(A) the fruits were frozen up for a week or two at a time during each winter.

Sea-water immersion favours rather than retards germination. Fruits that had been lying sunk two and three months in sea-water freely germinated, even in one experiment where the density had been increased by the addition of salt to 1·050.

If the postponement of germination had depended on the hardness of the seed-case, the fruits of *Sagittaria sagittifolia* would not have been able to defer the process. That they can do so is shown in the Table. They are also able to germinate freely after a period of drying which, in two experiments not given in the Table, covered three and four months. They can also withstand sea-water immersion. Out of 74 fruits that floated six and a half months in sea-water, 1 per cent. germinated in the first year, 60 per cent. in the second year, and 10 per cent. in the third year.

With regard to *Damasonium stellatum*, it may be here stated that the seeds sooner or later escape from the carpels. They can rest for a long time on the surface of still water, but sink at a touch; and it is remarkable that seeds matured in July, and placed at once on the surface of water, readily germinated there in a few days; whilst those allowed to

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[1] The discussion of the thermal conditions requisite for the germination of aquatic plants will be attempted in a future paper.

sink, for the most part did not germinate until the next year, and until the third year, as indicated in the Table. In some of the experiments the seeds were dried from three to five months and then placed in water, the result of which was that they germinated freely in a few days.

The fruits of *Alisma plantago,* as a rule, do not defer the germinating process beyond the first spring. In one experiment, however, fruits found in the Thames seed-drift in November 1892 did not germinate until April 1894. Fruits kept dry during a winter germinated but scantily in the first year.

When the freshly-detached fruits of *Alisma ranunculoides* are put in water, some of them germinate in a few weeks, but most defer the process to the next year. The effect of a winter's drying—that is to say, of drying for some three or four months—is to cause about 20 per cent. of the fruits to defer germination to the second year.

The seeds or fruits of all the four species of Alismaceæ above referred to, viz., *Sagittaria sagittifolia, Damasonium stellatum, Alisma plantago,* and *A. ranunculoides,* are able to withstand a week or two's inclosure in ice without any impairment of their germinative capacity.

The seeds of *Iris pseudacorus,* when placed in water, usually do not germinate in any numbers until the second year. Hitherto their capacity of deferring germination has not been tested beyond the second year. The only experiment in the Table which comes near in its thermal conditions to a pond or river is No. 49. In all the others the large number of germinating seeds resulted from the exposure of the vessel to very warm conditions. A good proportion of the seeds float for a year and more in the seed-drift of ponds and rivers, and an average collection of these drift-seeds comprises some that have been at least twelve months afloat. In the case of seeds gathered direct from the plant and placed at once in water, very few, if any, germinate in the first year. Out of a collection of seeds obtained from the winter drift of ponds and rivers, and placed in a vessel of water, between 20 and 50 per cent. germinate in the first year under ordinary thermal conditions.

The effect of light on the germination of these *Iris* seeds was tested in the same vessels of water, and contemporaneously with the seeds of *Nuphar luteum* and the fruits of *Potamogeton natans,* as already described. Thirty seeds were placed in December in each of the four vessels, one in bright diffused light and one in darkness in the greenhouse, and one in diffused light and one in darkness in the room.[1] Up to June, fourteen seeds had germinated in the darkened vessel in the greenhouse, and none in any of the other vessels.

Reference may here be made to one or two other aquatic plants which are not referred to in the Table.

The fruits of *Zannichellia palustris* germinate in fair proportion in the year of their growth. They also germinate freely in water after four and a half months' drying.

The fruits of *Callitriche aquatica,* which, it should be remarked, do not float, germinated well when placed in water after two years' drying. They failed to germinate, and rotted when the drying period was extended to three and a half years. The opposite conditions of light and darkness display a marked difference in their effects on the germination in water of these fruits under the same thermal conditions. If the experiment is begun in the middle of the summer, most of the fruits exposed to diffused light germinate in a few weeks, whilst none or scarcely any of the fruits in the dark will have germinated by the autumn; but by then exposing those in the darkened vessel to diffuse light, brisk germination of most of the fruits begins in a few days. If, on the other hand, the fruits are kept in the dark through the winter, few or none of them will germinate even in the spring until exposed to the light. These fruits, in my experiments, readily germinated in the year of their growth. I have found them at the end of summer and in the autumn germinating in numbers at the bottom of ponds where light could reach them. It, however, came out in the experiments that a slight covering of fluffy mud, assisted by the shade of the floating foliage, will in ponds prevent the sunken fruits

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[1] The mode of the experiment is described in the remarks on *Nuphar luteum.*

from germinating in the season of their growth. In no experiment was germination deferred to the second year.

With regard to *Ranunculus aquatilis*, it may be observed that all the British varieties of this species, including *R. hederaceus*, were experimented on. The achenes sink at a touch. Their germinative capacity is not impaired by many months of drying. Many of the fruits germinate in the season of their growth, and the rest all do so in the following spring. With regard to the influence of light on the germination of the sunken fruits, it may be said that darkness prevents or retards the process. This was well brought out in an experiment on *Ranunculus hederaceus*, where the same thermal conditions were secured by placing the two vessels beside each other, one being exposed to diffuse light, the other being covered over so as to produce darkness. The experiment was begun on June 27th; and whilst in the exposed vessel all had germinated by July 23rd, in the darkened vessel only 5 per cent. had germinated up to August 9th, when it was exposed to diffuse light, and in five days all but 20 per cent. of the fruits had germinated. This behaviour is precisely that exhibited by the fruits of *Callitriche aquatica* under the same conditions of experiment.

Recurring once more to the subject of the postponement of germination of aquatic plants, attention should be paid to the latter part of the Table, where I have given examples, which might have been largely increased in number, of the postponement of germination in water on the part of land-plants. The seeds or fruits of nearly all the plants here named form constant constituents of the floating seed-drift of ponds and rivers, and that which occurred in my experiments on this drift, without a doubt also occurs in the pond and in the river.[1] This is not the place to enter into any detail about this matter. It will be enough to state that not only did the seeds or fruits of these and other land-plants germinate in the vessels of water after floating or lying at the bottom for two or three years, but they performed the process completely, and vigorous seedlings were raised from them.

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[1] River drift was dealt with by the author in a paper in vol. 29, Linn. Soc. Journ. Bot. For pond drift see also Science Gossip for October 1895.

There are, in fact, a large number of land-plants, not merely those which frequent the river or pond side, but plants so diverse in their stations as *Arenaria peploides, Symphytum officinale,* and *Rhinanthus crista-galli,* and many of the British Labiatæ of the roadside and waste-ground, that in their ability to germinate in water and in the early growth of the seedling behave practically like aquatic plants. I found water the best medium for procuring the germination of plants of all kinds of stations, and certainly the best for the observation of the germinative process and of the growth of the seedling.[1]

The results of the experiments on the effect of light on germination in water may be thus summed up. With *Ranunculus hederaceus, R. sceleratus, Nasturtium officinale, Hottonia palustris, Callitriche aquatica, Juncus communis,* and *J. glaucus,* darkness was decidedly repressive in its influence. Whilst a large number and often all the fruits or seeds germinated in diffused light, very few and often none germinated in the darkness. But when the darkened vessel was uncovered, germination commenced briskly in a few days, and in a short time most if not all the seeds or fruits were germinating. It has been shown that diffused light also favours the germination of the seeds of *Nuphar luteum,* although darkness does not repress it. On the other hand, darkness favours the germination of the fruits of *Potamogeton natans* more than light. The fruits of *Myriophyllum alterniflorum, M. spicatum, Stellaria aquatica,* and *S. media* germinate equally well both in light and darkness. By placing the vessels side by side, the same thermal conditions, as indicated by the thermometer, were obtained.

In conclusion, one or two general remarks may be made on the capacity of the seeds or fruits of aquatic plants to withstand drying. It will have been already observed that almost all of them can retain their powers of germination after a winter's drying. But the experiments were not often sufficiently extended to test this capacity beyond four or five months. It has been shown, however, that in the case of

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[1] Some of the facts dealt with in this paper were given in a paper read before the Royal Society of Edinburgh about two years ago, but not yet published.

prolonged experiments successful (as a rule) results followed. Thus, with *Limnanthemum nymphæoides* healthy germination occurred after a drying period of thirty months, with *Callitriche aquatica* after twenty-four months, with *Myriophyllum spicatum* and *Potamogeton crispus* after eighteen months, and with *Myriophyllum alterniflorum* after twelve months. On the other hand, the seeds of *Nuphar luteum* and *Nymphæa alba* lose their vitality after two months' drying, and probably a month's drying would prove destructive to them.

Now, if a pond in which flourished *Ranunculus aquatilis, Nuphar luteum, Nymphæa alba, Myriophyllum spicatum, Callitriche aquatica,* and *Zannichellia palustris* was dried up for some months during the summer, and was refilled by the autumnal rains, the result would be the disappearance from its waters of the two water-lilies, *Nuphar luteum* and *Nymphæa alba,* whilst all the other plants above-named would soon be thriving again. This was in part illustrated in a pond near Kingston-on-Thames, where *Ranunculus aquatilis* and *Myriophyllum alterniflorum* thrived. The pond was dried up for some months during the drought of the summer of 1893; but in the following year the two aquatic plants reappeared. The operation of this principle during the course of ages would tend to the exclusion of these two water-lilies from pools, ponds, and streams liable to the effects of a period of drought. These plants in the lapse of time would, as a rule, only be found in rivers, lakes, and ponds fed by rivers or perennial springs. This is, in fact, the case. On the other hand, *Myriophyllum, Callitriche, Zannichellia,* etc., would frequent not only the waters where *Nuphar* and *Nymphæa* thrived, but also ditches, pools, and shallow ponds liable to disappear for a time at each period of dessication, and where the water-lilies do not occur. This also is a fact of observation. In assigning or limiting a station to particular plants, Nature avails herself of the endless variety of their capacities —capacities not always very apparent, and often seemingly trivial in their character.[1]

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[1] For some time I have been endeavouring to approach the problem connected with the "station" of plants by various roads, following different lines of research for different sets of plants.

Limnanthemum nymphæoides, however, which frequents much the same waters as *Nuphar luteum* and *Nymphæa alba*, offers an apparent exception to this principle, since its seeds germinate after thirty months' drying. Yet this plant on the muddy shores of ponds often lives like a land-plant. How little yet, however, do we know of the history of this and other dicotyledonous aquatic plants! If we could but penetrate for a moment the black cloud that hides their past, we might become witnesses of some strange event in the history of plant-descent that would excite the intense interest of the student of plant-life. It may be that each dicotyledon among the aquatic plants represents a great catastrophe in some region of the earth's surface where only the land-plant that was able to adapt itself to aquatic conditions survived; and it may be that in the dicotyledons of the pond and of the river Nature has preserved mementos of these disasters. At all events, we can only follow with safety the sure road of observation and experiment in approaching this mystery; and however plausible they may seem, guesses in the dark can of themselves afford us but little aid.[1]

In the appended Table, I have selected from my experiments those most fitted to illustrate the postponement of the germinating process in water and wet mud. The capital letters in the last column signify as follows:—

E implies that the experiment was brought to an end before all the seeds had germinated, and whilst some or all of the rest were still sound.

P implies that the experiment is still in progress.

R implies that the experiment was completed, the seeds that failed to germinate having decayed.

S implies that the experiment was brought to a close in the spring, before all the seeds had germinated.

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[1] Experiments extending over some years have been carried out by me, with the object of testing the capacity of *Limnanthemum, Myriophyllum*, etc., to acquire the habits of land-plants.

Table illustrating the Postponement of Germination, chiefly of Aquatic Plants.

SPECIES.	Number of Experiment.	Number of Seeds.	Conditions of Experiment.	Percentage of Germinating Seeds in successive years.						
				Year of Growth.	I.	II.	III.	IV.	V.	
Nuphar luteum, frozen	1	28	Wet Mud.	0	7	7	7	40	18	E
	2	2340	Water.	0	4	13	7	....	....	P
	3	200	Wet Mud.	0	14	13	17	....	....	E
	4	50	Wet Mud, after 6 weeks sea-water immersion.	0	28	22	4	6	....	R
Nymphæa alba,	5	1820	Water.	0	86	*	0	....	....	E
	6	100	Wet Mud.	1	51	1	1	....	....	R
frozen	7	50	Wet Mud.	0	70	0	10	....	....	R
	8	200	Wet Mud.	0	37	26	20	....	....	E
Myriophyllum spicatum,	9	30	Water.	45	44	....	....	....	....	S
	10	25	Water.	24	....	....	....	....	....	E
	11	105	Water.	11	32	....	....	....	....	S
	12	40	Water.	0	47	12	....	....	....	S
Limnanthemum nymphæoides,	13	50	Wet Mud.	0	38	32	12	0	....	E
	14	66	Wet Mud.	0	24	39	....	....	....	E
	15	200	Water.	0	52	34	....	....	....	S
	16	110	Water.	0	91	4	....	....	....	R
	17	40	Water, after drying 3 months.	0	18	40	....	....	....	R
Ceratophyllum demersum,	18(A)	13	Wet Mud.	0	23	54	....	....	....	E
	18(B)	20	Water.	0	10	60	10	....	....	E
	19	8	Water, after drying 2 months.	0	62	12	....	....	....	R
Sparganium ramosum,	20	117	Water.	0	6	7	21	3	....	E
	21	70	Water.	0	13	7	16	14	2	E
	22	68	Water.	0	10	....	....	....	....	E
	23	12	Water.	0	0	8	0	....	....	E
Sparganium simplex,	24	6	Water.	0	0	17	0	66	....	E
	25	100	Water.	0	0	0	0	....	....	E
	26	40	Wet Mud, after 3 weeks immersion in sea-water.	0	22	....	....	....	....	E
Calla palustris,	27	33	Water.	0	0	90	....	....	....	E
	28	33	Water.	0	55	42	....	....	....	R
	29	31	Water.	0	100	....	....	....	....	R
	30	20	Water, after drying 3½ months.	0	10	45	....	....	....	S
Potamogeton densus,	31	30	Water.	0	13	40	3	....	....	E
	32	33	Water.	3	97	....	....	....	....	R
Potamogeton obtusifolius,	33	24	Wet Mud.	0	0	8	62	8	4	R

* A single seed germinated in this year.

SPECIES.	Number of Experiment.	Number of Seeds.	Conditions of Experiment.	Percentage of Germinating Seeds in successive years.						
				Year of Growth.	I.	II.	III.	IV.	V.	
Potamogeton lucens, . .	34	40	Wet Mud.	0	10	8	10	10	5	R
Potamogeton crispus, . .	35	100	Water.	0	68	10	....	....	....	S
	36	60	Wet Mud.	0	6	26	....	....	....	E
Potamogeton natans, . .	37	3500	Water.	0	½[*]	16	22	38	....	P
	38	250	Water.	0	0	11	35	....	....	E
	39	250	Water.	0	0	9	8	55	....	E
	40	36	Water.	0	6	25	19	9	....	E
	41(A)	23	Wet Mud.	0	48	30	....	....	....	R
	41(B)	76	Water.	0	0	3	2	20	....	E
Potamogeton oblongus, . .	42	170	Water.	0	31	14	....	....	....	R
	43	260	Water.	0	32	58	....	....	....	R
	44	100	Water.	1	48	14	....	....	....	E
	45	50	Wet Mud.	0	42	24	....	....	....	R
Potamogeton pusillus, . .	46	125	Water.	0	7	14	8	24	....	E
	47	100	Wet Mud.	0	4	9	4	12	....	E
Sagittaria sagittifolia, . .	48(A)	50	Wet Mud.	0	20	8	....	....	....	R
	48(B)	90	Water, after drying 7 weeks.	0	3	75	3	....	....	E
Damasonium stellatum, . .	48(C)	50	Water.	0	66	6	22	....	....	R
Iris pseudacorus, . . .	49	120	Water.	0	12	0	....	....	....	P
	50	129	Water.	0	85	14	....	....	....	R
	51	16	Water.	0	19	81	....	....	....	R
	52	21	Water.	0	0	100	....	....	....	R
Arundo phragmites, . .	53	50	Water.	0	100	....	....	....	....	R
Ranunculus repens, . .	54	150	Water.	12	25	22	....	....	....	E
Rhinanthus crista-galli, . .	55	70	Water.	0	27	15	4	....	....	R
Lycopus europæus, . . .	56	220	Water.	0	6	70	....	....	....	R
Scutellaria galericulata, . .	57	50	Water.	0	0	94	....	....	....	R
Rumex hydrolapathum, . .	58	500	Water.	25	28	14	....	....	....	E
Alnus glutinosa, . . .	59	370	Water.	0	38	20	....	....	....	R
Carex paniculata, . . .	60	115	Water.	0	3	59	0	37	....	R
Carex paludosa, . . .	61	100	Water.	0	0	50	7	2	....	E

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[*] Only 18 fruits of *P. natans* germinated in this year.

XXVII. *On* Cryptoxylon Forfarense, *a New Species of Fossil Plant from the Old Red Sandstone.* By ROBERT KIDSTON, F.R.S.E., F.G.S. [Plates VIII., IX.]

(Read 21st April 1897.)

