THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

THE

EDINBURGH NEW PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

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JANUARY ...... APRIL 1859.

VOL. IX. NEW SERIES.

EDINBURGH:
ADAM AND CHARLES BLACK.
LONGMAN, BROWN, GREEN, & LONGMANS, LONDON.
MDCCCLIX.

EDINBURGH:
PRINTED BY NEILL AND COMPANY, OLD FISHMARKET.

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*Some Observations on the Fishes of the Lake District.** By JOHN DAVY, M.D., F.R.S., London and Edinburgh, &c.

On this subject I can hardly flatter myself that it will be in my power to offer any observations new to the icthyologist familiar with British fishes. I shall be satisfied if any of the remarks I may make should have the effect of exciting discussion, and calling forth information from those gentlemen present so competent to afford it.

From the very nature of the district, implied in its name, it might be expected to be a favourite habitat of the finny race; and that, as the physical conditions of its waters—such as depth, extent of surface, stillness and motion, elevation above the level of the sea, &c.—are so various, so likewise would be the varieties or species of fish inhabiting them—an inference tolerably according with the facts.

I may commence with giving a list of the fish,—of such as have come to my knowledge, belonging to the district, occurring in lake, river, and estuary,—not doubting that, on further and more careful inquiry, other species may be discovered, and the catalogue somewhat extended. Belonging to the Salmonidæ are the following:—The salmon, sea-trout, common trout, charr, vendace, schelly, and smelt. The remaining species, as to classification, are miscellaneous; they are the pike, perch, tench, roach, chub, barbel, eel, millar's thumb, thornback, minnow.

* Read at the last meeting of the British Association.

It would be superfluous and out of place here to enter into minute particulars respecting any of the fish named. I shall confine myself to some general remarks, chiefly regarding points which are not altogether settled, and are open to inquiry, or to some few others which I hope are settled, but which need to be dwelt on and enforced to make them generally known and popular.

1. *Of the Habitats of the Species.*—Of all of them, the common trout of the Salmonidæ is the most widely diffused. There are few streams and no lakes in which this fish is not to be found. Its being so widely spread indicates a hardihood of nature, an absence of that delicacy which seems to mark the next I shall mention—the charr. Of its hardihood, indeed, we have the strongest proof, if we extend our view from a district to a country, or continent, and consider its wide range, reaching from the extreme north of Europe almost to the extreme south, and in Asia found even so far south as Palestine—if I may rely on the assurance of an intelligent traveller, well acquainted with that country, who informs me that it occurs in the Jordan, and that he has partaken of it caught in that river, and of excellent quality and goodly size. And this may easily be credited, as we know for certain that the trout flourishes in some of the streams of the south of France, the Sorgue for instance, even at its source, at Vaucluse,* and in some of the rivers of Portugal, Sardinia, and Corsica. The charr, I have said, is a more delicate fish. It is confined to certain of the many lakes of the district, viz., Windermere, Coniston Water, Hawes Water, Buttermere, Crunmock Water, Waswater, and Ennerdale Lake. The sensitiveness of this fish to noxious influences is indicated by the circumstance, that since the mines have been opened in the vicinity of Ulswater, the charr, before abundant in that fine lake, have gradually diminished in number, and have now entirely disappeared; and the same effect of mine water, though in a less degree, has been witnessed in Coniston Water, where, before the copper mines in that neighbourhood had been opened, charr were far more plentiful than they

* On the 10th of April 1830, I found the temperature of the water at Vaucluse, just where the stream gushes from the rock, 54°.

have been since. The delicacy, too, of this fish is shown by the failure of attempts to introduce it into other lakes, such as Derwent Water, in which the trial has been repeatedly made without success. I am disposed to infer, that in all the instances of these abortive attempts, the failure has been chiefly owing to the water not being sufficiently pure, and not to the circumstance of insufficient depth of water. That this fish is intolerant of heat seems indeed certain, and that in summer it retreats to the deepest parts of the lakes it inhabits ; yet mere want of great depth of water seems hardly to be an adequate cause, as it is met with in other countries, in Ireland, for example, where it occurs in comparatively shallow water, and also in the Highlands of Scotland, in certain lakes where I believe the water is not deep. Of the latter I speak from what I have heard related ; of the former from my own experience. I may add, in confirmation, the difficulty of keeping it in stews or wells in which trout can be kept in health for a long while: so confined, I am assured, the charr rapidly gets out of condition, and often becomes blind, and infested with a parasitical growth.

Even less diffused than the charr are the vendace and its congener, the schelly, both of the coregonus genus, and allied to the greyling—this last a fish unknown in the district, though many of its rivers are well adapted for it. Both the vendace and the schelly are restricted to a very few localities. The schelly has been long known as occurring, and that abundantly, in Ulswater, Hawe's Water, Brother's Water, and Red Tarn. The vendace, which was supposed to have been peculiar to the lochs in the neighbourhood of Lochmaben in Dumfriesshire, has recently been ascertained to be an inhabitant of Derwent Water and Basenthwaite Lake, the two connected by a short reach of the River Derwent.

Of the rivers frequented by the more interesting and valuable fish, the migratory species of the Salmonidæ, the principal are the Derwent, Duddon, Leven, and Irt ; but besides these there are many smaller streams, which are the resort either of the salmon or sea-trout for spawning purposes, as is proved by the presence of their fry, though the parent fish are seldom seen by the honest angler, these commonly falling a prey to the poacher.

Of the other fish, as regards their habitats, having paid less attention to them, I have little information of any value to offer. The pike, perch, and eel are of very common occurrence. The eel, indeed, is found in almost every lake and river in the district, and even in the mountain tarns. The minnow and thornback are also widely diffused in both lake and river. The tench and roach are less frequently met with, and are confined chiefly to ponds into which they have been introduced, brought from other counties. The barbel, too, is of rare occurrence as a river fish. And the same remark applies to the smelt, an estuary migratory fish. Hitherto I have heard of it as taken only in the estuary of the Kent.

2*d*. *Of the Causes affecting the Dispersion or Limitation of the Species.*—The preceding brief notice of the habitats of the fishes of the district naturally leads to the inquiry, how is it that some are so widely distributed,—such as the pike, the trout, the perch; and others are so limited,—to be found in so few waters,—such as the vendace, the schelly, and charr? The causes operating must be of two kinds, either natural or artificial; the latter of course implying the interference of man. Which of these have been most concerned it may not be easy to determine in the majority of cases. I shall request attention chiefly to those fish of very limited distribution, and which, considering the habits of the fish, and the places in which they are found, it is difficult to suppose could owe their introduction to other than natural means. The vendace and schelly are the best examples. As these fish are rarely taken by the angle, or by any method except the net, and are comparatively of little value, we can hardly infer that where they occur they were originally placed by man, especially in the instance of the schelly, in a tarn such as the Red Tarn, situated under the brow of Helvellyn, many hundred feet above Ulswater, and so difficult of access. Much the same reflection presents itself as regards the vendace in Derwent Water and Basenthwaite Lake, taking into account the distance of these lakes from Lochmaben. If, as more easy of credence, we have recourse to natural causes, I fear we can only indulge in conjectures as to their nature, founded on probabilities. The first conjecture I would venture to offer is, that their ova, after impregnation, may have been conveyed by birds (water fowl), adhering either to their feet, or retained in their bills. The circumstances which seem to favour this view are, that the impregnated ova (at least of the salmon) preserve their vitality for many days in a moist air, and are capable of resisting a degree of cold sufficient to freeze water, so as to be included in ice. And the fact of the spawning season of the schelly and vendace being in the winter season, as in the instance of the other Salmonidæ, is favourable to this view. The only other conjecture I can presume to offer is, that the ova, having the power of resisting cold, might possibly have found their way originally to the places where the fish now exist by means of glaciers. Of the two, the first, which we owe to a distinguished naturalist, Mr Charles Darwin, seems the most probable, especially in the instance of the schelly of Red Tarn. As regards the vendace, another conjecture may be proposed, and which would become probable could it be proved that this fish is capable of enduring the sea. I mention it, arising out of an observation of Sir John Richardson, that he has known a vendace to have been taken in the brackish water of the Solway. If, in the way of objection to either of these conjectures, it be asked—Granted that any one of them has had effect, how is it that the fish in question are not more widely spread? May it not be answered, that the presumed causes must be held to be only occasional ones, the favouring circumstances rarely occurring together; moreover, that a limit may arise, from the quality of water, comprising the feed it yields, not being suitable to the species. The charr affords an instance; so do the salmon and sea-trout; the former, it would appear, as regards impurity of water; the latter principally as regards its temperature, a comparatively low temperature being essential to the health and wellbeing of these fish. Were it not so, it can hardly be doubted that they would be found in the Mediterranean and the Indian Ocean. I have known a stray salmon taken in the sea, off the coast of Malta. Had that sea suited its habits, and could it have met another stray wanderer from the Atlantic of a different sex, the breed might have been propagated; that is, if they could enter the same river in company, and the temperature of its water, and other circumstances belonging to it, were such as would allow of the hatching of the ova. The subject, in its generality, is well adapted for experiment, and on that account mostly I have ventured thus to bring it under your notice, keeping clear from all speculations relative to the habitats *ab origine* of species—a matter even more obscure than the preceding, and truly transcendental.