About two years ago, through the kind permission of Sir Archibald Geikie, F.R.S., etc., Director of the Geological Survey of Great Britain, I had an opportunity given me of examining the Old Red Sandstone plants in the Jermyn Street Museum, London, and among them I observed a small specimen from Reswallie, Forfar, having its internal structure preserved. This was placed in my hands for examination, and has revealed a type of structure hitherto unknown.

CRYPTOXYLON FORFARENSE, Kidston.

[Plates VIII., IX.]

The fossil consists of a portion of a stem, slightly compressed, and preserved in silica of a dark colour. It measures about 8 inches in circumference, and is shown natural size in side view at Fig. 1.

The outer surface is covered with small, slightly fusiform papillæ, which correspond to groups of smaller cells to be described later. Most probably the stem originally possessed an epidermal layer which has now disappeared, but from the manner in which the groups of smaller cells become more numerous and less in size as they approach the periphery of the stem, as shown in the photograph (Fig. 2), one is led to infer that little of the outer portion of the stem is wanting, and that possibly the outer envelope consisted more of an aggregation of the elements of the stem than of a true cortex.

The plant is entirely cellular in structure, but the cells are of two sizes, the smaller occurring in groups scattered somewhat irregularly, but showing a distinct tendency to a concentric arrangement.

In section, the larger cells forming the ground mass are more or less globular or slightly angular from mutual pressure. On an average they are $\frac{1}{300}$ inch in diameter and have thin walls, though their mode of preservation often causes them to appear as if possessing thick walls, but this appearance arises from the presence of a mineral deposit on the walls which is frequently stained with carbonaceous particles (Fig. 5; ×75).

The cells which form the isolated groups are much smaller than the matrix (about $\frac{1}{600}$ inch in diameter), and the infilling material is always of a dark brown colour. They are surrounded on all sides by the larger cells, and the longitudinal length of the group is always greater than its transverse diameter, the groups being fusiform in shape.

Two groups shown in transverse section are given at Figs. 6 and 7 (×75), and a longitudinal section is given at Fig. 8 (×75). The cells are of the same form as those composing the matrix, and differ only in size, though their function was probably different. The circumstance that the mineral filling the groups of smaller cells is always deeply stained, and clearly differentiated from the larger cells of the matrix, indicates clearly that their cell-contents were of a different substance from that filling the larger cells, and may possibly have been of a resinous nature.

This staining of the infilling material in the groups of smaller cells is better seen in Figs. 3 and 4, which are magnified 22 times; Fig. 3 being a transverse and Fig. 4 a longitudinal section, which latter shows the fusiform shape of the groups of smaller cells.

CRYPTOXYLON, Kidston, n. g.

Stem entirely composed of parenchymatous tissue, of which the ground mass consists of lax globular cells, among which are placed groups of smaller cells.

CRYPTOXYLON FORFARENSE, Kidston, n. sp.

[Plates VIII., IX.]

Stem composed of lax hyaline thin-walled parenchymatous tissue, in which are embedded fusiform groups of smaller parenchymatous tissue with dark coloured contents roughly arranged in concentric lines which become more numerous, smaller, and closer together as they approach the periphery of the stem.

Locality.—Reswallie, near Forfar.

Horizon.—Lower Old Red Sandstone.

The specimen is in the collection of the Geological Survey of England, Museum, Jermyn Street, London.

Remarks.—I am unable to determine the affinities of this fossil. At first sight *Cryptoxylon* has somewhat the appearance of *Kalymma unger;*[1] but here the stem is described as having a circle of slightly separated bundles protected by an outer bark, and towards the centre of the stem, and within the outer circle of bundles, a second series of more distant and somewhat irregularly-shaped bundles occur, which are also placed roughly in a circle. The minute structure of the elements composing these bundles does not seem to be clearly made out, though Sir William Dawson and Professor Penhallow state that "in one case a single cell shows fine transverse bars, possibly the remains of a spiral, annular, or scaliform structure."[2]

Though the full structure of the "bundles" in *Kalymma* is imperfectly known, still they are composed of *elongated* tissue. In *Cryptoxylon* there are no bundles or vascular tissue of any kind, and the little dark "spots" seen by the unaided eye in transverse and longitudinal sections are only formed of groups of cells, smaller than those of the surrounding matrix.

From *Prototaxites*, Dawson (*Nematophycus*, Carr.), it is essentially distinct. In *Prototaxites* the tissue is entirely composed of long felted tubes.

That *Cryptoxylon* is cryptogamic is evident, and though the stem is entirely composed of cellular elements, this does not appear to me to be sufficient evidence on which to conclude

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[1] Beitrage zur Palæontologie des Thüringer Waldes—Denk d. Math.-Naturwissen classe d. k. Akad. d. Wissensch, vol. xi., 1856, p. 71.

[2] *Kalymma grandis.* Note on specimens of fossil wood from the Erian (Devonian) of New York and Kentucky—Canad. Record of Science, vol. iv., January 1891, plate i.

that it is algoidal. We have very little intimate knowledge of the Land Plants of Devonian Age, and it seems quite possible that *Cryptoxylon* may be the stem of some primeval form of terrestrial vegetation. I do not, however, feel myself in a position to offer any satisfactory opinion on the affinities of this interesting fossil, so must leave that question an open one.

My thanks are due to Sir Archibald Geikie, F.R.S., etc., for kind permission to describe the specimen.

Explanation of Plates.

Plate VIII.

Cryptoxylon Forfarense, Kidston.

Fig. 1. Specimen showing outer surface ; nat. size.
Fig. 2. Transverse section ; nat. size.
Fig. 3. Transverse section ; × 22.
Fig. 4. Longitudinal section ; × 22.

Plate IX.

Fig. 5. Transverse section, cellular matrix ; × 75.
Fig. 6. Transverse section, group of smaller cells ; × 75.
Fig. 7. Transverse section, group of smaller cells ; × 75.
Fig. 8. Longitudinal section, group of smaller cells ; × 75.

Note.—All the above figures are from photographs.

XXVIII. *A Catalogue of Recent Cephalopoda.* Supplement, 1887–96. By William Evans Hoyle, M.A.(Oxon.), F.R.S.E., Keeper of the Manchester Musuem, Owens College.

(Read 21st April 1897.)

Eleven years ago the Royal Physical Society did me the honour of publishing a list of the species of recent Cephalopoda, as complete as I could make it, up to that date.[1] The decennium which has since elapsed has witnessed the issue of several important memoirs on this group of animals, as well as the usual number of scattered papers. For the purpose of my own studies, I have found it necessary to keep this Catalogue up to date, and it has occurred to me

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[1] Proc. Roy. Phys. Soc. Edin., vol. ix., pp. 205-267, 1886.

that it might be worth while to place the result in the hands of my fellow-workers through the medium of this Society.

The number of new species which have been created during the past ten years is 79, and, as usually happens, the largest genera have received the most numerous accessions. The already unwieldy genus *Octopus*, for example, has been enriched by 21 new names, and *Sepia*, another large genus, has received 9 additions. The number of new genera described is 9, all of which are based upon new species, whilst 3 include in addition species previously known.

The new forms are in nearly all cases adequately described, and in the majority of instances figured with sufficient detail, so that there has been comparatively little room for doubt as to their claim to specific distinction. In cases of uncertainty I have adhered to the principle, mentioned in my previous list, of not registering species as identical without very strong evidence. In the case of a Catalogue like the present, which makes no pretensions to monographic completeness, less harm is done by letting two names stand side by side than by hastily entering them as synonymous.

Most of the novelties are from the eastern seas, and are due to the investigations of Dr Ortmann into the Japanese forms, of the late Dr Brock, whose untimely death deprived zoological science of a promising worker in this interesting field, and of Mr Goodrich, who has reported upon the collections in the Calcutta Museum.

It is, however, no injustice to these workers to say that the most important systematic work on the Cephalopoda which has appeared in recent years is the Monograph which Dr Jatta has published in the "Fauna and Flora of the Gulf of Naples." It is the result of more than ten years work, and is based upon abundant material prepared with all the resources which have rendered the Naples station famous all over the world. The descriptions are careful and elaborate, and there is a wealth of illustrations, which should render it impossible in future to mistake any of the species there enumerated.

The arrangement of this Supplement is on the same lines as that of the Catalogue. It has appeared desirable, on grounds of convenience, to adhere to the classification there adopted, and I have felt the less hesitation in so doing by reason of the commendation which it has received from the pen of Dr Jatta. A reference has been given to the creation of each species, and to other places where information of importance will be found, and also an indication of its habitat. A few notes on previously known species have been added. In conclusion, I desire to express my appreciation of the value and completeness of the "Zoological Record": I have found scarcely any omissions in its pages.

CLASS **CEPHALOPODA**, CUVIER.

Order I. DIBRANCHIATA, Owen, 1832.

Suborder I. OCTOPODA, Leach, 1818.

Division 1. Lioglossa, Lütken, 1882.

Family I. PTEROTI, Reinhardt et Prosch, 1846.

Cirroteuthis, Eschricht, 1836.

8. **C. caudani**, Joubin, Ann. Univ. Lyon, vol. xxvi., p. 247, fig., 1896.
Lusitanian Region.

Opisthoteuthis, Verrill, 1883.

2. **O. depressa**, Ijima and Ikeda, J. Coll. Sci. Tokyo, viii., pp. 1-15, pl. xxxiii., 1895.
Japanese Region.

Family III. ARGONAUTIDÆ, Cantraine, 1841.

Argonauta, Linné, 1756.

6. **A. Bœttgeri**, Maltzan: Smith, Ann. and Mag. Nat. Hist. (5), xx., p. 409, pl. xvii., figs. 1-6, 1887.
Indo-Malayan Region.

8. **A. Bulleri**, Kirk, Trans. N. Zeal. Inst., vol. xviii., p. 138, pl. iv., 1885.
New Zealand Region.

Family IV. PHILONEXIDÆ, d'Orbigny, 1838.

Tremoctopus, delle Chiaje, 1830.

10. **T. Dœderleini**, Ortm., Jap. Ceph., p. 642, pl. xx., 1888.
Japanese Region.

11. **T. microstoma**, Joubin, Céph. "Melita," pp. 218-225, cuts, 1893.[1]

12. **T. hirondellei**, Joubin, Céph. atlant. nord, pp. 10-13, pls. i., figs. 1, 2; ii., figs. 1-3, 1895.
Atlantic Region.

Family VI. OCTOPODIDÆ, d'Orbigny, 1838.

Octopus, Lamarck, 1799.

7A. **O. Hyadesi**, Roch. & Mab., Moll. Cap Horn, p. H6, 1889.
Patagonian Region.

15A. **O. Brocki**, Ortm., Jap. Ceph., p. 645, pl. xxi., fig. 4; pl. xxii., fig. 1, 1888.
Japanese Region.

27A. **O. kagoshimensis**, Ortm., Jap. Ceph., p. 644, pl. xxi., fig. 2, 1888.
Japanese Region.

34A. **O. robustus**, Brock, Nachr. Ges. Göttingen, 1887, No. 11, p. 317.
Australian Region.

35A. **O. Chierchiæ**, Jatta, Boll. soc. nat. Napoli, iii., p. 65, 1889.
Peruvian Region.

44A. **O. pentherinus**, Roch. & Mab., Moll. Cap Horn, p. H7, 1889.
Patagonian Region.

79. **O. microphthalmus**, Goodrich, Ceph. Calcutta Mus., p. 20, pl. v., figs. 83, 84, 1896.
Indo-Malayan Region.

80 **O. pulcher**, Brock, Ind. Ceph., p. 607, 1887.
Indo-Malayan Region.

81. **O. chromatus**, Heilprin, P. Ac. Philad., p. 324, pl. xvi., fig. 1, 1888.

1889. *Octopus chromatus* (?), Heilprin, Bermuda Is., p. 167, pl. 15 (no description).

New England Region.

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[1] Gives an interesting account of the structure and disposition of the hectocotylised arm, whilst still enclosed in its sac.

82. **O. ergasticus**, P. & H. Fischer, Journ. de Conch., 1892 (3), xxxii., p. 298, fig. B [1893].
West African Region.

83. **O. sponsalis**, P. & H. Fischer, Journ. de Conch., 1892 (3), xxxii., p. 297, fig. A [1893].
West African Region.

84. **O. Alberti**, Joubin, Céph. atlant. nord, pp. 18-20, pl. i., figs. 3 and 4, 1895.
Lusitanian Region.

85. **O. Digueti**, Perrier & de Rochebrune, Comptes rendus, cxviii., p. 770, 1894.
1896. *O. Digueti*, Rochebr., Arch. Mus. Paris, t. viii., pp. 75-86, figg.
Californian Region.

86. **O. elegans**, Brock, Ind. Ceph., p. 597, 1887.
Indo-Malayan Region.

87. **O. amboinensis**, Brock, Ind. Ceph., p. 598, 1887.
1894. *O. amboinensis*, Joubin, Céph. d'Amboine, p. 31.
Indo-Malayan Region.

88. **O. Machiki**, Brock, Ind. Ceph., p. 599, 1887.
Indo-Malayan Region.

89. **O. pisiformis**, Brock, Ind. Ceph., p. 601, pl. 16, figs. 1 and 2, 1887.
Indo-Malayan Region.

90. **O. inconspicuus**, Brock, Ind. Ceph., p. 603, pl. 16, fig. 4, 1887.
1894. *O. inconspicuus*, Joubin, Céph. d'Amboine, p. 33.
Indo-Malayan Region.

91. **O. Harmandi**, Rochebr., Bull. Soc. Philom. (7), vi., p. 73, 1882.
Indo-Malayan Region.

92. **O. coerulescentes**, Fra Piero, Moll. Sardegna, p. 267, 1895.
Mediterranean Region.

93. **O. Monterosatoi**, Fra Piero, Moll. Sardegna, p. 268, 1895.
Mediterranean Region.

Enteroctopus,[1] Roch. & Mab., 1889.

1. **E. membranaceus**, Roch. & Mab., Moll. Cap Horn, p. H7, 1889.
Patagonian Region.

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[1] *Octopus megalocyathus*, Gould, is also included by the authors in this genus.

Eledone, Leach, 1817.

7. **E. Aldrovandi** (Raf.),[1] Précis découv. somiol., p. 29.
   1889. *E. Aldrovandi*, Posselt, Ceph., "Hauch's" Togter, p. 4, 1889.
   1896. ,, ,, Jatta, Cef. Napoli, p. 243, pl. 5, fig. 1, etc.
   Mediterranean Region.
8. **E. albus**, Fra Piero, Moll. Sardegna, p. 265, 1895.
   Mediterranean Region
9. **E. grisea**, Fra Piero, Moll. Sardegna, p. 266, 1895.
   Mediterranean Region.

Suborder II. DECAPODA, Leach, 1818.

Division 1. Myopsida, d'Orbigny, 1845.

Family VII. SEPIOLINI, Steenstrup, 1861.

Sepiola (Rondelet, 1554), Leach, 1817.

11. **S. Scandica**, Stp., Notæ teuthol., 6, p. 65, 1887.[2]
    Scandinavian Region.
12. **S. aurantiaca**, Jatta, Cef. Napoli, pp. 130-133, pl. v., fig. 4; pl. xiv., figs. 31-46, 1896.
    Mediterranean Region.

Inioteuthis,[3] Verrill, 1881.

3. **I. maculosa**, Goodrich, Ceph. Calcutta Mus., p. 2, pl. i., figs. 1-3, 1896.
   Indo-Malayan Region.

Microteuthis, Ortmann, 1888.

1. **M. paradoxa**, Ortm., Jap. Ceph., p. 649, pl. xxii., fig. 4, 1888.
   Japanese Region.

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[1] Posselt and Jatta have shown that I was mistaken in regarding this as a synonym of *E. cirrosa*.

[2] *S. Petersii*, Stp., is regarded by Jatta as a variety of *S. Rondeleti*, and I think his arguments are quite convincing.

[3] *Inioteuthis japonica* and *I. Morsei* are redescribed, with figures of hectocotylised arms and suckers, by Ortmann, Jap. Ceph., p. 647, pls. xxi., figs. 6, 7 ; and xxii., figs. 2, 3, 1888.

Rossia, Owen, 1834.

1. **R. palpebrosa**, Owen.[1]
   1896. *Rossia palpebrosa*, Jatta, Cef. Napoli, pp. 139-142, pl. xv., figs. 11-20.
   Arctic and Mediterranean Regions.

8. **R. Mölleri**, Stp., Becher, Moll. Jan Mayen, p. 81, fig. 9, 1886.
   Arctic Region.

Family VIII. Sepiarii, Steenstrup, 1861.

Sepidæ, d'Orb. (*pars*).

Subfamily Idiosepii, Steenstrup, 1881.

Idiosepius, Steenstrup, 1881.

2. **I. Picteti**, Joubin, Céph. d'Amboine, Compl., p. 459, 1895.
   1894. *Loligo Picteti*, Joubin, Céph. d'Amboine, pp. 60-64, pls. iii., iv.
   Indo-Malayan Region.

Subfamily Eusepii, Steenstrup, 1881.

Sepia, Linné, 1766.

23a. **S. torosa**, Ortm., Jap. Ceph., p. 652, pl. xxiii., fig. 2, 1888.
   Japanese Region.