3d. Of the Growth of Fish.—This, I am disposed to think, has hardly received the attention it deserves, whether we consider the effect, the growth itself, or the peculiarities of organization with which it is connected. It may be difficult to assign what are the limits of each species as to size, and still more as to progress of growth. This is certain, that some species, such as the minnow and thornback, always remain of comparatively diminutive size; whilst others, the majority of the other species, under favouring circumstances, are capable of attaining a great size. Appropriate food, and abundance of it, seem to be most concerned. The Salmonidæ afford striking examples. It is now well ascertained, that the young salmon, which, as a smolt, enters the sea only two or three ounces in weight, in five or six weeks may return to its native river augmented in weight to four or five pounds. It is equally well known, that the same fish may remain in fresh water several months without gaining weight—on the contrary losing, in its fasting or low feeding in lake or river, that fat which it acquired in the sea from high feeding, and losing also the rich colour of muscle characteristic of the fresh run fish. The common trout is scarcely a less striking instance. How small is the brook trout, especially in hungry streams, such as mountain torrents in a country of primary rock formation! Rarely is it taken exceeding a very few ounces. Yet, change its position; put it into water where it can satisfy its appetite,—where there is abundance of rich food,—and in a short time it will start into active growth, and soon become a large fish, and this chiefly from increase of muscle and fat. Very recently a remarkable instance of such rapid growth has come to my knowledge. About two years ago, I am informed, some small brook-trout were put into the ponds which have recently been formed at Rivington as reservoirs for securing a supply of water for

Liverpool. So soon as July last,—that is, in about two years,—these fish had attained a goodly size, and had become of excellent condition, like the finest lake trout; and one was taken by an angler that weighed seven pounds. Other instances of the like kind might be mentioned of rapid growth of brook-trout put into made pieces of water, well authenticated, though not quite so remarkable as the foregoing.

By some it is supposed that as regards size of fish there is some relation between it and the volume of water,—a relation of dependency. It is true that large fish of any kind are seldom taken in very small streams or ponds, and that the largest are to be found rarely excepting in water, either rivers or lakes, of ample dimensions; but is not this owing to the larger pieces of water affording more ample food, and also a better chance of escaping capture. For the mere purpose of respiration,—in the performance of which function, water, owing to the air it contains, is to the gills of the fish what atmosphere is to the lungs of the higher classes of animals,—no great quantity is required. The water of a small swiftly-flowing brook might answer, almost irrespective of size; and accordingly, sometimes a trout of two or three pounds is caught in a neglected pool of such a stream; and I have it on good authority that a charr of the extraordinary weight of four pounds was once captured in a tarn (Lillytarn, the water of which is remarkable for its purity) a few miles from Kendal, into which some charr had been placed as an experiment; the exact time it had been there I could not learn. No charr I believe of the same size was ever known to have been taken in Windermere, an ocean as it were in comparison, but severely fished and poached, whilst the Tarn was carefully preserved.

Passing from the main cause, that which is external, the abundance and good quality of food, I would beg to advert briefly to the other, the internal, that connected with organization and function. These, I am led to infer, consist chiefly in a stomach possessed of great power of active digestion, with associated parts conducive to a rapid assimilation, unchecked or little abstracted from either by the kidneys or gills;—these two organs acting in harmony, the one excreting chiefly azote,—*i.e.*, matter abounding in azote,—the other exclusively carbon. We know for certain, and it has been long known, that in accordance with the low temperature of fishes, the quantity of oxygen they consume respiring by their gills is very small; and such experiments as I have made have brought me to a similar conclusion as regards their urinary secretion: and hence, whilst feeding largely, losing little by excretion, their increase in size, it is easy to understand, must of necessity be rapid.

4. *Of Varieties of Species.*—In the instance of the Salmonidæ we have striking and instructive examples of varieties of the several species depending on external causes, and probably chiefly on the quantity and quality of food, the quality of water, and the nature of the bottom in relation to light. How different is the well-fed lake trout, or the well-fed beautiful river trout, and the trout of the mountain brook or of the peaty stream? Even in the same lake or river, how great is sometimes the difference of colour and quality of the fish; of so rich and bright a hue, and so brilliantly spotted, where there is full exposure to light, and much reflected light from a clear gravelly or sandy bottom, and the reverse where there is much shade and a dark bottom absorbing the rays of light. In the instance of the charr we have similar examples; so various are they, indeed, that in no two lakes do they perfectly agree either in their average size, form, and colouring, or even in their habits. Compare the charr of Windermere and Hawes Water; were it not for their scales and other distinctive features, there would be little hesitation in saying they are different species, the charr of Hawes Water is so much smaller, and thinner, and differently spotted; the one taking the artificial fly of the angler freely; the other, that of Windermere, rarely so tempted, and seldom caught except by trowling with the minnow. Much the same remarks are applicable to the salmon and sea-trout, those of each river having commonly some peculiarities by which they may be known.

Age and sex also, the latter especially, at the spawning season, have a great modifying influence. Thoughout the year, independent of season, the male of the salmon is distinguishable by the form of its head, narrower and more pointed anteriorly than that of the female. In all the Salmonidæ, as is well known, the under jaw of the male fish becomes more or less elongated and hooked towards the breeding season; and the colour of its belly acquires a distinctive bright red hue, by which it can be known from the female of the same species. These changes are observable in all the species, but most remarkably in the salmon and charr, and the larger varieties of trout. The changes which accompany growth with age are well seen in the young of the salmon, whilst in fresh water, in passing from the parr stage into the smolt, and again, after quitting the river, in becoming from the smolt the grilse. So remarkable is the difference of aspect of the parr and smolt, that the two, as you know, were for a long period held to be different species, and are still so regarded in the eye of the law and by the watchers of our salmon rivers; the capture of the former being tolerated, to the great destruction of the salmon fry, whilst the taking of the smolt is finable, subjecting the angler to a penalty of five pounds. One of the peculiarities of the parr, now well established, is the full development of its testes, and its power, in consequence, of impregnating the ova of the adult fish. It might be interesting to ascertain experimentally whether the male of the other species, of those not migratory, as the common trout and charr, in its early stage, is similarly gifted.

An opinion has been entertained by one or two naturalists that there is a parr, truly a distinct species, founded on the belief that it is somewhat different in form, and that it is found in rivers, which, owing to inaccessible falls in their course, salmon cannot reach. The difference of form, as it may be affected by difference of food, seems deserving of little attention. The other circumstance, if established as a fact, would be of weight in the argument; but I believe it to be fallacious. Lately in the Highlands I examined with care a stream, one of those said to have parr, *sui generis*, above such a reputed fall. I found the fall one that a salmon could easily surmount; and the parr which I caught for examination above and below the said fall proved alike in all respects. I cannot but conclude, therefore, adopting the view taken by the highest authorities in Icthyology, that a parr, a distinct species, is a creature of the imagination; and that the idea of such a species ought to be discontinued, as affording a pretence to allow of the wasteful, mischievous capture of the salmon and sea-trout fry.