24a. **S. Hoylei**, Ortm., Jap. Ceph., p. 650, pl. xxii., fig. 5; pl. xxiii., fig. 1, 1888.
   Japanese Region.

35a. **S. tokioensis**, Ortm., Jap. Ceph., p. 653, pl. xxiii., fig. 3, 1888.
   Japanese Region.

59. **S. microcotyledon**, Ortm., Ceph. Ceylon, p. 673, fig. 1, 1891.
   Indo-Malayan Region.

60. **S. hercules**, Pilsbry, Nautilus, vii., p. 144, 1894.
   Japanese Region.

61. **S. framea**, Ortm., Ceph. Ceylon, p. 675, fig. 2, 1891.
   Indo-Malayan Region.

62. **S. apama**, Gray, M'Coy, Prodr. Zool. Vict., Dec. xix., p. 325, pls. 188-190, 1889.

63. **S. singalensis**, Goodrich, Ceph. Calcutta Mus., p. 3, pl. i., figs. 4-8, 1896.
   Indo-Malayan Region.

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[1] The discovery of this rare Arctic form in the Mediterranean is very interesting.

64. **S. Veranyi**, Lagatu, Actes Soc. L. Bord., xlii., 2, pp. 115-117, pl. viii., 1889.
Mediterranean Region.

Family IX. LOLIGINEI, Steenstrup, 1861.

Sepioteuthis, Blainville, 1825.

18. **S. indica**, Goodrich, Ceph. Calcutta Mus., p. 5, pl. i., figs. 9-19, 1896.
Indo-Malayan Region.

Loligo, Lamarck, 1799.

19. **L. Bleekeri**, Joubin, Céph. d'Amboine, pp. 56-60, 1894.
Indo-Malayan Region.

20A. **L. tetradynamia**, Ortm., Jap. Ceph., p. 659, pl. xxiii., fig. 4; pl. xxv. fig. 1, 1888.
Japanese Region.

37. **L. aspera**, Ortm., Jap. Ceph., p. 661, pl. xxv., fig. 3, 1888.
Japanese Region.

38. **L. singhalensis**, Ortm., Ceph. Ceylon, p. 676, fig. 3, 1891.
Indo-Malayan Region.

39. **L. Stearnsii**, Hemphill, Zoe, iii., pp. 51, 52, 1892.[1]
Californian Region.

Loliolus, Steenstrup, 1856.

4. **L. investigatoris**, Goodrich, Ceph. Calcutta Mus., p. 8, pl. ii., figs. 29-37, 1896.
Indo-Malayan Region.

Division 2. Œgopsida, d'Orbigny, 1839.

Family X. OMMASTREPHINI, Steenstrup, 1861.

Subfamily OMMASTREPHIDÆ, Gill, 1871.

Ommastrephes, d'Orbigny, 1835.

11. **O. Caroli**, Furtado, Mem. Sci. Lisb., vol. 49, pt. 2, pp. 1-19, 2 pls., 1887.
1887. *Ommatostrephes Caroli*, Stp., Notæ Teuthol., 8, pp. 128-146.
Atlantic Region.

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[1] This is a mere *nomen nudum:* the description is quite worthless, as the species could never be recognised from it.

2. **O. gigas**, d'Orb.: v. Martens, Sitzungsb. Ges. naturf. Freunde Berlin, 1894, p. 234.[1]

12. **O. Gouldi**, M'Coy, Prodr. Zool. Victoria, Dec. xvii., p. 255, pls. 169, 170, 1888.

Australian Region.

Todarodes, Steenstrup, 1880.

1. **T. sagittatus** (Lmk.), Stp.

1890. *T. sagittatus*, Posselt, Vid. Medd. Kjöbenhavn, pp. 301-359, pls. viii., ix.[2]

Todaropsis, Girard, 1890.

1. **T. Veranyi**,[3] Girard, Nota ceph. Portugal, p. 204, 1890; Rév. moll. Lisbonne, pp. 261-264, figs. 4-10, 1890.

1896. *Todaropsis Veranyi*, Jatta, Cef. Napoli, pp. 76-80, pls. ii., fig. 7; xii., 4-19.

Atlantic Region.

2. **T. eblanæ**[3] (Ball), Proc. Roy. Irish Acad., i., p. 363, figs. 1-7, 1841.

Illex eblanæ, Hoyle, Journ. Mar. Biol. Assoc., N.S., vol. ii., pp. 189-192, cuts, 1892.

Todaropsis eblanæ, Posselt, Vid. Medd. Kjöbenhavn, Ap. i., 1892, 1893.

Martialia, Roch. & Mab., 1889.

1. **M. hyadesi**, Roch. & Mab., Moll. Cap Horn, p. H9, pl. i., 1889.

Patagonian Region.

Chtenopteryx, Appellöf, 1890.

1. **C. fimbriatus**, App., Teuthol. Beitr. I., pp. 4-6, figs. 1-6, 1890.

Mediterranean Region.

2. **C. cyprinoides**, Joubin, Bull. soc. zool. Fr., xix., p. 64, cut, 1894.

Mediterranean Region (from the stomach of a Dolphin).

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[1] Gives dimensions of a specimen captured off Chili, but no complete description.

[2] An elaborate account of the anatomy and external characters of this species, including a comparison with allied forms. The talented and industrious author, whose early death has cut short a career of great promise, proposed to divide the Ommatostrephidæ into two subfamilies, Ommatostrephinæ and Illicinæ.

[3] I think it more than probable that these two species will prove to be the same.

Architeuthis, Steenstrup, 1856.

7. **A. Kirkii**, Robson, Tr. N. Zeal. Inst., xix., p. 155, 1887.
New Zealand Region.
8. **Architeuthis** sp., Mitsukuri and Ikeda, Notes on a Gigantic Cephalopod, Zool. Mag. Tokyo, vol. vii., No. 77, pp. 39-50, pl. x., 1895.

Tracheloteuthis, Steenstrup, 1881.

5. **T. Guernei**, Joubin, Céph. atlant. nord, pp. 34-38, pls. i., figs. 5, 6; ii., figs. 4-9, 1895.
Atlantic Region.

Family XI. ONYCHII, Steenstrup, 1861.

Subfamily ONYCHOTEUTHIDÆ, Gray, 1849 (*sensu stricto*).

Abralia, Gray, 1849.

7. **A. andamanica**, Goodrich, Ceph. Calcutta Mus., p. 9, pl. ii., figs. 38-45, 1896.
Indo-Malayan Region.
8. **A. lineata**, Goodrich, *op. cit.*, p. 10, pl. iii., figs. 46-50, 1896.
Indo-Malayan Region.

Abraliopsis, Joubin, 1896.

1. **A. Pfefferi**, Joubin, Bull. soc. sci. et méd. Ouest, tom. v., No. 1, pp. 19-35, cuts, 1896.
2. **A. Hoylei**, Joubin, *op. cit.*
Enoploteuthis Hoylei, Pffr., Ceph. Hamb. Mus., p. 17, fig. 22, 1884.

Pterygioteuthis, H. Fischer, 1895.

1. **P. Giardi**, Fischer, Journ. de Conch., 1895, pp. 205-211, pl. ix., 1896.

Chaunoteuthis, Appellöf, 1891.

1. **C. mollis**, App., Teuthol. Beitr. I., pp. 3-27, 4 pls., 1891.

Subfamily GONATIDÆ, Hoyle, 1886.

Gonatus, Gray, 1849.

1. **G. Fabricii** (Licht.), Hoyle, Proc. Zool. Soc., 1889, pp. 117-135, pls. xiii., xiv.

Family XII. TAONOTEUTHI, Steenstrup, 1861.

Subfamily CHIROTEUTHIDÆ, Gray, 1849.

Chiroteuthis,[1] d'Orbigny, 1839.

4. **C. Picteti,** Joubin, Céph d'Amboine, pp. 40-56, pls. i., ii., 1894.
Indo-Malayan Region.

5. **C. macrosoma,** Goodrich, Ceph. Calcutta Mus., p. 12, pl. iii., figs. 51-57, 1896.
Indo-Malayan Region.

6. **C. pellucida,** Goodrich, *op. cit.*, p. 14, pl. iv., figs. 58-61, 1896.
Indo-Malayan Region.

7. **C. Grimaldii,** Joubin, Céph. atlant. nord, pp. 38-46, pls. iii., figs. 1-4; iv., figs. 1, 2; v., figs. 2, 4-9, 12, 1895.
Atlantic Region.

Histiopsis, Hoyle, 1885.

2. **H. Hoylei,** Goodrich, Ceph. Calcutta Mus., p. 15, pl. iv., figs. 62-71, 1896.
Indo-Malayan Region.

Calliteuthis, Verrill, 1880.

3. **C. Alessandrini,** App., Teuthol. Beitr. I., pp. 27-31, figs. 7-11, 1890.
1851. *Loligo Alessandrinii,* Vér., Céph. médit., p. 99, pl. xxxv. figs. *f, g, h.*

4. **C. nevroptera,** Jatta, Cef. Napoli, p. 118, pl. 31, figg. 1-10, 1896.
Mediterranean Region.

Histioteuthis, d'Orbigny, 1839.

2. **H. Ruppelli,** Vérany.[2]

Family XIII. CRANCHIÆFORMES, Steenstrup, 1861.

Subfamily CRANCHIADÆ, Gray, 1849.

Taonius, Steenstrup, 1861.

8. **T. Richardi,** Joubin, Céph. atlant. nord, pp. 46-50, pls. iii., figs. 5, 6; iv. figs. 3, 5, 1895.
Atlantic Region.

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[1] Joubin has given most interesting and important accounts of the suckers and cuticular organs in this genus (Quelques organes colorés de la peau chez deux céphalopodes du genre Chiroteuthis, *Mém. soc. zool. Fr.*, 1893, pp. 1-13, cuts).

[2] The luminous organs of this genus have received full and careful treatment at the hands of Professor Joubin (Recherches sur l'appareil lumineux d'un céphalopode *Histioteuthis Ruppellii,* Vérany; Rennes, 1893).

9. **T. abyssicola**, Goodrich, Ceph. Calcutta Mus., p. 17, pl. v., figs. 72-80, 1876.
Indo-Malayan Region.

Incertæ sedis.

Lepidoteuthis, Joubin, 1895.

1. **L. Grimaldii**, Joubin, Comptes rendus, cxxi., pp. 1172-1174, cuts, 1895.
Atlantic Region.

APPENDIX, 1897.

Mastigoteuthis levimana, Lönnberg, Notes rare Ceph., p. 605, 1897.
Atlantic Region.

Sepia verrucosa, Lönnberg, Two Ceph. Teneriffe, p. 697, 1897.
Atlantic Region.

Ommastrephes Bartrami, var. **sinuosa**, Lönnberg, *op. cit.*, p. 701.
Atlantic Region.

Explanation of the more Abbreviated References.

App., Teuthol. Beitr. I.,—Appellöf, Teuthologische Beiträge, I., *Chtenopteryx*, n.g., *Veranya sicula*, Krohn, *Calliteuthis*, Verrill, *Bergens Mus. Aarsber.*, for 1889, No. 3, pp. 1-34, pl., 1890.

,, **II.**, *op. cit.*, for 1890, No. 1, pp. 1-29, pls. i.-iii., 1891.

Arbanasich.—*See* Fra Piero.

Brock, Ind. Ceph.,—Indische Cephalopoden, *Zool. Jahrbücher*, v. 2, pp. 591-614, pl. 16, 1887.

Becher, Moll. Jan Mayen,—Die internationale Polarforschung, 1882-1883. Die österreichische Polarstation Jan Mayen ausgerüstet durch seine Excellenz Graf Hanns Wilczek, geleitet vom k.k. Corvetten-Capitän Emil Edlen von Wohlgemuth. Beobachtungs-Ergebnisse herausgegeben von der k. Akademie der Wissenchaften, iii. Band., vi. Theil., Zoologie, G. Mollusken, pp. 67-82, pl. vi. [1886].

Fra Piero, Moll. Sardegna,—(Pietro Arbanasich)—La enumerazione dei molluschi della Sardegna, *Bull. società malacologica italiana*, vol. xix., 1894, pp. 263-278, 1895.

Girard, Nota ceph. Portugal,—Nota sobre os cephalopodes de Portugal, *Jorn. sci. Lisboa* (2), iii., 1889 [published 1890].

,, **Rév. moll. Lisbonne,**—Révision des mollusques du muséum de Lisbonne, I. — Céphalopodes, *Jorn. sci. Lisboa* (2), vol. iv., 1890.

Goodrich, E. S., Ceph. Calcutta Mus.,—Report on a collection of Cephalopoda from the Calcutta Museum, *Trans. Linn. Soc.* (2), vol. vii., 24 p., 5 pl., 1896.

Jatta, Cef. Napoli,—I cefalopodi viventi nel Golfo di Napoli, Fauna u. Flora des Golfes von Neapel, xxiii., 11+268 pp., 31 pl., 4°. Berlin, 1896.

Joubin, Céph. "Melita,"—Voyages de la goëlette *Melita* sur les côtes orientales de l'océan atlantique et dans la Méditerranée. Céphalopodes, *Mém. soc. zool. Fr.*, vi., pp. 214-225, cuts, 1893.

,, **Céph. d'Amboine,**—*Revue suisse de zool.*, ii., pp. 23-64, pls. i.-v., 1894. Note complémentaire, *op. cit.*, iii., pp. 459-460, 1895.

,, **Céph. atl. nord,**—Résultats des campagnes scientifiques accomplies sur son yacht par Albert 1er. Fasc. ix., Contribution à l'étude des Céphalopodes de l'Atlantique Nord, 63 pp., 6 pls., 4°. Monaco, 1895.

Lönnberg, Notes rare Ceph.,—Notes on some rare Cephalopods, *Öfversigt k. Vetensk.-Akad. Förhandl.*, 1896, No. 8, pp. 603-612, cuts, 1897.

,, **Two Ceph. Teneriffe,**—Two Cephalopods from Teneriffe, collected by A. Tullgren, *Öfversigt k. Vetensk.-Akad. Förhandl.*, 1896, No. 10, pp. 697-706, 1897.

Ortm., Jap. Ceph.,—Ortmann, A., Japanische Cephalopoden, *Zool. Jahrbücher*, vol. iii., pp. 639-670, pls. 20-25, 1888.

,, **Ceylon Ceph.,**—Ortmann, A., Cephalopoden von Ceylon, *Zool. Jahrbücher*, vol. v., pp. 669-678, pl. xlvi., 1890.

Stp., Notæ Teuthol., 6,—Steenstrup, Notæ Teuthologicæ, 6, *Overs. k. Dansk. Vidensk. Forhandl.*, 1887, pp. 47-66.

,, **Notæ Teuthol., 7,**—*op. cit.*, 1887, pp. 67-126.

,, **Notæ Teuthol., 8,**—*op. cit.*, 1887, pp. 128-146, 2 pls.

Roch. and Mab., Moll. Cap Horn,—A. T. de Rochebrune and J. Mabille, Mollusques: *in*, Mission scientifique du Cap Horn, 1882-1883, t. vi., Zoologie. Paris, 1889,[1] pp. 1-10, pl. i.

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[1] The new species described in this work are dated by the authors 1887, but the title page of the work bears the year 1889, and there is no reference to an earlier publication.

XXIX. *Additional Notes on the Fossil Fishes of the Upper Old Red Sandstone of the Moray Firth Area.* By R. H. Traquair, M.D., LL.D., F.R.S. [Plates X. and XI.]

(Read 16th December 1896.)

Since the publication of my memoir on the "Extinct Vertebrata of the Moray Firth Area,"[1] a certain amount of new material from the Upper Old Red Sandstone of the districts of Elgin and Nairn has come to hand, for most of which I have to thank the untiring industry of my friend Mr William Taylor of Lhanbryde. I have also to thank Dr Woodward, F.R.S., and Mr Smith Woodward, F.L.S., for their kind permission to examine and to take notes and drawings of specimens in the Brickenden Collection, recently acquired by the Geological Department of the British Museum.

Fishes from the Nairn Sandstone.

As shown in the memoir referred to above, the fish-fauna of the Nairn beds, which apparently constitute a distinct division of the Upper Old Red Sandstone of the south side of the Moray Firth, is different from that which is contained in the strata of the adjoining district of Alves and Elgin. I had not, at the time I wrote, found any one species common to the two sets of rocks, and of especial interest was the fact that the characteristic fish of the Nairn strata belonged to a genus, namely *Asterolepis*, which occurs nowhere else in Great Britain, while not a vestige of any species of *Bothriolepis,* a genus otherwise so generally characteristic of the Upper Old Red, had ever been collected. In fact, palæontologically, the Nairn beds may be compared with those of Wenden in Russia; the Elgin strata with those of the Sjass in the same country.

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[1] In Harvie-Brown and Buckley's "Vertebrate Fauna of the Moray Basin," vol. ii., pp. 235-285. Edinburgh, D. Douglas, 1896.

One additional genus and species (*Psammosteus tesselatus*) must now be added to the Nairn list, while it now seems clear that at least one species (*Holoptychius decoratus*, Eichwald) extended into the Elgin beds.

Psammosteus tesselatus, sp. nov., Traquair.

[Plate XI., Figs. 1 and 2.]