In most salmon rivers fish are occasionally taken of an ambiguous character, having the markings, and the transverse bands of the parr, undiminished in intensity, and yet of the size of the smolt, or even larger, sometimes reaching half a pound, or even ten ounces. It has been conjectured that these fish may be a cross between the salmon and common trout, and that, owing to the mixture, the migratory habit has been checked. This is possible, as it has been ascertained that the ova of the salmon can be impregnated by the milt of the common trout. I think it however more likely that the fish in question are salmon or sea-trout parr, which have missed their time of passage to the sea, and have owed their growth to their remaining in the river, and the retention of the markings to the want of such food as is essential to effect the change to the smolt state,—*i.e.*, the growth of a new crop of scales so amply provided with the white lustrous lining as to entitle them to be called silvery scales. This food, I am inclined to think, is a sufficiency of insects,—insects, like the scales and their colouring matter, containing a considerable proportion of phosphate of lime. In confirmation of this view I may relate, that parr put into a pond from which they could not escape have grown in two or three years to be about half a pound in weight, and when caught were found to be in excellent condition, though still retaining their original transverse markings. The subject, it must be confessed, is obscure, and requires further and more exact observations for its elucidation.

Under the head of varieties, mention perhaps deserves to be made of a fish of Waswater, there called "a botling," which is chiefly taken in the fall of the year, in the spawning season, in the streams which flow into the lake. It is always a male, and is distinguished by its large size and thickness of body, and by the marked projection and curvature of the extremity of the lower jaw: in weight it often reaches seven pounds. By the people of the country it is held to be a distinct species. It seems more likely to be an example of the modifying influences of the causes referred to, and merely a lake trout of a certain age, well fed, that for successive seasons has escaped being captured, more fortunate than its less active mate when intent on spawning.

Before concluding, I must express regret, which I am sure is shared by very many of the inhabitants of the Lake District, that a region in its numerous lakes and rivers so peculiarly fitted for fresh-water fish, and where one might expect to find abundance, should, generally speaking, be so disappointing, affording as it now does but a scanty supply, and this mainly owing to want of due protection from the poacher, and, from the nature of the fishing laws, the difficulty of affording such protection. Whether we view fish in the light of a source of national wealth, as a wholesome diet, or in their capture by the angler as an innocent and healthy recreation, the subject, surely, is important, and deserving the attention of the legislature. What seems to be the main desiderata are, that a close season should be established by law; *that* regulated by the spawning time, and applicable to the trout and charr and other fish as well as to the salmon; and as regards the last-named fish and the sea-trout, that the parr, unquestionably their young, should be protected as well as the smolt. It is at the spawning season that the depredations of the poacher are carried on on the largest scale, when the fish are most easily taken, when they are of most value for keeping up the supply, and of least value as articles of food; and, if I may add another consideration, when the season of the year is least inviting for the angler's sport.

Chemical Examination of Cotton-Seed Oil. By J. SLESSOR, Assistant to Dr ANDERSON, University of Glasgow.

Cotton is cultivated to so great an extent, that the seeds of the plant are of considerable importance. The cotton of each pod is wrapped round these seeds, which are nearly the size of coffee beans, and are therefore got in large quantity. They have been pressed on the large scale, within the last few years, to extract the oil from them, which is now becoming a commercial article. A sample of the seeds examined by me contained 23·50 per cent. of oil. The cake left after pressing is now largely used for feeding cattle, and still retains oil, in various samples to the extent of from 5·0 to 8·0 per cent. One sample examined contained as much as 18·0 per cent.; but this is unusually high.

The crude oil at common temperatures is somewhat thick, has a dark colour, and when fresh a faint sweetish odour. It soon becomes rancid on standing, from the action of an albuminous ferment causing decomposition. Its specific gravity at 60° Fahr. is ·9246.

At the common temperature it slowly deposits a small quantity of solid fat, and when cooled to 32° Fahr., this increases considerably. The purified oil, which is also a commercial article, has a pale yellow colour, and becomes solid below 32° Fahr.

It readily yields, when boiled with caustic soda, a hard compact soap. This, after dissolving in water and separation by common salt, was decomposed with sulphuric acid. The cake of fatty acid obtained in this way was softer than butter. It was pressed to free it from oleic acid, when it yielded about 30 per cent. of hard fatty acid, which fused at 130° Fahr. This is about the fusing point of Price's large-sized candles; but the quantity obtained from the cotton-seed oil itself is only about 25 per cent., whilst palm oil yields about 30 per cent.*

The fatty acid was dissolved in alcohol, and allowed to stand for a day, when a considerable deposit was obtained. Three additional crops were procured from the mother liquor. The first deposit was thrice crystallized from alcohol, and its fusing point was then found to be 143·5° Fahr. It was then crystallized from ether, when the fusing point remained unaltered. It solidified at 130° Fahr. These being exactly the numbers given by Heintz for palmitic acid, a portion of the substance was burnt with chromate of lead, which gave results likewise agreeing with this body.

The following are the numbers obtained:—

$$\begin{cases} 4{\cdot}815 \text{ grains gave} & \\ 13{\cdot}222 \quad \ldots & \text{carbonic acid,} \\ 5{\cdot}410 \quad \ldots & \text{water.} \end{cases}$$

* Muspratt's Dictionary, p. 410.

		Experiment.	Calculation.	
Carbon,	.	74·89	75·00	C_{32}
Hydrogen,	.	12·84	12·50	H_{32}
Oxygen,	.	...	12·50	O_4
			100·00	

A portion of a baryta salt was ignited, when
{ 8·987 grains gave
{ 2·710 ... carbonate of baryta.

		Experiment.	Calculation.	
Carbon,	.	...	59·33	C_{32}
Hydrogen,	.	...	9·58	H_{31}
Baryta,	.	23·43	23·67	BaO
Oxygen,	.	...	7·42	O_3
			100·00	

As the first deposit after crystallization retained the fusing point of palmitic acid, it shows the absence of stearic acid, unless present in very minute quantity. To ascertain the presence of lower acids, the other crops of material were recrystallized several times from alcohol, when it was soon found that their fusing points and crystalline characters agreed with palmitic acid. In the mother liquors of the crystallization of the fourth deposit, it was expected that lower acids, if present in any quantity, would be found. A portion of the warm alcoholic fluid had acetate of baryta added to it, to remove, on cooling, a large part of the palmitic acid, a second addition of acetate of baryta produced a salt, which, when decomposed by boiling for about ten minutes with weak hydrochloric acid, gave a fatty acid, fusing at 143° Fahr., showing that the solid fat consists almost entirely, if not altogether, of pure palmitic acid.

From these results it appears that cotton-seed oil consists, like palm oil, of palmitine and oleine, the difference being that cotton-seed oil contains a smaller proportion of the former.

On the Geology of the Lower or Northern Part of the Province of Moray: its History, Present State of Inquiry, and Points for Future Examination. By the Rev. GEORGE GORDON, A.M., Birnie.

Last month the lengthened chain of rail was completed which connects the Capital of the Highlands with the Metropolis of the British Empire—Inverness with London. The latest formed links of this chain were laid on a portion of the North of Scotland, neither uninteresting nor altogether unknown to the naturalist, particularly if geology be the object of his recreative pursuits. This district having thus lately become so accessible to the most remote inhabitant of our island, and as the meeting of the British Association at Aberdeen next autumn must bring many of its members within some sixty miles, or three hours' run of its centre, a short outline of its geological features may not be deemed altogether unacceptable.

The extreme southern or upper portions of the counties of Elgin and Nairn abound in what has hitherto been considered metamorphic and plutonic rocks; but it is not of them, or of their subordinate beds and masses, that we are now to write at any length. Suffice it then, as regards them, to refer the inquirer to Professor Nicol's "Guide to the Geology of Scotland," an admirable manual and a fit companion for every geological wanderer in "the land of the mountain and the flood." The lower or northern portions of these counties, with an adjoining and narrow strip on either side, from Banff and Inverness-shires, form the district here to be described. It extends from the east bank of the River Spey to the west bank of the River Nairn, a distance of about forty miles, and has the out-cropping beds of gneiss and the protruding granites as its southern boundary, and the waters of the Moray Firth as its northern limit. The greater part, if not, indeed, the whole of the "formations," in this district may be comprehended, at least provisionally, in two widely-separated divisions of the great geological scale,—viz., the Old Red Sandstone formation, and the Northern Drift. For although there are several masses, and even regularly-formed strata of wealden and oolite, yet a strong doubt has arisen as to their being actually *in situ;* while the rocks here introduced as silurian are alluded to rather with a view to direct the attention of other and more competent observers to the several localities, than to give any great assurance that our own suggestions are correct. Two circumstances tend materially to render the examination of this part of the province of Moray difficult to the geologist. There are such vast accumulations of the boulder clay, of the gravels and sand-banks of the drift, and of the debris of ancient sea-margins, that few sections of the underlying strata are fully exposed; and, even where they are best seen, there seems to have been so great and so extensive a denudation during the time of their deposition, that a complete or uninterrupted sequence of strata and their beds has not been detected. Still, notwithstanding these difficulties, there is much in the formations of this district worthy of attention, both on account of the discoveries that have already been made and described, and of those which assuredly remain to be ascertained and determined by resident observers and geological visitors.