Shield shallow boat-shaped, resembling in form that of *P. Taylori*, but its substance is *thin* in comparison. Outer surface fretted with very closely placed stellate tubercles, polygonal, and often irregularly so, in form, their edges marked by *exceedingly minute serrations.*

No division of the outer layer into polygonal areas is observable, as in the case of *P. Taylori*, Traq., and some examples of *P. paradoxus*, Ag.

In the course of the past summer, Mr Taylor sent me the beautiful fragment now in the Edinburgh Museum, and of which a portion is represented in Pl. XI., Fig. 1, magnified two diameters, while the external sculpture, enlarged still further to eight diameters, is shown in Fig. 2. On examining it, I at once remembered two fish-plates which I had collected some years previously at Nairn (Kingsteps Quarry), and on re-examination I found that one of them presented the outline of a nearly entire *Psammosteus* shield, though the outer layer was unfortunately quite gone. The other, a portion of a larger plate, showed the smooth inner surface, but on raising a portion from the matrix, I found on the outer surface clear evidence of the same minute mosaic-like tuberculation, shown much more perfectly on the specimen sent to me by Mr Taylor.

In general aspect the ornament in this species resembles very considerably that in the Russian species *P. paradoxus* and *P. arenatus*, but the tuberculations are not so prominently rounded, while their marginal serrations are much finer.

Coccosteus magnus, Traquair.

[Plate X., Fig. 1.]

Extinct Verteb. Moray Firth Area, p. 258, pl. vi., fig. 10 (anterior median ventral plate).

In addition to the anterior median ventral plate of this species, figured in my previous memoir, I now give a drawing of a median dorsal plate, which was sent to me some time ago by Mr Taylor, and which is now in the Museum of Science and Art. Of course, I presume it to belong to the same species, as no other is known from the quarries in question (Kingsteps).

The plate measures 4¼ inches in length and 2⅛ inches in greatest breadth, and its contour is clearly shown, though, unfortunately, a large piece has been broken away from the right side in front. The greater part of the bone, showing the external sculptured surface, remains *in situ*, and the close tuberculation is proportionally finer, especially in the centre of the plate, than is usually the case in *C. decipiens*, Ag., of the Orcadian series. The sensory groove, like a V with backwardly directed rounded angle, is seen in the same position as that in which it occurs in the last-named species.

FISHES FROM THE ALVES AND ELGIN BEDS.

Psammosteus Taylori, Traquair.

[Plate XI., Fig. 5.]

Ann. Scot. Nat. Hist., Oct. 1894, p. 225; Ext. Verteb. Moray Firth Area, pp. 260-263, pl. vi., figs. 1-3.

Since I wrote my previous descriptions, more satisfactory examples of the external ornament of *Psammosteus Taylori* have turned up. Especially beautiful is one fragment recently obtained by Mr Taylor from Newton Quarry, and of which I have represented a small portion in Pl. XI., Fig. 5, magnified two diameters. The small polygonal areas into which the outer layer of the shield is divided, and which correspond to shallow depressions of similar form on the outer surface of the middle layer, are here very distinctly seen. The surface of each of these areas is slightly convex, and closely covered with stellate tubercles. In or near the centre of each area is a tubercle usually larger than the others, which tend to be arranged round it in a more or less concentric manner. The vertical thickness of this fragment is $\frac{1}{4}$ inch.

Psammosteus pustulatus, sp. nov., Traquair.

[Plate XI., Figs. 3 and 4.]

In my "Extinct Vertebrata," I mentioned the fact that small fragments of plates apparently belonging to *Psammosteus* had been found at Scaat Craig by Mr Taylor, in addition to the fragment of a "spine," which I figured from the collection of Mr Grant of Lossiemouth. I had also found, on an excursion which I made with Mr Taylor to the same locality, a similar fragment, which, when subsequently extracted entirely from the matrix, showed clearly on the outer surface the abraded remains of a *Psammosteus*-like tuberculation. Subsequently I found much better pieces in the Brickenden Collection in the British Museum, one of which (Pl. XI., Fig. 3) I have adopted as the type of a new and very distinct species.

These fragments are water worn at the edges, and generally abraded on the surface; when broken across, their internal structure is that of *Psammosteus* so far as can be seen with a good lens, as I have not yet obtained any section sufficiently thin for examination with a high power. The outer surface shows in most cases only the worn stumps of rounded tubercles, which are proportionally large, attaining a diameter at the base of $\frac{1}{32}$ to $\frac{1}{25}$ inch. In the specimen represented in Pl. XI., Fig. 3 (Brit. Mus., P. 8297), the tubercles are much more completely preserved than is usually the case.

This fragment measures $2\frac{1}{8}$ inches in length by $1\frac{5}{8}$ inch in breadth; its greatest thickness is $\frac{1}{8}$ inch, but this diminishes to $\frac{1}{16}$ at the middle of the side, which in the figure is placed to the left. On the external surface there is, along the side alluded to, a space bare of tubercles, and about half an inch in breadth; the rest of the outside of the plate is covered with tubercles of the dimensions stated, but the different sizes are not indiscriminately mixed, the smaller ones prevailing on the side opposite to the non-tuberculated area. These tubercles are in this instance pretty close together, but far enough apart to show between them some of the vascular surface of the middle layer below. Each of the tubercles, if perfect, shows when magnified (Fig. 4) an apical boss or cap of ganoine, which may often be seen to be nicked or crenulated round its margin with a variable number of identations; but this ganoid cap does not reach to the base of the tubercle, as may be seen in the figure. On the specimen figured, two wavy grooves are also seen on the surface.

In other examples the tubercles are more distantly scattered, so that there may be considerable intervals between them, and in worn specimens they are usually broken through and decapitated, or rubbed down.

The under surface shows a tissue of a dense laminated character, as in other species of the genus.

I have included these fragmentary plates under *Psammosteus*, on account of the similarity of the vascular network of the middle layer to that in the other species of the genus, although the nature of the tuberculation is somewhat aberrant. Nevertheless, even this external ornament corresponds more to that of *Psammosteus* than of any other plates with which I am acquainted.

Cosmacanthus Malcolmsoni, Ag.

[Plate X., Figs. 2 and 3.]

Agassiz, Poiss. Foss. v. g. r., p. 120, pl. 33, fig. 8; Traquair, Ext. Verteb. Moray Firth Area, p. 263, pl. vi., figs. 6-9.

In my "Extinct Vertebrata," I showed not only that Agassiz was right in referring the original fragment of *Cosmacanthus* to the category of Selachian spines, but that it was not bilaterally symmetrical, and consequently, like *Gyracanthus*, was pretty certainly a lateral appendage.

I am now able to repeat those statements, and to complete the description of *Cosmacanthus Malcolmsoni*, from a beautiful and nearly entire example contained in the Brickenden Collection in the British Museum (P. 8298). The spine (Pl. X., Figs. 2 and 3) measures 3¼ inches in length, and has the point nearly complete; in its form it is compressed, but one side (Fig. 3) is more convex than the other (Fig. 2). The anterior margin is rounded; on the posterior aspect is seen the sulcus, extending to about 1¼ inch from the point. The covered or inserted part of the lateral surface, behind, is broader on the flattened than on the rounded side of the spine, and is on both sides sharply defined from the sculptured surface; and as the sculptured surface is cut off at the basal end, it is clear that the inserted extremity has been lost. The exposed surface is covered with stellate tubercles, larger and more crowded on the front of the spine, smaller and not so closely placed on the sides; though there is some tendency to a linear arrangement of these tubercles on the sides, there is no longitudinal interval along the anterior margin, as in the other two specimens which are known. A posterior marginal row of large tubercles, sixteen in number, occupies the place of the marginal denticles of *Gyracanthus*, being placed along the hinder edge of the flat surface of the spine.

The present specimen, nearly entire as it is, in this way completely confirms the evidence of the fragment which I figured in my previous memoir, namely, that *Cosmacanthus* is a Selachian spine, which, in its general conformation, belongs to the *Gyracanthus*-type, however different may be the character of its surface ornament.

Holoptychius decoratus (Eichwald).

[Plate XI., Fig. 6.]

Sclerolepis decorata, Eichw., Bull. Soc. Imp. Nat. Moscow, vol. xvii., 1844, p. 832; *Ibid.*, vol. xix., 1846, pl. x., figs. 16, 17. Lethæa Rossica, vol. i., 1860, pl. 57, fig. 7. *Holoptychius decoratus*, Traq., Ext. Verteb. Moray Firth Area, p. 254, pl. vi., fig. 11.

Among the fossils from Scaat Craig in the Brickenden Collection (P. 8275) is an imperfect scale in a coarse reddish grit, which I cannot distinguish from the fossiliferous stone of that locality, and from which we must therefore presume that it was derived.

This specimen is represented magnified two diameters in Pl. XI., Fig. 6; it is 1 inch in length, but it is only the exposed portion of the scale which is anything like entire. The covered area is broken away on one side in front; what remains of it is covered with a beautiful and minute granulation. The exposed part of the surface shows first a zone of the tubercles characteristic of *H. decoratus*, this zone being a quarter of an inch broad in the middle, but narrowing towards the sides. Behind this the tubercles are smaller, and tend to become elongated backwards as fine elevated antero-posterior ridges or striæ, similar to those represented by Eichwald in his second figure given in the "Lethæa Rossica," as quoted above.

I have no doubt of the correct identification of this scale, and as it occurred among the Scaat Craig specimens in the Brickenden Collection, and on a matrix indistinguishable from the harder portions of rock in that locality, we must presume that we have here proof of the extension of the species in Scotland to another horizon than that of the Nairn Sandstone, in which it has hitherto only been found.

Holoptychius giganteus, Agassiz.

The fragmentary plate from Scaat Craig, described and figured by Agassiz (Poiss. Foss. v. g. r., p. 147, pl. 30*a*, fig. 16) as "*Asterolepis Malcolmsoni*," was supposed by Mr Smith Woodward, who had not seen the type, to be possibly identical with *A. maxima* (Cat. Foss. Fishes Brit. Mus., pt. ii., p. 207). However, I was fortunate enough to discover the original specimen in the Elgin Museum, and find that it is a broken jugular plate of *Holoptychius giganteus.*

Sauripterus crassidens, sp. nov., Traquair.

[Plate XI., Fig. 7.]

This conical tooth, represented in Pl. XI., Fig. 7, of the natural size, measures $\frac{1}{5}$ inch in length by nearly $\frac{1}{2}$ inch in greatest breadth at the base; the apex is rounded off by attrition; the shaft is laterally compressed with trenchant edges. Towards the base the surface of the tooth is "fluted," a number of sulci marking off vertical folds of the dentine; the primary folds being rather less than $\frac{1}{10}$ inch, the secondary about $\frac{1}{20}$ inch across.

The above-described tooth was collected by Mr William Taylor at Newton Quarry, Alves, and is now in the Edinburgh Museum; but there are also two others, identical in character, from Scaat Craig, in the Brickenden Collection in the British Museum (P. 8269A). All three are not only clearly Rhizodont in structure, but come, indeed, very close to the teeth of Agassiz's "*Bothriolepis*" *favosa*,[1] from Clashbennie in Perthshire, also a very decided Rhizodont, and which Mr Smith Woodward[2] has provisionally referred to Hall's genus *Sauripterus*.[3] However, on closely comparing them with the teeth in the Clashbennie jaws, I have come to

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[1] Poiss. Foss. v. g. r., pp. 61-100, pl. xxvii., fig. 7; pl. xxviii., figs. 12, 13.

[2] Cat. Foss. Fishes Brit. Mus., pt. ii., 1891, p. 365.

[3] Nat. Hist. New York, pt. iv., Geology, 1843, p. 282. The name is here spelt "*Sauripteris.*"

the conclusion that they represent a distinct species, from the considerably greater coarseness, in proportion, of the basal folding of the dentine.

Amended List of the Fossil Fishes of the Upper Old Red Sandstone of the Moray Firth area:—

FISHES OF THE NAIRN SANDSTONE.

Psammosteus tesselatus, Traq.
Asterolepis maxima (Ag.).
Holoptychius decoratus (Eichw.).
Polyplocodus leptognathus, Traq.
Coccosteus magnus, Traq.

FISHES FROM THE ALVES AND ELGIN BEDS.

Psammosteus Taylori, Traq.,	Newton, Millstone Quarry, Sweet Hillock.
Psammosteus pustulatus, Traq.,	Scaat Craig.
Cosmacanthus Malcolmsoni, Ag.,	Scaat Craig.
Bothriolepis major (Ag.),	Whitemire, Ernside, Newton, Sweet Hillock, Millstone Quarry, Carden Hill, Burgie, Rosebrae, Oakbrae, Laverockloch.
Phyllolepis concentrica, Ag.,	Hospital Quarry, Laverockloch, Rosebrae.
Conchodus ostreiformis, M'Coy,	Scaat Craig.
Holoptychius nobilissimus, Ag.,	Newton, Pluscarden, Leggat, Scaat Craig, Bishopmill, Rosebrae, Burgie.
Holoptychius giganteus, Ag.,	Whitemire, Newton, Sweet Hillock, Carden Hill, Millstone Quarry, Scaat Craig.
Holoptychius decoratus (Eichw.),	Scaat Craig.
Polyplocodus sp.,	Scaat Craig.
Glyptopomus minor, Ag.,	Rosebrae, Laverockloch.

EXPLANATION OF PLATES X. AND XI.

Plate X.

Fig. 1. Median dorsal plate of *Coccosteus magnus*, Traquair; natural size. Kingsteps, Nairn. Original in the Edinburgh Museum.

Fig. 2. *Cosmacanthus Malcolmsoni*, Agassiz; natural size, seen from the flat side. Scaat Craig near Elgin. Original in the Brickenden Collection, British Museum.

Fig. 3. The same spine seen from the convex side.

Plate XI.

Fig. 1. *Psammosteus tesselatus*, Traquair; portion of a shield showing the external sculpture, and magnified two diameters. From Kingsteps, in the Edinburgh Museum.

Fig. 2. External sculpture of the same; magnified eight diameters.

Fig. 3. *Psammosteus pustulatus*, Traquair; fragment of a shield; natural size. From Scaat Craig, in the Brickenden Collection, British Museum.

Fig. 4. External sculpture of the same; magnified.

Fig. 5. External sculpture of *Psammosteus Taylori*, Traquair; magnified two diameters. From Newton Quarry, Alves, in the collection of Mr W. Taylor, Lhanbryde.

Fig. 6. Scale of *Holoptychius decoratus* (Eichwald); magnified two diameters. From Scaat Craig, in the Brickenden Collection, British Museum.

Fig. 7. Tooth of *Sauripterus crassidens*, Traquair; natural size. From Newton Quarry, in the Edinburgh Museum.

JOURNAL OF PROCEEDINGS.

SESSION CXXIV.

Wednesday, 21st November 1894.—Professor H. ALLEYNE NICHOLSON, F.G.S., F.L.S., retiring President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Jean-François de Boissiére, Esq., M.D.; J. Ryland Whitaker, Esq., B.A., M.B. (Lond.), L.R.C.P.E.

The retiring President delivered an Opening Address on "The Doctrine of the Permanence of the Ocean Basins."

Wednesday, 19th December 1894.—WILLIAM RUSSELL, Esq., M.D., F.R.C.P.E., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: William Brendin Gubbin, Esq., M.D.; George Johnstone, Esq., Lieut. R.N.R., F.R.S.G.S.; Thomas R. Marr, Esq.; Professor A. G. Mettam; John Gunn Mitchell, Esq.

The following Office-Bearers for the Session were then elected:

President—Professor JOHN STRUTHERS, M.D., LL.D.

Vice-Presidents—WILLIAM RUSSELL, M.D., F.R.C.P.E.; J. G. GOODCHILD, F.G.S., F.Z.S.; Professor J. COSSAR EWART, F.R.S.

Secretary—JOHN GUNN, F.R.S.G.S.

Assistant-Secretary—PERCY H. GRIMSHAW, F.E.S.

Treasurer—GEORGE LISLE, C.A., F.F.A.

Librarian—J. ARTHUR THOMSON, M.A., F.R.S.E.

Councillors—Major Wardlaw Ramsay; Professor Johnson Symington, M.D., F.R.S.E.; Andrew Wilson, L.D.S.; Lieut.-Colonel Fred. Bailey, R.E., F.R.S.E.; W. Eagle Clarke, F.L.S.; W. Ivison Macadam, F.C.S., F.R.S.E.; George Carrington Purvis, M.D., B.Sc.; Professor Cargill G. Knott, D.Sc., F.R.S.E.; Gustav Mann, M.D.; Hugh Miller, F.R.S.E.; Robert C. Mossman, F.R.Met.S., F.R.S.E.; B. N. Peach, F.G.S., F.R.S.

The Secretary submitted the Annual Report by the Council, as follows:

REPORT OF COUNCIL, 1893–94.

The Council beg to submit the following Report upon the state of the Society.

I.—MEMBERSHIP.

During the past Session the number of Fellows admitted was twenty-one, being one Honorary and twenty Ordinary Fellows, against which have to be placed six resignations, and the deaths of one Honorary, one Corresponding, and eight Ordinary Fellows. The name of an Ordinary Fellow who was three Sessions in arrear with his subscriptions, and whose address was unknown, was removed from the roll. At the close of the Session the number of Fellows was—

	239	Ordinary Fellows,
	16	Honorary Fellows,
	18	Corresponding Fellows,
Total	273	Fellows.

An increase of five over the number on the Roll for the previous Session.

II.—ACCOUNTS.

An Abstract of the Treasurer's Accounts, in printed form, has been distributed with the Billet calling this meeting. These Accounts have been audited by Messrs R. C. Millar and Richard Brown.

III.—COMMUNICATIONS.

The number of Communications read before the Society during the past Session was twenty-one, of which eighteen, in addition to a paper received too late to be included in the former part, have appeared in Part II. Vol. XII. of the *Proceedings* already issued to Fellows not in arrear. Besides these Communications, objects of scientific interest were exhibited on two occasions.

IV.—CONCLUSION.

In conclusion, the Council would earnestly impress upon Members the necessity of introducing as Fellows of the Society, gentlemen who are likely to promote its interests in any way, especially by the contribution of papers calculated to add to the value and interest of its *Proceedings.*

For the Council,

JOHN GUNN, *Secretary.*

The Librarian submitted the following Report upon the Library:

HON. LIBRARIAN'S REPORT, 1894.

The Librarian reports the safety of the Society's Library, the continuance of the former exchanges, and the addition of two or three to the list. The money granted by the Council for binding has been expended to good purpose, but more is urgently needed. The Librarian begs to call attention to the disorderly over-crowding of the books, and hopes that steps will be taken to secure a new room.

J. ARTHUR THOMSON.

The Treasurer submitted and explained the printed Abstract of his Accounts, as passed by the Society's auditors.

The following communications were read:

1 "Obituary Notice of the late Dr George Leslie, F.R.S.E." By R. H. TRAQUAIR, Esq., M.D., LL.D., F.R.S.

2. "Note on the Solubility of Gypsum in Solutions of Sodium Chloride." By T. CUTHBERT DAY, Esq., F.C.S.

3. "The Starling in Scotland: its Increase and Distribution." By J. A. HARVIE-BROWN, Esq., F.R.S.E.

4. "Some Modes of Origin of Rock-Salt." By J. G. GOODCHILD, Esq., F.G.S., F.Z.S. With Limelight Illustrations.

5. "Exhibition of two Specimens of Spiders not hitherto recorded for the Lothians, viz., *Epeira umbratica* (Clk.), and *Tibellus oblongus* (Wlk.), taken at Tyninghame, near Dunbar, in September last." By WILLIAM EVANS, Esq., F.R.S.E.

Wednesday, 16th January 1895.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Rev. G. S. Dobbie, M.A.; David J. Vallance, Esq.

The following gentleman was elected an Honorary Fellow of the Society: Professor James Geikie, LL.D., D.C.L., F.R.S.

A letter was submitted from L'Institut de France in reference to a proposed memorial to the late M. Levoisier.

The following communications were read:

1. "Note on Muscle Fibre, Electric Disc, and Motor Plate." By GEORGE CARRINGTON PURVIS, Esq., B.Sc., M.D.

2. "River Temperature. Part II. The Temperature of the Nile compared with that of other great Rivers." By H. B. GUPPY, Esq., M.B., F.R.S.E.

3. "Remarks on Scyelite from Caithness, with Exhibition of Specimens." By J. G. GOODCHILD, Esq., F.G.S., F.Z.S.

4. "Exhibition of a Giant Earth-Worm from Ceylon." By J. ARTHUR THOMSON, Esq., M.A., F.R.S.E.

Wednesday, 20th February 1895.—J. ARTHUR THOMSON, Esq., M.A., F.R.S.E., in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Charles Bruce, Esq., J.P., F.S.A.(Scot.); Rev. Archibald Gunn; Henry Halcro Johnston, Esq., Surgeon, Army Medical Staff, D.Sc., M.D., C.M., F.L.S.

A letter was read from Professor Geikie, in which he thanked the Society for his election as an Honorary Fellow.

The following communications were read:

1. "On the Fossils of the Upper Red Sandstone of Nairn." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
2. "Results of Meteorological Observations taken at Edinburgh in 1894." By R. C. Mossman, Esq., F.R.S.E., F.R.Met.S.
3. "Exhibition of Specimens of *Eriozona syrphoides*, Fln., a rare Fly from the Harz Mountains." By Percy H. Grimshaw, Esq., F.E.S.
4. "Exhibition of the Eggs of the Leaf Insect." By J. Arthur Thomson, Esq., M.A., F.R.S.E.

Wednesday, 20th March 1895.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: C. T. Clough, Esq., M.A.

The following communications were read:

1. "On the genus *Psammosteus.*" By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
2. "On the Occurrence of *Sphenopteris communis,* Lesqx., in Britain." By Robert Kidston, Esq., F.G.S., F.R.S.E.
3. "Rockall." By J. A. Harvie-Brown, Esq., F.Z.S., F.R.S.E.
4. "Exhibition of *Calamites suckowii,* Brough." By Robert Kidston, Esq., F.G.S., F.R.S.E.

Wednesday, 17th April 1895.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Robert Munro, Esq., M.A., M.D., F.R.S.E., F.S.A.(Scot.).

Messrs R. C. Millar, C.A., and Richard Brown, C.A., were re-elected as Auditors for the current Session.

The following communications were read:

1. "On the Sternum of the Greenland Right Whale." By Professor Struthers, M.D., LL.D.
2. "A List of 'Harvestmen' (*Phalangidea*) and 'False Scorpions' (*Chernetidea*) collected in the Neighbourhood of Edinburgh." By George H. Carpenter, Esq., B.Sc., and William Evans, Esq., F.R.S.E.
3. "*Diomedea melanophris* in the Færöe Islands." By Knud Andersen, Esq ; communicated by W. Eagle Clarke, Esq., F.L.S.
4. "Exhibition of a Drawing of an Albatross taken from life in the Zoological Gardens, London." By J. G. Goodchild, Esq., F.G.S., F.Z.S.

SESSION CXXV.

Wednesday, 20th November 1895.—WILLIAM RUSSELL, Esq., M.D., F.R.C.P.E., retiring Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: William Douglas, Esq.; J. Kay Jamieson, Esq., M.B., C.M.

The retiring Vice-President, WILLIAM RUSSELL, Esq., M.D., F.R.C.P.E., delivered the usual Opening Address, on "The Light which recent Medical Investigations have thrown upon some Biological Processes."

Wednesday, 18th December 1895.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: John Smith Flett, Esq., M.B., B.Sc.; Gregg Wilson, Esq., Ph.D.; E. H. Aitken, Esq.

The following Office-Bearers for the Session were elected:

President—Professor JOHN STRUTHERS, M.D., LL.D.

Vice-Presidents—J. G. GOODCHILD, F.G.S., F.Z.S.; Professor J. COSSAR EWART, F.R.S.; ANDREW WILSON, L.D.S.

Secretary—R. H. TRAQUAIR, M.D., LL.D., F.R.S.

Assistant-Secretary—PERCY H. GRIMSHAW, F.E.S.

Treasurer—GEORGE LISLE, F.F.A., C.A.

Librarian—J. ARTHUR THOMSON, M.A., F.R.S.E.

Councillors—W. Eagle Clarke, F.L.S.; W. Ivison Macadam, F.C.S., F.R.S.E.; George Carrington Purvis, M.D., B.Sc.; Professor Cargill G. Knott, D.Sc., F.R.S.E.; Gustav Mann, M.D.; Hugh Miller, F.R.S.E.; Robert C. Mossman, F.R.Met.S., F.R.S.E.; B. N. Peach, F.R.S., F.G.S.; William Russell, M.D., F.R.C.P.E.; William C. Crawford, F.R.S.E.; Robert Kidston, F.G.S., F.R.S.E.; Lionel W. Hinxman, B.A.

The Secretary submitted the Annual Report by the Council, as follows:

REPORT OF COUNCIL, 1894–95.

The Council beg to submit the following Report upon the state of the Society.

I.—DEATH OF SECRETARY.

It is with great regret that the Council must in the first place refer to the death of Mr John Gunn, Secretary of the Society, which took place on the 29th of April last. At a Council Meeting held on the 5th of June, a resolution expressing condolence with the members of his family was submitted and adopted, and a copy ordered to be sent to Mrs Gunn.

II.—MEMBERSHIP.

During the past Session the number of Fellows admitted was fifteen, being one Honorary and fourteen Ordinary Fellows. On the other hand, there have been thirteen resignations and three deaths, while no less than ten members have been struck off the roll for non-payment of Subscriptions extending over a period of three years. The name of Professor Heddle, of St Andrews, an old Life Member, has been replaced on the roll, from which many years ago it seems to have been in some unexplained manner omitted. At the close of the Session the number of Fellows was—

	228	Ordinary Fellows,
	17	Honorary Fellows,
	18	Corresponding Fellows,
Total	263	Fellows,

a decrease of ten from the number on the roll for the previous Session.

III.—ACCOUNTS.

An Abstract of the Treasurer's Accounts, in printed form, has been sent out with the Billet calling this meeting. These Accounts have been audited by Messrs R. C. Millar and Richard Brown.

IV.—COMMUNICATIONS.

The number of Communications read before the Society during the past Session was sixteen, of which ten were printed in Part I. Vol XIII. of the *Proceedings.* Besides these Communications, objects of scientific interest were exhibited at five of the Meetings.

V.—CONCLUSION.

In conclusion, the Council would point to the diminution of Membership which has taken place during the past year as a reason why Fellows should still more earnestly strive to induce gentlemen whose tastes and acquirements lie in the direction of Natural Science to join the Society, the oldest of its kind in Edinburgh.

For the Council,

R. H. TRAQUAIR, *Acting-Secretary.*

The Treasurer submitted and explained an Abstract of his Accounts as audited by Messrs Millar and Brown.

The Librarian presented the following Report:

LIBRARIAN'S REPORT, 1895.

The Librarian begs to report that the books in the Society's Library are in good condition, and that the usual exchanges have been sustained. The overcrowded state of the room is, however, more and more marked, and requires the attention of the Society. J. ARTHUR THOMSON.

The following communications were read:

1. "The Tufted Duck: its Increase and Distribution in Scotland." By J. A. Harvie-Brown, Esq., F.R.S.E.
2. "Notes on Fossil Fishes from the Old Red Sandstone of Forfarshire." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
3. "Note on the Occurrence of the Larva of the Drone-Fly (*Eristalis tenax*) in Man." By J. Arthur Thomson, Esq., M.A., F.R.S.E.
4. "Exhibition, with Remarks, of Specimens of *Hesperia Ludoviciæ*, Mabille, *Carpocapsa saltitans*, Westwood, and *Cephenomyia rufibarbis*, Meigen." By Percy H. Grimshaw, Esq., F.E.S.

Wednesday, 15th January 1896.—J. G. Goodchild, Esq., F.G.S., F.Z.S., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Adam Bryden Steele, Esq.; R. Stewart MacDougall, Esq., B.Sc.; Lewis Beesly, Esq.

The following communications were read:

1. "Obituary Notice of the late Mr John Gunn, Secretary to the Society." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
2. "Obituary Notice of the late Dr Robert Brown." By J. G. Goodchild, Esq., F.G.S.
3. "Report on a Collection of Marine Dredgings and other Natural History Materials, made in the West of Scotland, by the late Mr George Brook, F.L.S." By Thomas Scott, Esq., F.L.S.
4. "Catalogue of the *Coleoptera* of Mid-Solway." By William Lennon, Esq.; communicated by R. Service, Esq. With an Introduction by Mr Service.
5. "Note on a Four Footed Duck, with Exhibition of Specimen." By J. Arthur Thomson, Esq., M.A.

Wednesday, 19th February 1896.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: John B. Yeoman, Esq., M.B.

The following communications were read:

1. "On Hereditary Polydactylism." By Gregg Wilson, Esq., Ph.D.
2. "On the Discovery in Orkney of the 'John o' Groats' Horizon of the Old Red Sandstone." By J. S. Flett, Esq., M.B., B.Sc.
3. "Notes on the Fossil Fishes collected by Mr J. S. Flett, M.B., B.Sc., at Deerness, in Orkney." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.

4. "On some Newly-Hatched Specimens and a late Embryo of *Opisthophthalmus.*" By Professor MALCOLM LAURIE, D.Sc.
5. "Note on the High Mean Barometric Pressure of January." By R. C. MOSSMAN, Esq., F.R.Met.S.

Wednesday, 18th March 1896.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Andrew J. Ramsay, Esq.

The following communications were read:

1. "On the Nests and Eggs of the Emus and the Cassowary of Australia." By A. J. CAMPBELL, Esq., Melbourne; communicated by JOHN J. DALGLEISH, Esq.
2. "River Temperature. Part III. Comparison of the Thermal Conditions of Rivers and Ponds in the South of England." By H. B. GUPPY, Esq., M.B.
3. "Notes on the Collecting and Breeding of Butterflies in Kanara, Western India." By E. H. AITKEN, Esq.
4. "Results of Meteorological Observations taken at Edinburgh in the Year 1895." By R. C. MOSSMAN, Esq., F.R.S.E., F.R.Met.S.

Wednesday, 15th April 1896.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

Messrs R. C. Millar, C.A., and Richard Brown, C.A., were re-elected as Auditors for the current Session.

The following communications were read:

1. "Some Additions to the List of Edinburgh Spiders." By G. H. CARPENTER, Esq., B.Sc., and WILLIAM EVANS, Esq., F.R.S.E.
2. "On *Sigillaria Brardii*, Brongt., and its Variations." By R. KIDSTON, Esq., F.G.S., F.R.S.E.
3. "A Preliminary Notice of a Parasitic Copepod from the vas deferens of *Nephrops norvegicus.*" By J. STUART THOMSON, Esq.
4. "Exhibition of Photographs illustrating Insect Attack on Spruce and Pine, with Notes on the possibilities of recovery after defoliation." By R. STEWART MACDOUGALL, Esq., B.Sc.
5. "Exhibition, with Remarks, of a dark Variety of the Barn Owl (*Strix flammea*)." By W. EAGLE CLARKE, Esq., F.L.S.
6. "Exhibition of a Specimen of *Nycteribia Latreillii*, Leach, a Dipterous Parasite from Daubenton's Bat." By PERCY H. GRIMSHAW, Esq., F.E.S.

· SESSION CXXVI.

Wednesday, 18th November 1896.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

The retiring Vice-President, J. G. GOODCHILD, Esq., F.G.S., F.Z.S., delivered the usual Opening Address, the subject being "Some Geological Evidence regarding the Age of the Earth."

Wednesday, 16th December 1896.—Professor STRUTHERS, M.D., LL.D., President, in the Chair.

The following Office-Bearers were elected:

President—Professor JOHN STRUTHERS, M.D., LL.D.

Vice-Presidents—Professor J. COSSAR EWART, F.R.S.; ANDREW WILSON, L.D.S.; Lieut.-Colonel BAILEY, F.R.G.S., F.R.S.E.

Secretary—R. H. TRAQUAIR, M.D., LL.D., F.R.S.

Assistant-Secretary—PERCY H. GRIMSHAW, F.E.S.

Treasurer—GEORGE LISLE, F.F.A., C.A.

Librarian—J. ARTHUR THOMSON, M.A., F.R.S.E.

Councillors—Gustav Mann, M.D.; Robert C. Mossman, F.R.Met.S., F.R.S.E.; B. N. Peach, F.G.S., F.R.S.; William Russell, M.D., F.R.C.P.E.; William C. Crawford, F.R.S.E.; Robert Kidston, F.G.S., F.R.S.E.; Lionel W. Hinxman, B.A.; Thomas Scott, F.L.S.; J. G. Goodchild, Esq., F.G.S.; Robert Munro, M.A., M.D., F.R.S.E.; R. Stewart MacDougall, B.Sc.; Professor Malcolm Laurie, M.A., D.Sc.

The Secretary submitted the Annual Report by the Council, as follows:

REPORT OF COUNCIL, 1895–96.

During the Session just concluded ten new Ordinary Fellows have been admitted, while, on the other hand, two deaths have occurred and three resignations have been received, giving a nett increase of five to the Membership of the Society. At the close of the Session the roll stood as follows:—

233	Ordinary Fellows,
17	Honorary Fellows,
18	Corresponding Fellows,
Total 268	Fellows.

The Communications laid before the Society were twenty in number, of which thirteen were printed in the fasciculus of *Proceedings* which was published on the 1st October. There were also five Exhibitions of Specimens.

An inspection of the last published Part of the *Proceedings* will show that the Society is prospering so far as scientific work is concerned. We require, however, more Members, and the Council must again, on the present occasion, repeat the hope often already expressed, that our Fellows will do their utmost to recruit the ranks of the Society by inducing as many as possible of their scientific friends to join it.

For the Council,

R. H. Traquair, *Secretary.*

The Treasurer submitted and explained an Abstract of his Accounts as audited by Messrs Millar and Brown.

The Librarian presented the following Report:

HON. LIBRARIAN'S REPORT, 1896.

The Librarian begs to report that the usual exchanges have been continued during the past year, and that the transference of the books to India Buildings has made order possible for the first time for many years. He wishes to take this opportunity of thanking Mr Stuart Thomson for his kindness in devoting over a fortnight's work to arranging the library. A review of the library has disclosed the absence of a number of volumes not accounted for in the Library Book, and the Librarian would beg any Members who may have taken out books without entering them to return these as soon as possible to the room at India Buildings.