Any observations on the province of Moray which we might select from the writings of earlier tourists and naturalists, such as Williams' description of the cherty rock and galena of Stotfield,* refer to the mineralogy rather than to the geology of the district. We therefore at once begin by narrating what has been written on the subject by two early and leading members of the modern English school of geology. Thus, the first notice of the geology of this locality is contained in a paper laid before the Geological Society of London, by Messrs Sedgwick and Murchison, so early as 1828, and published in the Transactions, Vol. III., second series. The leading object of the authors having been, to make known and describe the "deposits lying between the primary and oolitic series," on the opposite or northern shore of the Moray Firth; their equivalents on the southern shore (although minuter notices of the sections on the Findhorn and at Quarrywood, near Elgin, are given) are passed over with less detail. It is in this paper that we have a division made of the Old Red Sandstones of Caithness, Sutherland, and Ross

* He calls it a "composite granite."—"Mineral Kingdom," vol. i. p. 401.

into three parts—viz., the coarse conglomerates or fundamenta strata, the middle schistose or fish-bearing strata, and the superior or sandstone strata. No such division, however, was carried out by them in reference to the rocks on the southern shores of the Moray Firth ; the conclusion come to, representing the whole conglomerates, cornstones, and sandstones, except the Leys-ridge, near Inverness, is, that they formed but one of those three divisions—namely, the lowest. This member, or lowest division, as seen in the province of Moray, is indeed subdivided into three parts, as the following extract from this valuable paper shows :—" The secondary deposits on the southern shores of the Moray Firth, it appears, may be divided into three groups, the lowest of which is composed of red sandstone and conglomerate ; the middle of sandstone associated with variegated marls and sandstone ; the highest of light-coloured silicious sandstones. These three portions are, however, very ill defined ; and, as in our examination of this part of the country, we did not visit all the successive formations to the east of Burghead, there may be other beds, superior to the white sandstone, not noticed in this transverse section. A peculiar character is given to the deposits here described by the great abundance of cornstone, which may perhaps be considered to replace the lower portions of the calcareo-bituminous schist. Whatever be its relations, its appearance is not to be regarded as altogether anomalous ; for, in the county of Sutherland (especially in the immediate neighbourhood of Golspie, and between that place and Loch Fleet) there are several examples of this peculiar concretionary limestone associated with red sandstone, which alternates with and overlies the old conglomerate. And there may be many other examples of cornstone, with similar relations, which in the transverse sections through the secondary series entirely escaped our notice." These learned and experienced geologists in this paper* distinctly affirm,—what we believe to be the case,

* Much of this, and of another paper by the same authors on the Formations of the Moray Firth, with other information on the geology of the north of Scotland, will be found in the first edition of " Anderson's Guide to the Highlands," &c., a work which, says a good judge, " is not to be mentioned without honour."

although it has been denied by some resident observers, —that the cornstones under and around the town of Elgin are surmounted by the great system of sandstone strata. These sandstone strata, which contain in some places "small specks of kaolin," they truly state to be, in some of their beds, "the most beautiful light-coloured building-stone of the north of Scotland." Linksfield and Lethenbar, now two interesting and fertile fossil localities, are mentioned by Messrs Sedgwick and Murchison; but their curious contents were then undetected, at least unknown to the scientific world.

Mr Martin, of Anderson's Institution, Elgin, in 1835, wrote an "Essay on the Geology of Morayshire," for which he obtained a gold medal from the Highland and Agricultural Society of Scotland. It is published in the fifth volume, new series, p. 417, of their Prize Essays and Transactions. In this essay, Mr Martin, after a short sketch of the physical geography of the district, describes its geology in the descending order, treating, 1*st*, of the alluvium, including the sedimentary deposits,—the peat (subterranean and submarine), the sand drift, and the change by the sea; 2*d*, the diluvium; 3*d*, the limestone; 4*th*, the sandstone; 5*th*, the gneiss; and concludes his paper, which is illustrated by the first published map of the geology of the district, by some interesting remarks on its minerals, and on the relation between the underlying rocks and the soil. In 1836 Mr Martin made the most important discovery in the geology of Moray, by detecting organic remains (plates and scales of fish) in the now widely-celebrated locality of Scāāt Craig, four miles south from Elgin, and near the road that leads to the Glen of Rothes. The commencement, in that year, of that large and multifarious collection which forms the contents of the Elgin Museum, by the presentation to his native town of a valuable assortment of armour, birds, &c., from New Zealand and New South Wales, by John Masson, Esq. of London, gave a stimulus to others to add whatever antiquities, curiosities, and specimens in natural history they could procure, either at home or abroad. The Scāāt Craig, from the time of Mr Martin's discovery, became a point of attraction for this purpose. One of the largest ichthyolitic plates, and still one of the best ever dug from that locality, was soon found and presented to the museum, by the Rev. John Allan, of Peterculter, then acting as its efficient curator. Indeed, the Scāāt Craig may be regarded as the starting point of a successful search for fossils in the sandstones of Moray,—strata which had hitherto been looked upon as entirely devoid of any such interesting relics. Numerous and varied were the conjectures ventured upon as to the nature of the animals to which the remains at Scāāt Craig had belonged, and to the relative age of the rock in which they were found embedded. Some geologists, both of the north and south, supposed they were bones of gigantic reptiles,—saurians of enormous dimensions,—and that their matrix was so recent as the greensand of England. The late Dr Fleming, to whom we sent some specimens from this locality in March 1838, stated that "these organisms had a very strong resemblance to those found in the sandstone series immediately below the mountain limestone and coal measures of Fife." Thus the great similarity of the fossils to those of Fife, and the better known geological position of the rocks of that county, gave the first clue to the true allocation of the Scāāt Craig beds among those of the Old Red Sandstone series.

Early in 1838, Dr John Malcolmson, of the H.E.I.C.S., most opportunely appeared on this field. By his own geological knowledge, zeal, and experience, by an example so animating, and a bearing so encouraging to others, a large, decided, and firm step was made in elucidating the structure of the country, and in placing its formations before the scientific world in a light worthy both of the advanced state of geology and of the interest which the nature and contents of the rocks themselves were calculated to produce. In January 1838, in company with Patrick Duff, Esq., he paid a visit to the Scāāt Craig; but owing to the unfavourable state of the weather he was unsuccessful in obtaining fossil remains. He also visited Linksfield with a like unpromising result.