J. Arthur Thomson.

The following communications were read:

1. "Note on the Prolonged Sunless Weather in Edinburgh during the present Autumn." By R. C. Mossman, Esq., F.R.Met.S., F.R.S.E.
2. "Additional Notes on the Fossil Fishes of the Upper Old Red Sandstone of the Moray Firth Area." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
3. "Exhibition of an enlarged Model of *Palæospondylus Gunni.*" By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
4. "On Zebra Hybrids, with Limelight Illustrations." By Prof. J. Cossar Ewart, M.D., F.R.S.

Wednesday, 20th January 1897.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following communications were read:

1. "Note on a Human Skull showing divided Malar Bone." By Professor J. Struthers, M.D., LL.D.
2. "Soil Bacteriology in Relation to Agriculture." By R. Stewart MacDougall, Esq., M.A., B.Sc.
3. "On the Probable Origin of the Bituminoid Cement of the Caithness Flagstones." By J. G. Goodchild, Esq., F.G.S.
4. "Exhibition of *Bipalium kewense* from Corstorphine." By J. Arthur Thomson, Esq., M.A.

Wednesday, 17th February 1897.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Francis C. Crawford, Esq.

The following communications were read :

1. "Notes on 'Fossil Man.'" By Dr Robert Munro, M.A., F.R.S.E.
2. "An Obscure Chapter in the Struggle for Existence." By J. Arthur Thomson, Esq., M.A.

Wednesday, 17th March 1897.—R. C. Mossman, Esq., F.R.S.E., in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: E. H. Cunningham Craig, Esq., B.A., F.G.S.

The following communications were read :

1. "On the Postponement of the Germination of the Seeds of Aquatic Plants." By H. B. Guppy, Esq., M.B.
2. "Results of Meteorological Observations taken in Edinburgh during 1896." By R. C. Mossman, Esq., F.R.Met.S.
3. "On the Mollusca of the Laminarian Zone at Leith." By J. G. Goodchild, Esq., F.Z.S.

Wednesday, 21st April 1897.—Professor Struthers, M.D., LL.D., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Richard J. A. Berry, Esq., M.D.

Messrs R. C. Millar, C.A., and Richard Brown, C.A., were re-elected as Auditors for the current Session.

The following communications were read :

1. "A Catalogue of Recent Cephalopoda—Supplement 1887-96." By W. E. Hoyle, Esq., M.A., F.R.S.E.
2. "On a New Species of Fossil Plant from the Old Red Sandstone of Forfarshire." By R. Kidston, Esq., F.G.S., F.R.S.E.
3. "Exhibition of Specimens of *Stellascolites radiatus*, Etheridge, and *Buthotrephis Harknessi*, Nicholson, from the Skiddaw Slates." By R. Kidston, Esq., F.G.S., F.R.S.E.
4. "Exhibition, with Remarks, of a Specimen of the Great Bustard (*Otis tarda*, L.), obtained 8th February 1892, at Housebay, Stronsay, Orkney." By R. H. Traquair, Esq., M.D., LL.D., F.R.S.
5. "Exhibition of a New Species of Butterfly from Northern India." By Percy H. Grimshaw, Esq., F.E.S.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS."

Those Institutions from which Publications have been received in return are indicated by an asterisk.

ENGLAND.

Birmingham,	*Philosophical Society, King Edward's Grammar School.
Do.	*Natural History Society, Sir Josiah Mason's College.
Cambridge,	*Philosophical Society.
Do.	University Library.
Cirencester,	*Editor of the *Agricultural Students' Gazette.*
Durham,	University Library.
Halifax,	*Yorkshire Geological and Polytechnic Society.
Leeds,	*The Conchological Society of Great Britain and Ireland.
Liverpool,	*Biological Society, University College.
Do.	*Literary and Philosophical Society.
Do.	*Engineering Society, Royal Institution.
London,	British Museum Library.
Do.	*British (Natural History) Museum, South Kensington.
Do.	*Royal Society, Burlington House, Piccadilly, W.
Do.	Chemical Society, Burlington House, Piccadilly, W.
Do.	*Geological Society, Burlington House, Piccadilly, W.
Do.	*Linnean Society, Burlington House, Piccadilly, W.
Do.	*Royal Microscopical Society, King's College.
Do.	Museum of Economic Geology, Jermyn Street.
Do.	Editor of *Nature,* 29 Bedford Street, Covent Garden.
Do.	*Zoological Society, Hanover Square.
Do.	*Geologists' Association, University College, W.C.
Manchester,	*Geological Society, 36 George Street.
Do.	*Literary and Philosophical Society, 36 George Street.
Do.	*The Owens College.
Norwich,	*Norfolk and Norwich Naturalists' Society, The Museum.
Oxford,	Bodleian Library.
Truro,	*Royal Institution of Cornwall.
Watford,	*Hertfordshire Natural History Society and Field Club.

SCOTLAND.

Aberdeen,	University Library.
Cockburnspath,	*Berwickshire Naturalists' Field Club, Old Cambus.
Edinburgh,	Advocates' Library.
Do.	University Library.
Do.	*Royal Society.
Do.	Royal Medical Society.

Edinburgh,	*Royal Scottish Society of Arts.
Do.	*Royal Scottish Geographical Society.
Do.	*Botanical Society.
Do.	*Highland and Agricultural Society.
Do.	*Geological Society.
Glasgow,	*Philosophical Society.
Do.	*Natural History Society.
Do.	*Geological Society.
Do.	*Andersonian Society.
Do	University Library.
Perth,	Perthshire Society of Natural History.
St Andrews,	University Library.

IRELAND.

Belfast,	Natural History and Philosophical Society.
Dublin,	*Royal Irish Academy.
Do.	*Royal Dublin Society.
Do.	*Royal Geological Society of Ireland.

HOLLAND.

Amsterdam,	*De Koninklijke Akademie van Wetenschappen.
Leyden,	*Museum van Naturlijke Histoire.
Utrecht,	Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

Basle,	*Die Naturforschende Gesellschaft.
Bern,	*Allgemeine Schweizerische Gesellschaft für die gesammten Naturwissenschaften.
Do.	*Die Naturforschende Gesellschaft.
Geneva,	*Société de Physique et d'Histoire Naturelle.
Neufchatel,	*Société des Sciences Naturelles.
Zürich,	*Die Naturforschende Gesellschaft.

GERMANY.

Berlin,	*Königliche Akademie der Wissenschaften.
Do.	*Deutsche Geologische Gesellschaft.
Do.	*Gesellschaft Naturforschender Freunde.
Bonn,	*Naturhistorischer Verein der preussischen Rheinlande Westfalens, und des Reg.-Bezirks Osnabrück.
Bremen,	*Verein für Naturwissenschaft.
Breslau,	*Schlesische Gesellschaft für Vaterländische Cultur.
Brunswick,	*Naturwissenschaftlicher Verein.
Dresden,	Königliche Sammlungen für Kunst und Wissenschaft.
Do.	*Der Verein für Erdkunde.
Elberfeld,	*Naturwissenschaftlicher Verein.
Erlangen,	University Library.
Frankfort-on-Main,	*Senckenbergische Naturforschende Gesellschaft.
Do.	*Deutsche Malakozoologische Gesellschaft, Dr Kobelt, Schwanheim.
Frieburg, i. B.,	Die Naturforschende Gesellschaft.
Göttingen,	*Königliche Gesellschaft der Wissenschaften.
Halle,	*Kaiserliche Akademie der Naturforscher.

Jena,	*Medicinisch-naturwissenschaftliche Gesellschaft.
Leipzig,	*Königliche Sächsische Gesellschaft der Wissenschaften.
Do.	Naturforschende Gesellschaft.
Do.	Editor of the *Zoologischer Anzeiger.*
Munich,	*Königliche Baierische Akademie der Wissenschaften.
Stuttgart,	*Verein für Vaterländische Cultur in Württemberg.
Wurzburg,	*Physikalisch-medicinische Gesellschaft.

AUSTRIA.

Agram,	*Societas Croatica Historico-naturalis.
Hermannstadt,	*Siebenbürgischer Verein für Naturwissenschaft.
Prague,	Königliche-böhmische Gesellschaft der Wissenschaften.
Trieste,	Società Adriatica di Scienze Naturali.
Vienna,	*K.k. zoologisch-botanische Gesellschaft.
Do.	*K.k. Naturhistorisches Hof-Museum.

ITALY.

Bologna,	*Accademia delle Scienze dell' Istituto.
Milan,	*Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do.	Società Italiana di Scienze Naturali.
Modena,	Società dei Naturalisti.
Naples,	Editor of the *Zoologischer Jahresbericht*, Zoological Station.
Padua,	*Società Veneto-Trentina di Scienze Naturali residente in Padova.
Rome,	*Reale Accademia dei Lincei.
Turin,	*Reale Accademia delle Scienze.

SPAIN.

Madrid,	*Real Academia de Ciencias exactas, fisicas e naturales.
Do.	Sociedad española de Historia natural.

PORTUGAL.

Coimbra,	Bibliothèque de l'Université.
Lisbon,	*Academia Real das Sciencias.

FRANCE.

Bordeaux,	La Société Linnéenne.
Caen,	Société Linnéenne de Normandie.
Cherbourg,	*Société Nationale des Sciences Naturelles.
Paris,	*Académie des Sciences de l'Institut.
Do.	*Société Géologique de France, Rue des grands Augustins, 7.
Do.	*Société Zoologique de France, Rue des grands Augustins, 7.
Do.	Société de Biologie.
Do.	École des Mines.

BELGIUM.

Brussels,	*Académie Royale des Sciences, des Lettres, et des beaux Arts.
Do.	*Société Royale Malacologique de Belgique.
Do.	*Société Belge de Microscopie.

SCANDINAVIA.

Bergen,	*The Museum.
Christiania,	*Den Naturhistoriske Forening.
Do.	Universitets Bibliothek.
Copenhagen,	*Kongelige Danske Videnskabernes Selskab.
Do.	*Naturhistoriske Forening.
Stockholm,	*Kongliga Svenska Vetenskaps-Akademie.
Upsala,	*Kongliga Vetenskaps-Societeten.
Do.	*Observatoire Météorologique.

RUSSIA.

Dorpat,	*Naturforscher Gesellschaft.
Kiev,	*Natural History Society.
Moscow,	*Société Impériale des Naturalistes.
St Petersburg,	*Académie Impériale des Sciences.
Do.	*Imperial Botanic Garden.

AMERICA.

United States.

Albany, N. Y.,	*New York State Library.
Baltimore,	*Johns-Hopkins University Library.
Boston,	*American Academy of Arts and Sciences.
Do.	*Society of Natural History.
Brookville, Ind.,	*Brookville Society of Natural History.
Cambridge, Mass.,	*Harvard University Library.
Do.	*Museum of Comparative Zoology.
Chicago,	*Academy of Sciences.
Cincinnati,	*Society of Natural History.
Newhaven, Conn.,	*Connecticut Academy of Arts and Sciences.
Do.	Yale College Library.
New York,	*New York Academy of Sciences.
Ohio,	*Mechanics Institute.
Philadelphia,	*Academy of Natural Sciences.
Do.	*Wagner Free Institute.
San Francisco,	*California Academy of Sciences.
St Louis,	*Academy of Sciences.
Washington,	*Smithsonian Institute.
Do.	Philosophical Society.
Do.	*United States National Museum.
Do.	*United States Geological Survey.
Do.	*United States Commissioner of Fish and Fisheries.
Wisconsin,	*Academy of Sciences, Arts, and Letters.

Mexico.

Mexico,	*Ministerio de Fomento de la Republica, Osservatorio Meteorologico.
Do.	*Sociedad Cientifica, "Antonio Alzate," Osservatorio Meteorologico Central.

Canada.

Hamilton,	*The Hamilton Association.
Kingston,	*Queen's University.

MANITOBA, . .	*Historical and Scientific Society, Winnipeg.
MONTREAL, . .	*The Natural History Society.
OTTAWA, . .	*Canadian Geological Survey.
Do. . .	*Royal Society of Canada.
TORONTO, . .	*The Canadian Institute.

NOVA SCOTIA.

HALIFAX, . .	*Nova Scotia Institute of Natural Science.

BRAZIL.

RIO DE JANEIRO, .	Museu Nacional.

AFRICA.

CAPE TOWN, . .	South African Philosophical Society.

ASIA.

BATAVIA, . .	*Koninklijke Natuurkundige Vereeniging in Nederlandsch Indie.
CALCUTTA, . .	Royal Asiatic Society of Bengal.
SHANGHAI, . .	*China Branch of the Asiatic Society.
TOKIO, JAPAN, .	*Imperial University of Japan.

AUSTRALASIA.

ADELAIDE, . .	*Royal Society of South Australia.
MELBOURNE, . .	*Royal Society of Victoria.
SYDNEY, . .	*Royal Society of New South Wales.
Do. . .	*The Australian Museum.
Do. . .	*Linnean Society of New South Wales.
WELLINGTON, .	*New Zealand Institute.

LIST OF FELLOWS,

As at 30th June 1897.

*Those marked * are Life Members.*

Date of Election.

1895. Aitken, E. H., Salt Department, Bombay.
1893. Alexander, John, M.D., L.R.C.P., L.R.C.S., D.P.H., Wick.
1856. *Anderson, J., M.D., LL.D., F.R.SS. L. & E., F.L.S., F.Z.S., F.A.S., 71 Harrington Gardens, London, S.W.
1872. Anderson, James, "Avenel," Mortonhall Road, Edinburgh.
1888. Ap Iwan, Mihangel, M.B., C.M., Independent College, Bala, N. Wales.
1884. Armitage, J. A., B.A., 28 Waterloo Road South, Wolverhampton.
1893. Bailey, Lieut.-Colonel Fred., (*late*) R.E., F.R.G.S., F.R.S.E., 7 Drummond Place.
1890. Bainbridge, A. F., Tanfield, Edinburgh.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 14 Charlotte Square.
1885. Barrett, W. H., M.B., C.M., 21 Learmonth Terrace.
1884. Beaumont, Alfred, The Red Cottage, Blackheath Park, London.
1880. *Beddard, Frank E., M.A., F.R.S., Zoological Gardens, London.
1896. Beesly, Lewis, University Hall, Ramsay Lodge.
1875. Bennie, James, Geological Survey, George IV. Bridge.
1897. Berry, Richard J. A., M.D., 4 Howard Place.
1881. *Berry, W., Tayfield, Newport, Fife.
1880. Bird, George, 31 Inverleith Row.
1894. Boissiére, de, Jean-François, M.D., 18 Torrington Square, London, W.C.
1891. Bosse, Fr., Edinburgh Geographical Institute, Park Road.
1892. Bowhill, Thomas, F.R.C.V.S., 1307 California Street, San Francisco, U.S.A.
1883. Bowie, A. F., 16 Duncan Street, Newington.
1893. Bradley, O. C., M.R.C.V.S., 41 Elm Row.
1876. Brown, J. A. Harvie-, F.Z.S., F.R.S.E., Dunipace House, Larbert.
1885. Brown, J. Macdonald, M.B., F.R.C.S., Apsley Lodge, Grange.
1891. Brown, Richard, C.A., 23 St Andrew Square.
1876. *Bruce, W. P., Kinleith Mill, Currie.
1894. Bruce, W. S., c/o R. Turnbull, Esq., Newton Cottage, Joppa.
1885. Buckley, T. E., B.A., F.Z.S., Rossal, Inverness.
1894. Burrage, J. H., B.A.(Oxon.), Royal Botanic Garden.
1885. Burt, Robert F., M.B., 124 Stroud Green Road, Finsbury Park, London, N.
1887. Calderwood, W. L., F.R.S.E., 7 Napier Road.
1886. Campbell, Andrew, Burmah Oil Company, Rangoon.