Dr Malcolmson had now to go to London, and, anxious that the savans of the metropolis should know and determine the value of Mr Martin's discovery at Scāāt Craig, we furnished him with as characteristic a selection of fossils from that locality, and also from Linksfield, as the short interval permitted, accompanying the specimens with a few notes and illustrative sections of the district. Mr Martin greatly enhanced this selection by contributing, among other specimens, a fine large tooth, which was immediately figured for Sir Roderick Murchison's great work on the Silurian Rocks. The exhibition of these fossils at the Geological Society excited much interest among its members. Their views, and his own researches among the specimens and books of the Society, with the comparisons he was then enabled to make, fully satisfied Dr Malcolmson that the fossils from Scāāt Craig were of the Old Red Sandstone formation. He was then confirmed in an opinion formerly expressed by him, that the deposit at Linksfield, of which he read a notice to the Society on 25th April, was of the wealden, and not of the lias formation. From London, Dr Malcolmson went to the Continent in April 1838, carrying along with him some of the Morayshire, and also of the Cromarty specimens. He returned to Forres in the end of the autumn of the same year, and then commenced that more extensive and minute examination, the result of which is given in his most valuable, but little known paper,—read before the Geological Society of London, on 5th June 1839,—"On the relations of the different parts of the Old Red Sandstone system in the counties of Moray, &c." Ere this paper was completed, he had visited many parts of Scotland, and especially those localities which might present illustrations and examples for enabling him to unravel the state of the southern shore of the Moray Firth. The district itself was of course known to him in every spot where the underlying rocks crop out. Well do we recollect the many excursions in which we fondly joined him,—such as by the shores of the Firth, tracing its ancient levels, its regular and far-spreading shingly beaches,—by the margin of the Loch of Spynie, picking up the remains of its salt and of its fresh-water mollusca, and marvelling at the extent of its now extinct oyster-bed,—by the rocky channels of the Lossie, and by those of its tributaries, marking in them the contortions of the more ancient rocks, the bluff projections of the conglomerates and their sandstones; here, in their fractures, with angles well defined and sharp as at first, there the rock crumbling before the slightest touch,—or by the upper stretches of moorland, finding on them traces of morains and lines of smoothed boulders, resembling what he had seen among the Alps. Never can we forget the entrancing joy with which nodule after nodule was broken, on 14th November 1838, at Dipple, on the Spey, as all the while evidence of embedded organisms slowly, gradually, surely increased, as the light of the rising sun. Great, however, as was the pleasure of discovering fossil fish in this locality, where, indeed, they are in the worst state of preservation, that pleasure was exceeded on a subsequent day when we came upon those at Tynat, where the fish are well defined and in a better state of preservation than in any other locality in the north of Scotland. Residing in its immediate neighbourhood, Dr Malcolmson paid many visits of discovery to the peerless banks of the Findhorn, where the largest sections of the strata are to be met with. Accompanied by Mr Stables, of Cawdor, he examined the valley of the Nairn, and that of the Burn of Brodie. Perhaps Dr Malcolmson's noble heart reached the acme of scientific satisfaction on the 27th March 1839, when his friend and fellow-labourer, Mr Stables, laid open in his presence a nodule, at Lethen Bar, that first revealed a form clearly distinct from any previously known fossil. Yes; "that singular creature," as he soon afterwards read to the Geological Society, "which, notwithstanding its anomalous form, I believe to be a fish." This was what was afterwards named by Agassiz, *Pterichthys*. We have a letter from Dr Malcolmson, dated the next day (28th), in which he says, "Stables got a magnificent *coccosteus*, showing the tail and wings, and also a fine small specimen of the species with the large tubercles, showing the tail as I saw it in some of Trail's Orkney fish." On the day following (29th), he writes to Mr Stables, "The more I think of our discovery the more important it seems. You must let me have the two tailed species of *coccosteus*, and the large tuberculated fish found by Dunbar, to have drawings of them made; and the first, I fancy, must be sent to Agassiz." And, in a letter Dr Malcolmson sent us from London, of date the 13th May following, he says, "He" (Mr Murchison, who then paid a visit to Paris) "took the winged creature with him—two specimens. If you can get the use of any others showing its structure, I should like to have them here before the first week of June. I have promised to draw up a short account of our discoveries, &c." "*P.S.*—Agassiz is to be here in a few weeks, and his painter is now here." Of the same date (London, 13th May 1839), he writes to Mr Stables, "I was sorry to find Mr Murchison setting off this morning for the Continent. He, however, met Mr Lonsdale on Saturday, and we looked at a few of our discoveries, and he was astonished beyond measure, urged an immediate memoir, which I have promised for Wednesday four weeks, the last meeting—the next one being full. Mr Murchison said he and Sedgwick had no notion that organic remains lay under their feet;—admits all my inferences as to relation of rocks. The *strange creature* excites more of their surprise and interest; and I have allowed Mr Murchison to take two good specimens to afford work for the Parisians, and also Steven's drawings," &c. "If you have any good winged creatures, pray send them by next steamer." The following extract from his paper, read before the Geological Society of London, 5th June of the same year, will show how broadly he had drawn the line of demarcation between "the winged creature" and any previously known form of fossil from the Old Red Sandstone:—"I have ascertained, by comparisons with numerous specimens, that they (viz., the fossil fish of the Old Red Sandstone of Moray) belong to the same genera and species which are found in Orkney, Caithness, Cromarty, and Gamrie—the most common belonging to the genera *Dipterus, Diplopterus, Cheiracanthus, Cheirolepis, Osteolepis;* a very important fossil, belonging to an undescribed genus of Ray, to be named by M. Agassiz, *Coccosteus;* and the singular creature figured (No.), which, notwithstanding its anomalous form, I believe to be a fish. Regarding this very remarkable fossil I propose to submit some observations at another time; but would now call attention to the part of the bony structure on which the arms rest, resembling that of some fishes of the cornstone series and mountain limestone, and to the resemblance in form of the convex plate on the back to those of the Findhorn and Clashbinnie already referred to. I saw one specimen of this fossil from Orkney in Dr Trail's collection. Imperfect specimens also occur at Cromarty; and two from Gamrie are in the Society's museum." A few days after this paper had been read,—viz., on 12th June 1839,—Dr Malcolmson writes to us:—"The fossils I presented in our names, jointly with Mr Stables and I propose leaving most of the specimens here for the present, as Agassiz is expected the end of the summer; and those belonging to Martin, and such of our own as it may be expedient to keep for the north, can be packed up after he has had the use of them." "Mr Lyell gave into the idea of the winged creature being a fish." "Nobody in Paris could make anything of it." In a letter to Mr Duff, dated London, 2d March 1840, among other compliments he meant to pay, he says, "I propose naming the winged creature after our friend Miller." In this letter he also states, that Valenciennes could make nothing of the creature, whether fish, crab, or tortoise; "but I don't care for that," he adds; "I shall spend a day or two" (he was then on the eve of returning to India) "in describing the fossils slightly, a selection of which will be engraved for the Transactions of the Geological Society, to illustrate my paper. I hope you will have no objections to some of yours being selected for this purpose." A manuscript copy of Dr Malcolmson's paper is now in the possession of Mr Stables. From it we have been able to give much information, without which these pages would have been comparatively of little value.

It is, indeed, much to be regretted that this valuable paper did not at the time obtain a place in the Transactions of the learned Society before which it was read, and by whose members it was so highly and justly applauded. Its discoveries and conclusions were characterized as most important; and the illustrations which accompanied it (chiefly the fossils themselves laid on the table) were declared to be singular, wonderful, unknown. Dr Malcolmson himself fully expected that it was to be given to the scientific world under the auspices of the Society, in those printed records that so well and fully preserve an account of the progress of geology in Britain. It is still our surprise that so a long a time has elapsed during which this omission has neither been remedied nor accounted for by the officials of the Society. The memory and merits of the author, as well as the great importance of the discoveries his paper made known to them, surely deserved a better fate at their hands.*

Dr Malcolmson in his paper divides the Old Red Sandstone rocks, as seen on the southern shores of the Moray Firth, into,—1, the inferior or great conglomerate; 2, the central or cornstone; and, 3, the silicious conglomerates or sandstones. He makes known, and identifies, the fish-beds of Tynat, Dipple, and Lethen Bar with those of Gamrie, Caithness, Orkney, and Cromarty. Of the last locality he says,—"A careful examination of the ichthyolite beds discovered by my friend Mr Miller on both sides of the South Sutor of Cromarty, satisfies me that they were subordinate to, and interstratified with, the Old Red Sandstone, and I soon had an opportunity of identifying several species of the fish found there with those of Gamrie, Caithness, and Orkney. M. Agassiz confirmed this with respect to the Cromarty species of *Cheiracanthus*, *Diplopterus*, and a very remarkable fossil to which he has

* In Hugh Miller's world-widely known, and justly appreciated, "Old Red-sandstone," p. 165, 3d edition, it is said a right was "challenged at the late meeting (1840?) of the British Association at Glasgow, by a gentleman of Elgin, to be regarded as the original discoverer of the Pterichthys." Now, no gentleman of Elgin or of its neighbourhood attended at Glasgow on that occasion, and of course could not have thus preferred a claim for the discovery of this animal. The repetition, or rather the stereotyping of this, which, with Mr Miller, we believe to have been a groundless claim, in the pages of his lasting work, demands a notice here in order to disabuse the public of any false impression on this point. Upon inquiry, it turned out that this claim was made by Mr Kier, a stranger, who delivered some lectures on Geology in Elgin. How much he had examined or come to know of that locality, either in a lithological or palæontological view, we have never ascertained. His claim seemed to have dropped dead at Glasgow, and we have to regret that it was resuscitated by Mr Miller, and kept alive in his pages, as if it had ever been made "by a gentleman of Elgin." Perhaps, had Dr Malcolmson's paper, read to the Geological Society of London, been printed at the time, with its illustrations, this *contretemps* would not have occurred. Is it now too late to publish it in their Transactions?

given the name of *Coccosteus*, and of which he had only seen specimens from Orkney and Caithness." This quotation is made to show that Dr Malcomson's correct eye and tried experience elsewhere made discoveries, and for the first time fixed the position of other fossiliferous beds than those of Moray. While afterwards referring to the different places where the strata are best seen, and describing them in their lithological and fossiliferous aspects, and, in short, while giving a condensed account of the present state of our geological knowledge of this district, we shall quote largely from the paper of Dr Macolmson, and be much influenced and guided by his opinions.

In 1842 was published the "Sketch of the Geology of Moray, by Patrick Duff, Esq." It is an excellent guide, amply descriptive of the superficial and underlying formations of the province. We shall afterwards refer to this treatise, and to the geological conclusions at which its accomplished author arrives. But we cannot let the opportunity pass without now stating that Mr Duff merits the best regards and warmest thanks, not only for having thus given to the public, in a separate form, the first general view of our local geology, and for having illustrated it by many expensive plates, but also for his indefatigable zeal in personally working out many a rare fossil from Scāāt Craig and Linksfield, now preserved in his cabinet, which is ever open to all who can in any degree appreciate its valuable contents. To him we are indebted for having secured and made known to the scientific world the *Stagonolepis Robertsoni*, and the still unique *Telerpeton Elginense*, which were brought to him,—the former from Lossiemouth in August 1844, the latter from Spynie in 1851,—by the observant workmen who found them, as offerings not less on account of Mr Duff's affability and gentlemanly bearing to all, than of his well-established reputation for scientific attainments.

A clear and correct epitome of the geology of the country around Elgin will be found in a note, p. 344 of the third edition of "Anderson's Guide to the Highlands," a valuable work already referred to. This note was drawn up by the late Mr Robertson of Woodside, formerly of Inverugie. We heartily recommend it to the attention of all, specially of tourists through this district, who would desire, at the least expense of time, to obtain an acquaintance with the formation of the ground on which they wander, and with those localities, around their track where the most striking and instructive sections, and the various fossils, are to be met with.

Some footprints were noticed in the sandstone beds at Cummingston, near Burghead, in 1850, by Mr Anderson, tenant of the quarry. Some of the slabs were procured by Captain Lambert Brickenden, and exhibited by him to the Elgin Scientific Association. A notice of them he also communicated to the Geological Society. A plate of one is given in the postscript to the third edition of "Lyell's Manual." Captain Brickenden, during his residence at Elgin, prepared a paper on the Wealden beds of Linksfield, published in the "Proceedings of the Geological Society" of London, Vol. VII., Part I., p. 289.

In this Journal we need not do more than remind our readers of Mr Martin's graphic article on the "Northern Drift," published in the number for October 1856, as containing much information of that deposit so largely developed in the plains of Moray. An article, entitled "Morayshire," in the "Westminster Review" for January 1858, written by M. E. Grant Duff, Esq., M.P., contains not only an admirable *resumé* of the present state of our local geological knowledge, but also several very pertinent suggestions as to its advancement on this field of inquiry. When to this list we add the various articles and paragraphs that have appeared in the local press, we shall have mentioned all that at present occurs to us that has been published or printed regarding the geology of the province of Moray, and enumerated the several sources whence information on this subject is to be derived by the inquirer.

Present State of Inquiry.—So much ; and we suspect our readers will say "hold, enough !" for the historical part. We now come to the next division in the plan proposed for this paper, viz., to give a short outline of the views which local observers and other inquirers seem to entertain at the present moment regarding the geology of the lower or northern portion of the province of Moray. We shall take the formations in the ascending order.

Upon the publication, in 1828, of Messrs Murchison and Sedgwick's paper above alluded to, it was seen that the northern and southern shores of the Moray Firth exhibited some of the subordinate beds of the Old Red Sandstone in common. Dr Malcolmson's examination of, and his discoveries in, these two regions confirmed this, and carried out the resemblance or equivalents in many other particulars.

Professor Nicol's late researches among the rocks of the north of Sutherlandshire and of the north-west of Ross-shire, as detailed in his paper published in the "Quarterly Journal of the Geological Society of London," for February 1857, and the report, published in the "Geologist" for April last, of Sir Roderick Murchison's views of the same rocks, have induced us to re-examine what has hitherto been considered the unquestioned and unquestionable line of demarcation between the so-called primary and secondary rocks of the old geological school, or between the gneiss and the sandstones of Moray. This re-examination leads us to suspect that the *Silurian* formation may be found largely developed in the district under review.

In three of the river beds, and in some intermediate localities which we have lately revisited, the rocks that underlie the Old Red Sandstone are found of the same general aspect. They are for the most part gneissose, but contrast greatly with the coarse-grained, well-defined gneiss, as seen in the boulders scattered over the country, and occasionally met with in the very ravines that expose the gneissose strata. They lie unconformably under the Old Red Sandstone strata, having their dip to the east of north, and at a much more acute angle than the overlying conglomerates which dip to the west, at a low angle, of the same cardinal point. Their beds are much fractured, and present many cleavage surfaces, to such an extent, and so regular, that in some places these surfaces are apt to be taken as indications of the lie of the strata. The southern boundary of this underlying rock, which we would venture to presume is Silurian, we have not yet had an opportunity of ascertaining. Taking into account the wide range which Sir Roderick Murchison contemplates for this system on the west and south-west of Scotland, it may be found most likely to extend many miles southward from the localities to which we have as yet traced it,—viz., Craigellachie on the Spey, Kellas on the Lossie, and Logie on the Findhorn.

Lower Craigellachie, the hill of Conrack, and the ravines which radiate from the village of Rothes, are good points for the examination of these rocks on the eastern part of the province of Moray. Conrack is interesting on account of the extent and varieties of quartz that are found there. Although of considerable thickness, so as to form the body of the strata, yet it resembles that generally found in veins. It is white, with iron-shot streaks, and at times coarsely fibrous or radiating. Drusy cavities, lined with rock crystal and amethystine quartz, are also found in it. In a ravine, running westward from the north end of the Glen of Rothes, large sections of this portion of Silurian strata are to be seen. About half way up this ravine more traces of hæmatitic iron ore are to be met with than in any other known locality in Morayshire, but still not of that amount or quality as would encourage the idea of its having been the mine whence this metal was taken at some distant period, when the smelting of it must have been carried on to some extent, as is proved by the heaps of rich slag so frequently found along the face of the Manoch Hill, and in other places. It is a problem yet to be solved where the ore was dug, although there is little doubt it was brought hither in order to be smelted by the charcoal made from the then abounding remains of the "Sylva Caledonica." In this ravine the veins that contain these traces of iron may be easily discovered. They are indicated by the strong chalybeate springs that issue from them, and by the bog-iron ore deposited where these springs emerge from the rock. On the Lossie, and in the ravines through which its tributaries, the Shoggle and the Lenock burns flow, from five to eight miles south from Elgin, these strata are best developed, and exhibit large sections well adapted for their study. On the west side, and above the fall of water at the linn of the Shoggle, the overlying conglomerate is seen resting unconformably. Some hundred yards further down the stream, on the same side, the upper surfaces of some of the thinner strata are recently laid bare, so that not only the dip but the flexures, and the apparent effects of side pressure, are distinctly seen over a considerable space. The upper beds of this series on the Lossie, as at the Dun Cow's Loup, are of a hard, compact flinty nature. As we descend they become less quartzy and more gneissose ; the latter being their prevailing character. Some of the strata, however, are coarsely micaceous. Veins of white quartz cut across the strata at all angles. Pluscarden Hill presents the same series of strata, and with the same dip as seen on the Lossie. Beginning at the east end we have the flinty, and, occasionally, brecciated rock as the uppermost beds. Then they pass into those that have a gneissose appearance. In this hill, and nearer the Priory, a second set of beds present the quartzy appearance again, which in its turn gives place to the gneissose character. Immediately north of the Priory a bed of mica-slate of no great thickness crops out. The strata that underlie the well-developed Old Red Sandstones of the Findhorn begin at Sluie. Lithologically, these rocks (Silurian ?) on the Findhorn, from Sluie to Logie, do not differ from those of the Lossie. They contain, however, many granitic veins which are absent from the former locality, and their dip is not so uniform and distinct. Immediately above the junction of the two formations at Sluie the older rock seems, from some under pressure, to have assumed the saddle-shaped form, the beds dipping in opposite directions at no great distance asunder. In no part of this district have the granitic or quartz veins been seen to enter the overlying sandstones. Hence, as Dr Malcolmson suggests, it may be inferred that these sandstone beds have received their present inclination from forces that bore upon them from a greater depth than has generally been alleged.