Date of Election.
1893. Campbell, Kenneth Findlater, C.E., Hon.M.Inst.C.E., M.S.I., Town Hall, Stockton-on-Tees.
1892. Carlier, Edmond W., B.Sc., M.D., Physiological Laboratory, The University.
1876. *Carmichael, Sir T. D. Gibson, Bart., Castlecraig, Dolphinton.
1858. Carruthers, W., F.R.S., British Museum, London.
1887. Clarke, E. Wearne, M.D., B.Sc.(Edin.), Kilblean House, Chesterfield.
1888. Clarke, W. Eagle, F.L.S., Museum of Science and Art.
1893. Clemons, G. Ernest, M.B., C.M., Hospital, Launceston, Tasmania.
1895. Clough, C. T., M.A., Geological Survey, George IV. Bridge.
1893. Coates, H., F.R.S.E., Pitcullen House, Perth.
1881. Cook, C., W.S., 11 Great King Street.
1887. *Corke, H. C., F.R.S., 178 High Street, Southampton.
1892. Corstorphine, Professor George S., B.Sc., The University, Cape Town.
1897. Craig, E. H. Cunningham, B.A., F.G.S., Geological Survey, George IV. Bridge.
1897. Crawford, Francis C., 19 Royal Terrace.
1874. Crawford, W. C., M.A., Lockharton Gardens, Slateford.
1877. *Dalgleish, J. J., Brankston Grange, Bogside Station, Stirling.
1894. Day, T. Cuthbert, F.C.S., 36 Hillside Crescent.
1885. Dendy, Arthur, B.Sc., c/o Dulau & Co., 37 Soho Square, London, W.
1895. Dobbie, Rev. G. S., 2 Hailes Street.
1894. Dobbie, James Bell, 2 Hailes Street.
1893. Donald, Charles W., M.B., C.M., Konsgarth, Braid Road.
1895. Douglas, William, 10 Castle Street.
1889. Drieberg, Principal C., Agricultural College, Colombo, Ceylon.
1880. Drummond, W., S.S.C., 4 Learmonth Terrace.
1886. Duncan, James, Estate Office, Abercairny, Crieff.
1885. Duncan, J. Barker, W.S., 6 Hill Street.
1883. Dunn, Malcolm, Palace Gardens, Dalkeith.
1864. *Duns, Professor, D.D., F.R.S.E., 14 Greenhill Place.
1888. Edington, Alexander, M.B., C.M., Bacteriological Laboratory, Cape Town, South Africa.
1889. Elsworth, R. C., M.B., C.M., St Helen's Road, Swansea.
1880. Erskine, W., Oaklands, Trinity Road.
1880. Evans, Wm., F.F.A., F.R.S.E., 38 Morningside Park.
1883. Ewart, Professor Cossar, M.D., F.R.S., The University.
1884. Fenton, Gerald A., Bellary, Madras, India.
1882. Ferguson, J., 18 Clyde Street.
1884. *Ferguson, James A. E., M.B., Public Lunatic Asylum, Berbice, British Guiana.
1885. Ferguson, James Haig, M.D., F.R.C.P.E., 25 Rutland Street.
1895. Flett, John Smith, M.B., B.Sc., The University.
1889. Fox, Fortescue, M.D., Strathpeffer Spa.
1887. Fulton, T. Wemyss, M.B., C.M., 8 Cameron Crescent.
1883. Gibson, E., 1 Eglinton Crescent.
1881. Gibson, J., Ph.D., F.R.S.E., 20 George Square.
1892. Gilchrist, John D. F., M.A., B.Sc., Ph.D., Carvenom, Anstruther.

Date of Election.

1880. Glover, J., S.S.C., 1 Hill Street.
1889. Goodchild, J. G., F.Z.S., F.G.S., Museum of Science and Art.
1877. Grieve, S., 21 Queen's Crescent.
1886. Grieve, Symington, 11 Lauder Road.
1893. Grimshaw, Percy H., F.E.S., Museum of Science and Art, *Assistant-Secretary.*
1895. Gunn, Rev. Archibald, St Andrews, New Brunswick, Canada.
1893. Guppy, H. B., M.B., C.M., F.R.S.E., 6 Fairfield West, Kingston-on-Thames.
1883. Henderson, Professor, M.B., F.L.S., Christian College, Madras.
1883. Hepburn, David, M.D., The University.
1884. Hinxman, Lionel, B.A., Geological Survey, George IV. Bridge.
1882. Hogg, A., 3 Cambridge Street.
1878. Horne, J., F.G.S., Geological Survey, George IV. Bridge.
1884. Howell, Henry H., Geological Survey, George IV. Bridge.
1883. Hoyle, W. E., M.A., F.R.S.E., Owens College, Manchester.
1891. Hughes, Professor Alfred W., M.B., F.R.C.S.E., University College, Cardiff.
1892. Hughes, Hugh Lewis, Surgeon, Dowlais, South Wales.
1880. Hunter, James, F.R.C.S.E., F.R.A.S., Rosetta, Liberton.
1874. Hunter, John, F.C.S., 29 Chambers Street.
1888. Hutchinson, Alfred, B.Sc., The Leys, Cambridge.
1895. Jamieson, J. Kay, M.B., C.M., Yorkshire College, Leeds.
1877. Joass, Edward C., F.F.A., Standard Life Insurance Co., 3 George Street.
1895. Johnston, Surgeon-Major Henry Halcro, D.Sc., M.D., C.M., F.L.S., 1 Great Wellington Street, Leith.
1880. Johnston, J. A., 7 Annandale Street.
1894. Johnstone, Lieut. George, R.N.R., F.R.S.G.S., British India Steam Navigation Co., Strand Road, Calcutta.
1893. Jong, E. F. de, M.R.C.V.S., 42 Elm Row.
1886. Kelso, J. E. H., M.B., C.M., Downlee, St Andrews Road, Elmgrove, Southsea, Hants.
1869. *Kennedy, Rev. J., M.A., B.D., 9 Hartington Place.
1892. Kerr, J. Graham, Christ's College, Cambridge.
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1893. Knott, Professor Cargill G., D.Sc., F.R.S.E., 42 Upper Gray Street.
1890. Laidlaw, T. G., 8 Morningside Road.
1890. Laing, J. H. A., M.B., C.M., 11 Melville Street.
1880. Laughton, W., 58 Polwarth Gardens.
1884. Laurie, Professor Malcolm, D.Sc., St Mungo's College, Glasgow
1884. Lindsay, R., Windsor House, Ferry Road.
1892. Lintern, Albert A., B.Sc. Kendrick School, Reading.
1886. Lisle, George, C.A., F.F.A., 5 N. St David Street, *Treasurer.*
1861. Logan, A., Register House.
1893. Longden, D. C., M.B., C.M., M.R.C.S., D.P.H., F.R.C.S.E., 137 Warrender Park Road.
1855. *Macadam, Stevenson, Ph.D., Surgeons' Hall.

Date of Election.

1885. Macadam, W. Ivison, F.C.S., F.R.S.E., Surgeons' Hall.
1881. Macalpine, A. N., B.Sc., 109 Stanmore Road, Glasgow.
1878. Macconochie, A., Geological Survey, George IV. Bridge.
1886. M'Cracken, Professor, Crewe.
1893. Macdonald, Alexander, M.B., C.M., 11 Ardmillan Terrace.
1882. *M'Donald, L. M., Skaebost, Skye.
1896. MacDougall, R. Stewart, M.A., B.Sc., Royal Botanic Garden.
1885. Macgregor, John, L.R.C.P., Rashcliff, Huddersfield.
1893. Mackay, Alexander, Solicitor, Bank of Scotland, Thurso.
1889. Mackie, John, Geographical Institute, Park Road.
1878. Maclauchlan, J., Albert Institute, Dundee.
1882. M'Vean, C. A., C.E., Killiemore House, Pennyghael, Isle of Mull, Oban.
1893. Mann, Gustav, M.D., C.M., Oxford.
1894. Marr, Thomas R., University Hall, Riddle's Court, Lawnmarket.
1880. Marsden, R. S., D.Sc., 64 Park Road South, Birkenhead.
1894. Mettam, Professor A. G., Royal Veterinary College.
1889. Millar, Robert C., C.A., 8 Broughton Place.
1891. Mitchell, J. C., B.Sc., Agricultural College, Ghizeh, Cairo, Egypt.
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1883. Mitchell, Robert, 14 Marchhall Road.
1890. Mossman, R. C., F.R.Met.S., F.R.S.E., 10 Blacket Place.
1880. Muirhead, G., F.R.S.E., Mains of Haddo, Aberdeen.
1895. Munro, Robert, M.A., M.D., F.R.S.E., F.S.A.(Scot.), 48 Manor Place.
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1881. Murdoch, T. Burn, M.B., C.M., Charlotte Square.
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1877. Murray, John, Ph.D., LL.D., F.L.S., F.R.S.E., 32 Palmerston Place.
1884. Murray, R. Milne, M.A., M.B., 10 Hope Street.
1889. Musgrove, James, M.D., University Hall, Ramsay Garden.
1880. Nicholson, Professor H. Alleyne, D.Sc., F.L.S., F.G.S., Aberdeen.
1890. Nimmo, Alexander, jun., M.A., Westbank, Falkirk.
1887. Norman, Rev. Canon, M.A., D.C.L., Burnmoor Rectory, Fence Houses, Co. Durham.
1891. Norwell, John Stewart, B.Sc., 48 Merchiston Avenue.
1887. Oliver, John S., 12 Greenhill Park.
1886. *Panton, George A., F.R.S.E., 73 Westfield Road, Edgbaston, Birmingham.
1893. Parkinson, Thos. Wright, M.B., C.M., Brechin.
1893. Paterson, T. Lewis, M.B., C.M., 59 Grange Mount, Claughton, Birkenhead.
1870. Peach, B. N., F.G.S., F.R.S., Geological Survey, George IV. Bridge.
1891. Pentland, Young J., 5 Bruntsfield Terrace.
1888. Porter, George, M.B., 7 Tanza Road, Hampstead, London, N.W.
1879. Pullar, R. D., Ochil, Perth.
1889. Purvis, G. Carrington, B.Sc., M.D., Bacteriological Institute, Grahamstown, Cape Colony.

Date of Election.

1885. Raeburn, Harold, 22 Castle Terrace.

1896. Ramsay, Andrew J., Royal Observatory, Blackford Hill.

1881. *Ramsay, Major Wardlaw, Tillicoultry House, Tillicoultry.

1861. *Robertson, T., c/o J. Nisbet & Co., 21 Berners Street, London, W.

1883. Robertson, W. W., Wardie Bank.

1894. Roebuck, W. Denison, F.L.S., Sunny Bank, Leeds.

1890. Rogerson, John J., M.A., LL.D., Merchiston Castle.

1880. Rowland, Professor, M.A., M.D., The University, Salem, Oregon, U.S.A.

1887. Russell, William, M.D., F.R.C.P.E., 46 Albany Street.

1893. Scott, Matthew, C.E., Town Hall, Thornaby-on-Tees.

1889. Scott, Thomas, F.L.S., 14 Lorne Street, Leith Walk.

1878. *Selkirk, J. R. S. Hunter, LL.D., Daleville House, Carluke.

1891. Shannon, Rev. John A., M.A., F.S.Sc., U.P. Manse, Markinch.

1894. Simpson, D. R., Fernbank, Wick.

1882. Simpson, James, Anatomical Museum, The University.

1869. *Skirving, R. Scot-, 29 Drummond Place.

1877. Smith, J. A. J., F.R.C.S.E., Kimberley, South Africa.

1886. Somerville, Professor Wm., B.Sc., F.R.S.E., D.Œc., F.L.S., Durham College of Science, Newcastle-on-Tyne.

1880. Sprague, T. Bond, M.A., LL.D., F.R.S.E., 29 Buckingham Terrace

1880. Stark, A. C., M.B., C.M., Eccleston, Newton Road, Torquay, Devon.

1896. Steele, Adam Bryden, 5 Brighton Terrace, Joppa.

1882. Stewart, R., S.S.C., 7 E. Claremont Street.

Struthers, Professor John, M.D., LL.D., 24 Buckingham Terrace, *President.*

1882. Swinburne, J., 21 Saumarez Street, St Peter's Port, Guernsey.

1879. Symington, Professor J., M.D., F.R.S.E., Queen's College, Belfast.

1881. Tanner, S. T., 104b Mount Street, Berkeley Square, London, W.

1851. *Taylor, A., 11 Lutton Place.

1892. Taylor, Wm. A., M.A., F.R.S.E., Royal Scottish Geographical Society, Queen Street.

1894. Taylor, William, Lhanbryde.

1893. Terras, James A., B.Sc., Royal Botanic Garden.

1892. Thomson, E. Laidlaw, 20 Pitt Street.

1887. Thomson, J. Arthur, M.A., F.R.S.E., 11 Ramsay Garden, *Librarian.*

1892. Thomson, James Stuart, 19 Kilmaurs Road.

1876. *Thomson, John.

1874. *Thomson, R., LL.B., 6 Shandwick Place.

1885. Tomlinson, Henry T., M.B., C.M., Coton Road, Nuneaton.

1859. Traquair, R. H., M.D., LL.D., F.R.S., Museum of Science and Art, *Secretary.*

1891. Tress, Wm. Maxwell, 7 Melville Crescent.

1885. Turnbull, Percy M.

1858. *Turner, Professor Sir Wm., LL.D., F.R.S., 6 Eton Terrace.

1889. Tweedy, James, Solicitor, 14 Hartington Road, Stockton-on-Tees.

1893. Tyrie, Charles Campbell Baxter, M.B., C.M., Medical School, Leeds.

1895. Vallance, David J., Museum of Science and Art.

Date of Election.	
1882.	Wallace, Professor R., The University.
1893.	Waters, Edward J. W., Surgeons' Hall.
1884.	Watson, Wm., M.D., Lockharton, Slateford.
1884.	Webster, A. D., M.D., 20 Newington Road.
1887.	Webster, Hugh A., M.A., F.R.S.E., F.R.S.G.S., The University.
1894.	Whitaker, J. Ryland, B.A., M.B.(Lond.), L.R.C.P.E., 27 Castle Terrace.
1884.	White, J. Martin, Balruddery, Dundee.
1888.	White, Philip J., M.B., C.M., University College, Bangor.
1878.	White, Thomas, S.S.C., 114 George Street.
1890.	Williams, John D., M.D., B.Sc., Gwernllwyn House, Dowlais.
1890.	Williams, John Robert, M.B., C.M., Glandwr, Penmaenmawr.
	Williams, Principal, F.R.S.E., New Veterinary College.
1885.	Williams, W. Owen, M.R.C.V.S., New Veterinary College.
1885.	Wilson, A., L.D.S., 2 N. Charlotte Street.
1895.	Wilson, Gregg, Ph.D., The University.
1890.	Wilson, Wm., M.A., Physical Laboratory, Merchant Venturers' School, Bristol.
1886.	Wood, George E. C., M.B., C.M., Baileyfield, Portobello.
1883.	Woodhead, G. S., M.D., F.R.S.E., Beverley, Nightingale Lane, Balham, London, S.W.
1896.	Yeoman, John B., M.B., Neston, Cheshire.
1881.	Young, F. W., F.C.S., F.R.S.E., High School, Dundee.
1882.	Young, J., 64 Hereford Road, Bayswater, London, S.W.

CORRESPONDING.

Date of Election.	
	Andrew, Rev. J., Newbury, Fifeshire.
1875.	Coughtrey, Millen, M.D., Prof. Anat. and Physiology, University of Otago, New Zealand.
1858.	Duncan, Rev. J., Denholm.
1870.	Fraser, Rev. Samuel, Melbourne.
1871.	Grieve, A. F., Brisbane, Queensland.
1852.	Howden, J. C., M.D., Montrose.
1874.	Joass, Rev. J. M., LL.D., Golspie.
1874.	Jolly, William, Inspector of Schools.
1885.	Lindström, Professor Gustav, Stockholm.
1871.	Macdonald, John, S.S.C., 19 York Place, Edinburgh.
	Mushet, David, Gloucester.
1885.	Nathorst, Professor A. G., Surveyor-General, Geological Survey of Sweden, Stockholm.
1867.	Robb, Rev. Alexander, Old Calabar.
1874.	Stewart, Rev. Alexander, LL.D., Ballachulish.

HONORARY.

1857.	Chevrolat, Auguste, Paris.
1865.	Colloredo-Mannsfeldt, Prince, Vienna.
1857.	Dohrn, C. A., Stettin.
1857.	Fairmaire, Léon, Paris.
1883.	Geikie, Archibald, Director-General of the Geological Survey (Ord. Memb. 1878), *Olim Præses.*
1895.	Geikie, Professor James, LL.D., D.C.L., F.R.S., The University, Edinburgh.
1857.	Gerstaecker, A., Greifswald.
1857.	Javet, Charles, Paris.
1857.	Kraatz, G., Berlin.
1886.	Lacaze-Duthiers, H. de, Paris.
1888.	Lankester, Professor E. R., F.R.S., University College, London.
1893.	Lapworth, Professor, F.R.S., Mason College, Birmingham.
1869.	Lütken, Chr., University Museum, Copenhagen.
1857.	Obert, M., St Petersburg.
1888.	Vines, Sydney H., M.A., F.R.S., Christ's College, Cambridge.

Fellows are requested to intimate change of Address to
MR PERCY H. GRIMSHAW, F.E.S., *Assistant-Secretary,*
MUSEUM OF SCIENCE AND ART, EDINBURGH.

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M'Farlane & Erskine, Printers, Edinburgh.

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R. Kidston. M'Farlane & Erskine Lith^rs Edin^r

SPHENOPTERIS COMMUNIS, *Lesquereux.*

PLATE II.

THE STACKS OF MYGGANES: The haunt of the Gannets and Albatross.

From a Photo by Mr W. Norrie. 1894.

PLATE III.

DIOMEDIA MELANOPHRYS.

Killed on 15th June 1878, in lat. 80° 11′ N., and long. 4° E. Presented to the Museum at Peterhead by DAVID GRAY.