Many other localities might be instanced ; but those now noticed are the points where the character of those (Silurian) rocks best appears. How far southwards they extend we have not had the opportunity of tracing. But in no part of the district examined have we found limestone beds or strata, or any vestige of an organism. This latter deficiency must for a time leave the exact geological age of these rocks undecided,— at least until they be inspected by those geologists who are so well versed in all the phases of the Silurian formation as to say, from evidence other than fossils, whether or not they belong to that series of rocks. The mere suggestion that they are Silurian is here given with the view rather of inviting inquiry from others, and of pointing out localities to them, than of fixing their position in the geological scale. Mr Cunningham, in his paper on the neighbouring county of Banff ("Prize Essays, &c., of the Highland and Agricultural Society of Scotland," Vol. XIV., p. 447), considers the floetz rocks there as of the Transition series, which is now generally held to have been but another name for Silurian and Cambrian. Yet there are other differences, than the absence of limestones from the rocks now under consideration, that seem to exist between them and those of Banffshire. The dip is materially different. In the province of Moray we have neither such clay-slates nor grauwackes as are there to be seen. The hornblendes and the serpentines are awanting on this side of the Spey. And here the quartz rock itself is met with in a very inferior scale of development.

Old Red Sandstone or Devonian.—We now come to safer, because more frequently trodden ground, when we would speak of the age and sequence of the next series of strata in the ascending order,—the Old Red Sandstone or Devonian rocks of the province of Moray. As this is the formation that Dr Malcolmson, in the above-mentioned paper, so fully discusses, we shall best consult not only our own wishes, but the profit of the readers, by giving his views in pretty full outline, occasionally introducing some observations of our own as we go along.

Inferior or Great Conglomerate.—"The great conglomerate," says Dr Malcolmson, "forming the lower part of the Old Red system in Sutherland and Ross, extends into this district, and is seen in various ravines on the right bank of the River Nairn, to the east of Inverness, where, however, it attains no great thickness. But on passing the spur of gneiss which crosses the river at Kilravock Castle, it is seen, in the ravines above Cawdor Castle, to form the sides of deep and inaccessible chasms, from 100 to 200 feet in depth, resting uncomformably, a mile above the castle, on gneiss traversed by granite veins.

Before it disappears under the drift near the entrance of the castle, it alternates with gray sandstones and sandstone conglomerates. Two and a half miles to the eastward, at Geddes, and near the junction of granite and gneiss at Rait Castle, the upper fine-grained sandstones rest directly on the edges of the contorted primary rocks. I am therefore satisfied that this important member of the Old Red Sandstone system has suffered great and extensive denudations previous to the deposit of the upper parts of the series, a fact not sufficiently indicated by its being said to thin off, or to appear in a 'degraded form.' On the eastern side of the hill of Rait they again occur, extending along the burn of Lethen for several miles. They cannot be traced on the Findhorn; but at Birnie, and in the vale of Rothes, to the south of Elgin, and along the Spey, they form considerable round-topped hills, enveloping the sides of the gneiss. This conglomerate consists, as in other parts of Scotland, of a vast accumulation of imperfectly rounded fragments of primary rocks, mostly derived from the gneiss, granite, &c., of the neighbourhood. These fragments are often greatly decomposed, and cemented by a small quantity of ferruginous sandstone with more or less carbonate of lime. In some places small portions of a hæmatitic red sandstone are interposed in interrupted lines, which show the dip of the beds. The conglomerate is traversed by many nearly vertical joints and fissures; and many of the large imbedded blocks are fractured, the rents being for the most part vertical, and their edges almost always sharp. In most cases it wastes rapidly when exposed to the weather, being cut into deep chasms, or mouldering into turret-shaped cliffs and projections, forming a great quantity of wreck, and, on the right bank of the Spey, ravines of the most singularly desolate aspect. The soil covering it is usually fertile. In no part of the district are any fine-grained sandstones interposed between it and the primitive rocks, as is the case at Gamrie, and at Stonehaven and some other places to the south of the Grampians. But on the banks of the Spey above Fochabers the lower beds pass into a small-grained, very hard conglomerate." We would here suggest that these last-mentioned hard conglomerate beds are likely to be found the upper quartzy beds of the underlying formation, which, together with the gneiss to which Dr Malcolmson refers, we presume are Silurian. No organic remains have as yet been detected in this inferior or great conglomerate within the province of Moray.

The Central or Cornstone is the largest of the three divisions made of the Old Red system by Dr Malcolmson. It extends over a wide area, as indicated by its different beds cropping out at distant localities through the superincumbent clays and sands of the drift. These beds are best seen on the Findhorn, from Sluie to Cothall. At the former place they abut against the side of a fissure of the underlying strata (gneissose) of about twenty feet. Dr Malcolmson says, "The appearance is exactly what would be produced by the deposit of sandstone against any of the ancient elevated shores near the coast. It would also be caused by a fault. The strata next to the older rocks consist in great part of unrolled fragments of the micaceous gneiss on which they rest (the felspar being in a state of decomposition), cemented together by a red argillaceous sandstone, the bands of which alternate with the conglomerate. No fossils have been found in this part of the strata. They pass rapidly through micaceous thin-bedded strata, with ripple marks, into a soft laminated freestone without pebbles, but full of deep-red clay-balls, and alternate with laminated clays of the same colour. In the upper part of this portion one or two scales have been found. Then it passes rapidly into, and alternates with, a coarse-grained, pretty hard sandstone conglomerate, containing rolled pebbles of common gneiss and quartz, and of a greenish quartzose gneiss common to the higher mountains to the west. Partially rolled fragments of the fine red felspar of the neighbouring granite veins also occur, as they do in all the other strata below the cornstone and in the upper silicious sandstones near the coast. In these beds a few scales, teeth, and bones, have been found. A good deal of iron is diffused through these strata in streaks, and portions of brownish-red sandstone, spotted with round white or yellowish markings, forming a round compact case around the organic remains. The sand, as in almost every part of the central division of the formation, is coarse and angular, and more resembles that of rivers or of temporary floods than that of a permanent sea. The same fossils occur in great abundance higher in the series, above a stratum of a very coarse conglomerate, twenty feet thick, containing rounded pebbles of great size, united by calcspar, and a small quantity of red sandstone which is composed of a ferruginous cement and coarse particles of white quartz and mica. The lower part of this conglomerate is irregular, filling up the hollows that had been worked out of the inferior sandstone, of which it contains a few angular fragments. Several remarkable faults are seen below Sluie, where contiguous masses of this conglomerate have been raised or depressed a few feet, by which movement the larger boulders near them have been split in the manner so often observed throughout the inferior great conglomerate. Much saline matter is diffused through this and other parts of the formation. A specimen from the soft sandstone under the Cothall cornstone consisted of common salt and a little sulphate of soda, much of which is also diffused through the silicious conglomerates of Burghead. This bed of coarse conglomerate acquired a fictitious importance, from no fossils having for some time been found under it; but its occurrence cannot be considered unimportant, as it shows the violence of the changes that were in progress during the period in which the animals lived whose bony armour is entombed in these rocks, and which we cannot believe to have been given them without an object. The cuirass of one species appears to have consisted of very solid bone, one-third of an inch thick. No remains have been found in this conglomerate; but they occur abundantly immediately above in the coarser strata of a series of white and reddish sandstone conglomerates, and may also be detected by their plum-blue colour for nearly a mile down the river, through a succession of soft calciferous conglomerates, containing small rounded concretions of carbonate of lime, more compact yellowish and reddish beds, and soft crumbly marls and incoherent red, brown, and variegated sands. Everywhere indications are afforded of the various and sudden changes in the force and direction of the currents of waves of the ancient sea by the interposition of nests of gravel, sand, and clay among the other strata, by their thinning off, and by the various directions of their laminæ constituting their false bedding. Between these beds and the cornstones of Cothall other similar strata occur in which I have not yet found fossils. This limestone of Cothall has been so accurately described by Professor Sedgwick and Mr Murchison, that it is only necessary to add, that its lower beds pass into a conglomerate, in which I observed some angular fragments of a yellow sandstone. This limestone is also seen a mile down the river at the Suspension-bridge, beyond which the country is covered by drift, alluvial gravel and blown sand. But in a morass behind the House of Moy, and within the line of ancient shore, under a stratum of recent sea shells, a reddish-brown silicious sandstone, containing no lime, has been quarried.