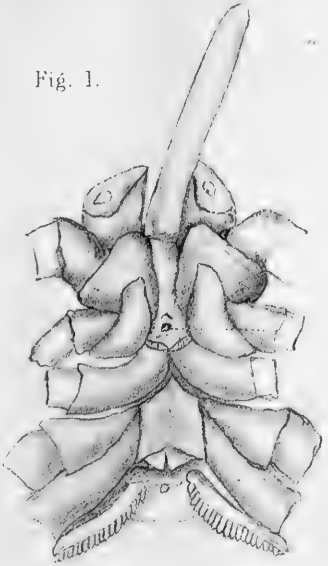
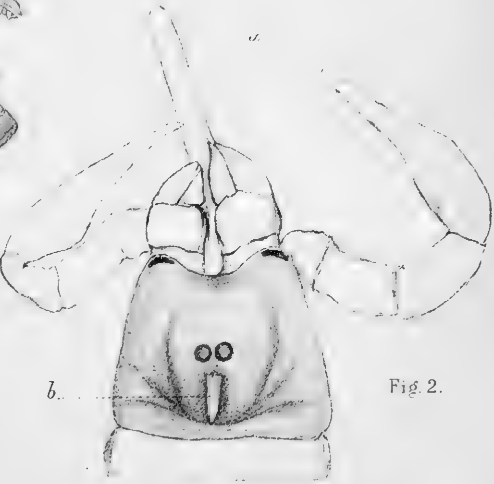


Fig. 1.

Fig. 3.

Fig. 4.



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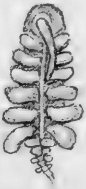

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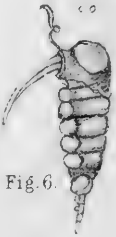

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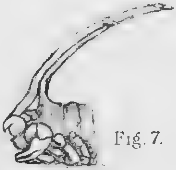

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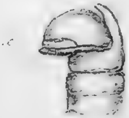

Fig 8.

M. Laurie, del.　McFarlane & Erskine, Lithrs Edinr

PLATE V.

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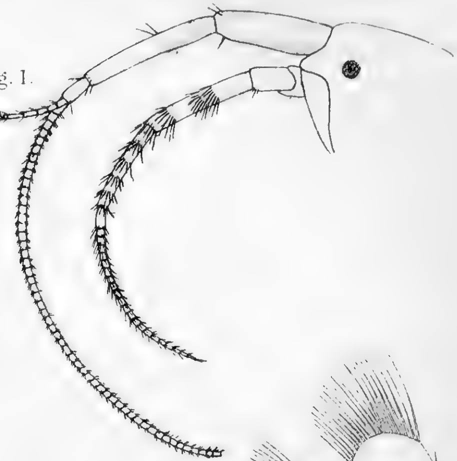
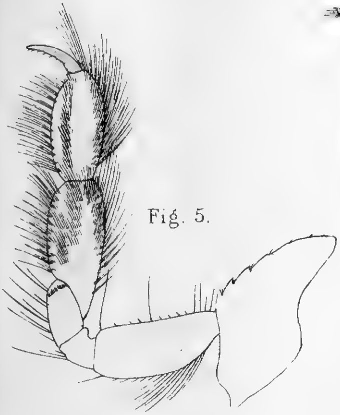


Fig. 1.



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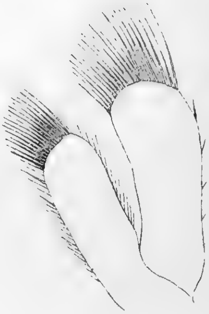

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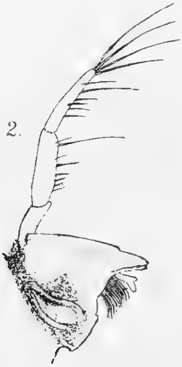

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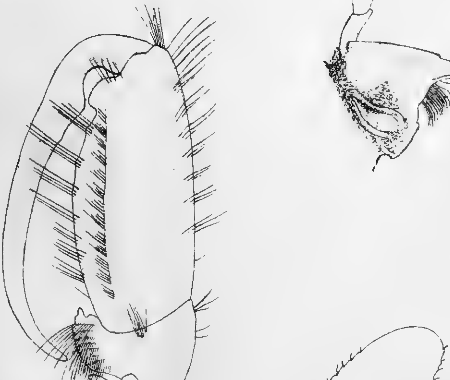

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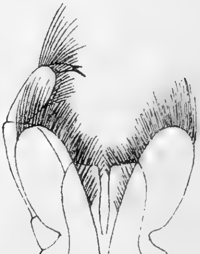


Fig. 4.

A. Scott, del.

M^cFarlane & Erskine, Lith^rs Edin^r

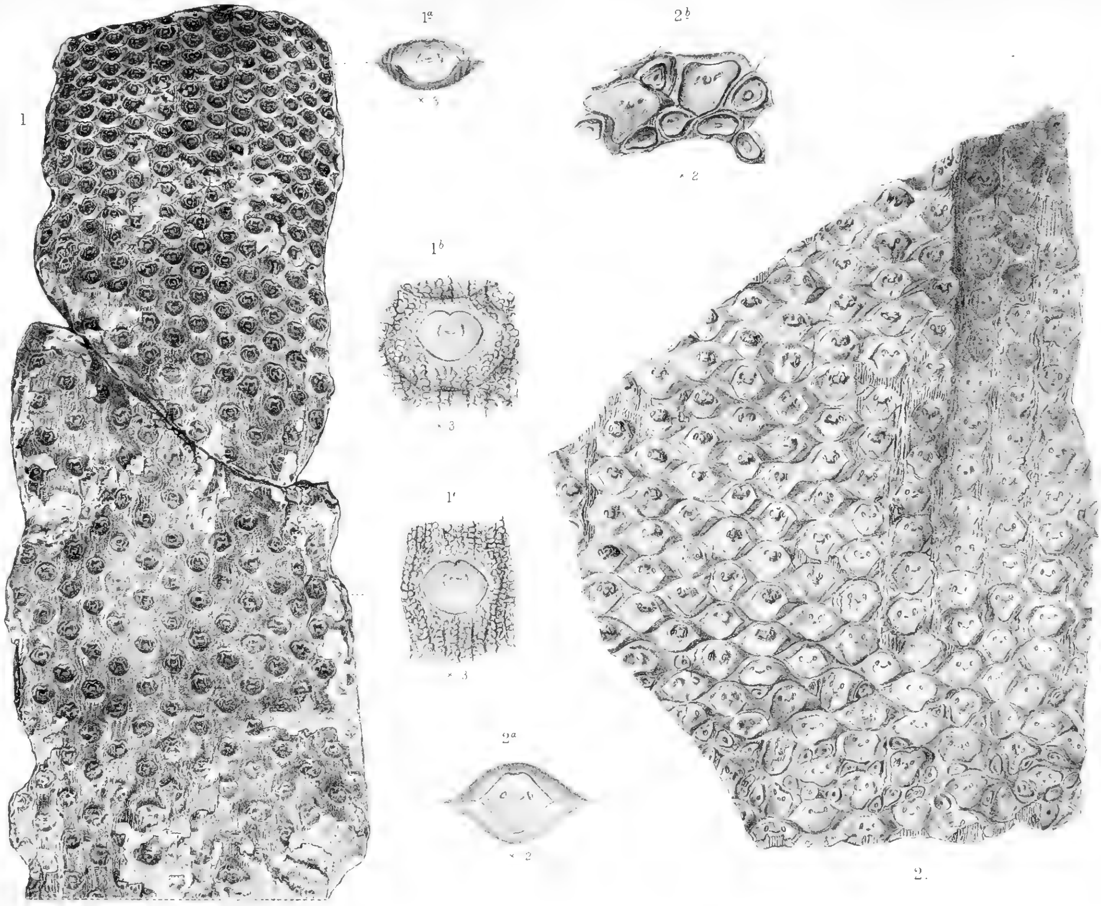
MÆRA BROOKI, Sp. n.

PLATE VI.

NEST OF THE EMU.

From a Photograph by A. J. Campbell.

PLATE VII.



R Kidston.
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SIGILLARIA BRARDII, *Brongniart.*

PLATE VIII.

Vol. XIII. *Royal Physical Society. Edinburgh.*

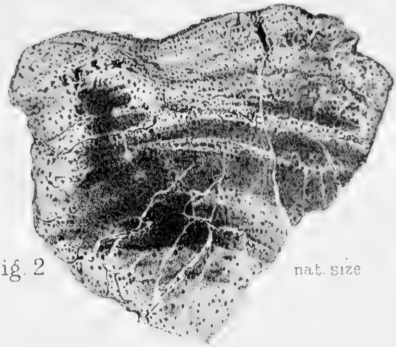

Fig. 2

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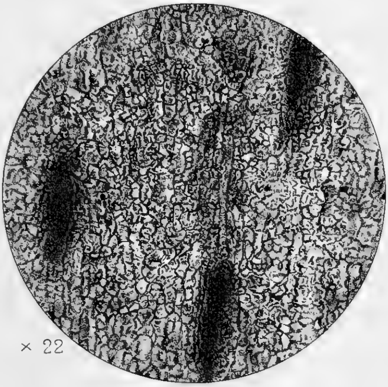
Fig. 4



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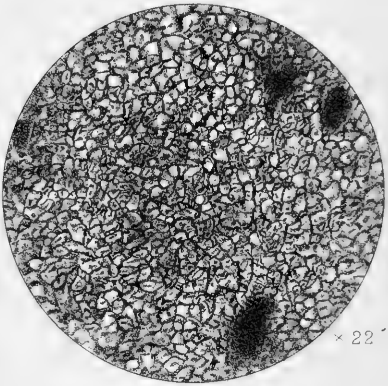

× 22

Fig. 1.

nat. size.

R. Kidston, Photo-micro.
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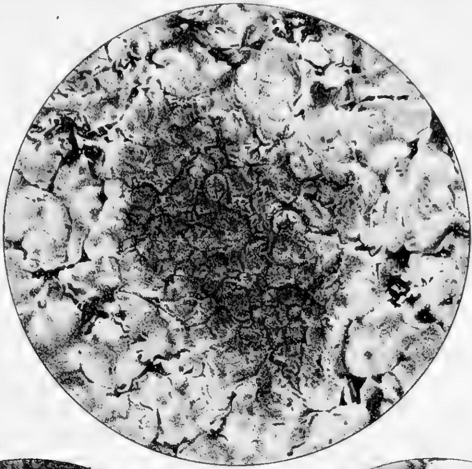
CRYPTOXYLON FORFARENSE. *Kidston.*

PLATE IX



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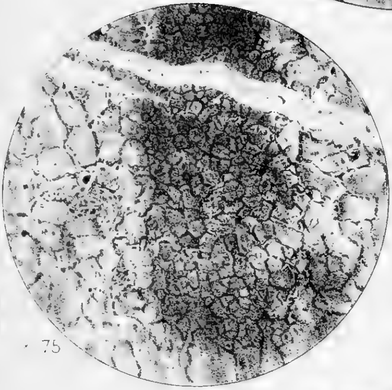

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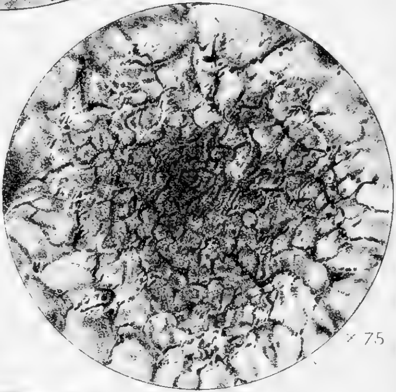

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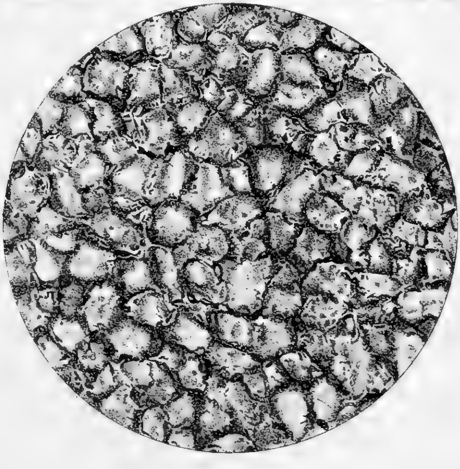

Fig. 5. × 75

R. Kidston, Photo micro

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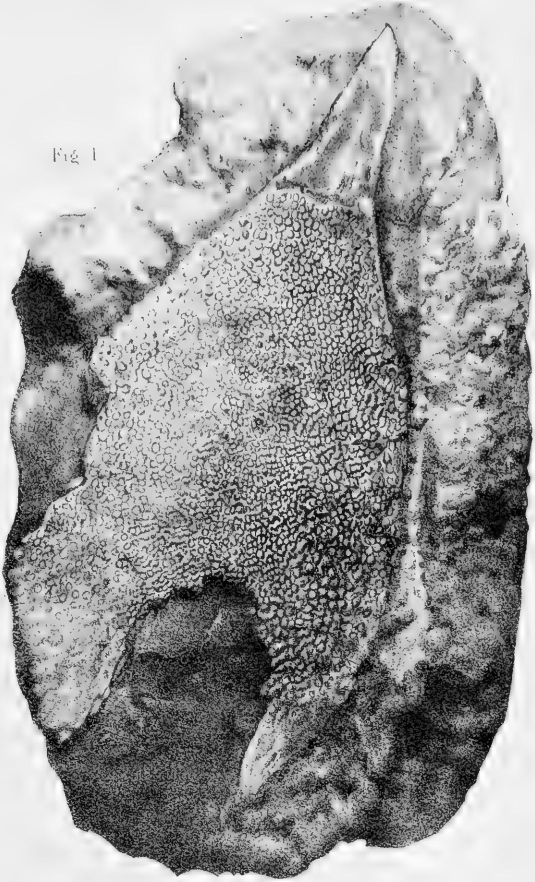
CRYPTOXYLON FORFARENSE *Kidston*

Fig 1



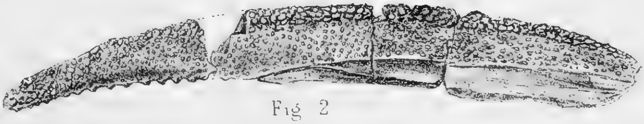


Fig 2

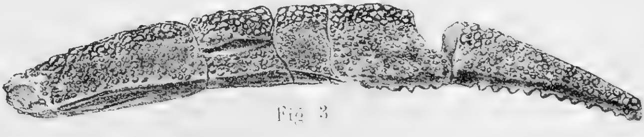


Fig 3

Fig 1 [illegible] Green
Figs 2 & 3 [illegible]

McFarlane & Erskine, Lithrs [illegible]

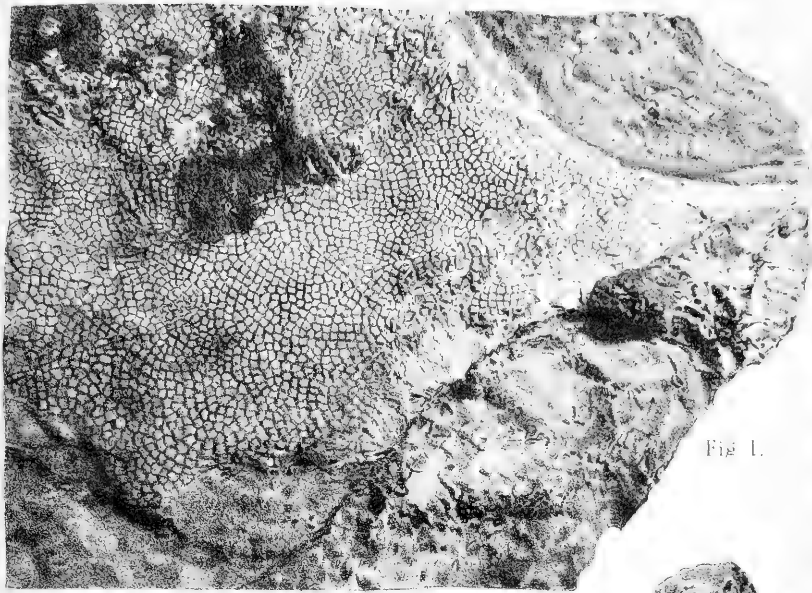


Fig 1.

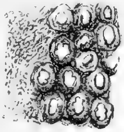


Fig. 4.

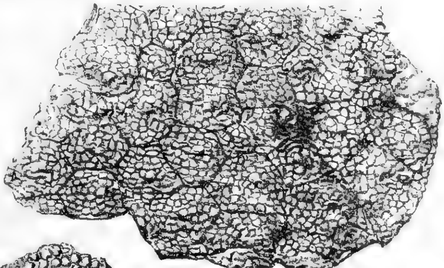


Fig. 5.

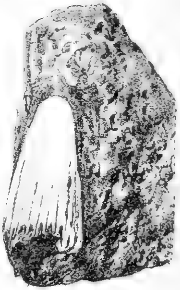


Fig. 7

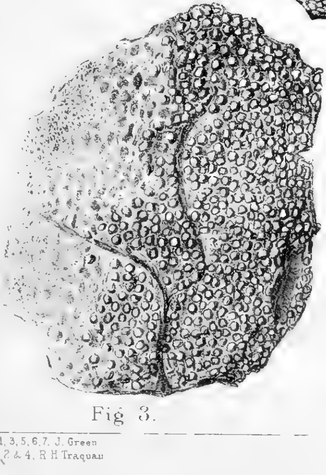


Fig 3.

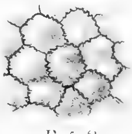


Fig. 2.

Fig 6.

Figs. 1, 3, 5, 6, 7. J. Green
Figs. 2 & 4. R H Traquair

M'Farlane & Erskine, Lith^rs Edin^r