"The red conglomerate, forming the lower part of the strata of the section just described, has very much the appearance of a local deposit; and, accordingly, in the burn of Forres, two miles to the north-east of the Findhorn, and three quarters of a mile from Altyre, red, white, and gray marly sandstones are exposed for a hundred and eighty paces resting on the gneiss, of which fragments are seen in a thin bed of limestone, three feet thick, forming the base of the secondary rocks. In the upper part of these marly beds I have found fragments of scales identical with those of the Findhorn."

In order to show the position, in this part of the series, of the nodular fish-beds of Lethenbar and Clune, in Nairnshire, Dr Malcolmson then describes the sections as unfolded in the Meikleburn and burn of Lethen—a continuation of the same stream—which at Boghole approaches within two miles to the north-west of the Findhorn, and ultimately falls into its estuary. "This burn," says Dr Malcomson, "is separated from the Findhorn higher up by the hill of Cairnbar, which is in part composed of gneiss; and on the south side, near Coulmony, of granite, in which portions of the gneiss are entangled. To the east of this hill the sandstones extend between the river of Findhorn and the burn of Lethen, over a slightly undulating plain, encumbered with drift, much intermixed with fragments of sandstone, and covered by the forest of Darnaway, which is one of the finest in the kingdom; the soil, like that of the cornstone districts in Herefordshire, being favourable to the growth of oak. Along the burn from Earlsmill to Cauldhame fine sections of sandstone, calciferous conglomerates, and marls of the same character as the Findhorn beds, with which they are continuous, are laid open, and the same organic remains are found in considerable numbers and variety. In addition to these, the singular buckler-shaped bones, allied to Cephalaspis, were procured near the Chapel of Boghole, from a soft yellowish sandstone, which dips under marly sandstones, and rests on a structure of red laminated micaceous schist and conglomerate. In a compact part of the same rock, a little higher up, the very remarkable impression and smooth bones (——— *Randolphi*) were found, to which I am inclined to refer many smooth bony plates found at Scāāt Craig and on the Findhorn." In a note, he here adds—" Remains were first discovered on the Findhorn 6th October 1838, and in the course of the same month I found them here (Lethen Burn). I would suggest that this specimen should be named after the celebrated Randolph, Earl of Moray, one of the most distinguished leaders in the wars of Robert the Bruce, and to whom the neighbouring domains belonged. It was in the adjoining forest that he baffled Edward III.'s army, as described in 'Winton's Chronicle.'" So completely seems this paper to have been unknown to those into whose hands Dr Malcolmson's specimens fell at London, that even this simple patriotic wish of his does not appear to have been realized. For in none of the lists of the fishes of the Old Red Sandstone do we find *Randolphi* as one of the specific names. Again we ask, why was it so?

"At Cauldhame these fossiliferous rocks rest on thin bedded sandstones, alternating with harder bands of conglomerate; and from underneath these, and having the same dip and direction, a considerable thickness of hæmatitic red schistose sandstones crop out in several places, and appear to rest on the Clune limestone, containing ichthyolites, which is situated on the eastern slope of Cairnbar, about five hundred feet above the level of the sea. Where these slaty beds appear to wrap round the eastern extremity of the hill, they dip to the eastward of north; but they resume their usual dip a little west of north, when traced along the lengthened ridge which extends from Cauldhame to the gneiss hill of Rait. They resemble the upper red sandstones of Cromarty and Ross, and decompose readily into a fertile argillo-calcareous wheat soil. In a small quarry in the grounds of Lethen, thin beds of shale and clay dip under the red sandstones, and contain nodules like those of Gamrie, except in being of a darker colour. Many of them contain black elastic bituminous layers, arranged like the scales of fish, which burn with a bright flame. At a subsequent visit Mr Gordon found portions of fish sufficiently well preserved to be identified with the Cheiracanthus, and two other species found at Clune, &c. The shales abound with remains of plants resembling *fuci;* imperfect specimens of which we also found in the nodules. They appear to have been compressed. The more solid part, forming the centre of the impression, is sometimes so well preserved that it retains its elasticity, and can be removed from the stone, while a soft coaly powder marks the softer structure. These plants I have identified with specimens associated with the ichthyolites of Gamrie and Cromarty. A fact of much greater importance is their appearing to belong to the same plants recently discovered by Professor Sedgwick and Mr Murchison in the Old Red Sandstones of Devonshire. These fucoids, and all the other fossils in this neighbourhood, and in the valley of the Nairn, were discovered by Mr Stables, jun. of Cawdor, and myself, between the 25th January and the 4th ult. (May 1839).

"There are a few feet of soft white freestone visible below the shales; and, on the opposite side of the burn, and dipping under them, the great inferior conglomerate appears in its most characteristic form, and can be traced in a series of steep cliffs and rounded slopes several miles up the stream, and is in one or two places covered by fine-grained sandstones. If the shales were prolonged across the stream in the line of dip, they would pass over this conglomerate, and strike the hill of Cairnbar near an excavation lately made at Lethenbar, from which the finest fish have been procured. At Lethenbar the fossils occur in large nodules, which are thickly deposited in a soft reddish-brown schist, which is intersected by numerous vertical joints, many of which pass through the nodules, and hence the corresponding parts of many of the finest specimens are lost. These fractures were probably the effect of the same movements which rent the boulders of the great conglomerate. The nodules are flattened, and, when they contain a fish, are generally of a lengthened form. The colour of the fish is pale blue when first extracted, but they soon acquire a reddish tinge when exposed. At Clune, a mile to the eastward, nodules and flat slabs of limestone occur in a stratum of clay and decomposed shale, which abound in the same fish. Five hundred yards up the hill, the slop of which corresponds to the dip, the same beds were formerly quarried. Under them, at this spot, there are a few thin strata of gray conglomerate, which have a dip of 12° N. The conglomerate rests on gneiss. As has been already mentioned, these strata (of Lethenbar and Clune) dip under the red schistose beds of Cauldhame, and the other members of the series on the Findhorn. It is hoped that the minuteness of these details will be excused on account of the great importance of establishing by actual sections the superposition of the central or cornstone division of the Old Red Sandstone to these beds, from which so many beautiful and characteristic fossils have been procured, not one of which has yet been found in the upper series." "The beautiful specimens of *Dipterus macrolepidotus* from Clune and Lethenbar, and the plants found along with them, connect the whole of these fossils with the English strata of the inferior division of the Old Red Sandstone, and render it probable that the fish, about which so many discordant opinions have been entertained, inhabited salt water. We also found these plants at the termination of the ridge of red schistose sandstone near the hill of Rait, where there are some thin beds of limestone containing nodules exactly resembling those of Lethen.

"In the valley of the Nairn, although none have hitherto been found in the conglomerates and sandstones that lie between the granite of Park and the gneiss hill to the west of Cawdor Castle, yet fossils appear at Balfriesh on the confines of Invernesshire. On the south bank of the river, opposite Cantray House, the great conglomerate appears in the bed of a small stream resting unconformably on the gneiss, which is traversed by several thick dykes of a beautiful red felspar and veins of granite, fragments of which abound in the conglomerate. This rock passes into a compact blue limestone containing many angular fragments of the neighbouring gneiss, porphyry, &c. The limestone is still worked at Balfriesh, where it is about ten feet thick, and is covered by a very hard red conglomerate. A deal of heavy spar occurs in layers, and is disseminated through the limestone and conglomerate; and an imbedded angular fragment of porphyry, which had been previously fractured, had the rents filled with it. Through this limestone, and the conglomerate immediately covering it, we found fragments and casts of tuberculated scales and bones resembling some of those at Lethenbar." "These beds dip, west of north, at an angle of about 10°, under black slates and sandstones exposed on the opposite side of the river. Above them, again, there is a fine reddish freestone, which has been quarried for the erection of the neighbouring mansion. Higher up the river, at the south-east extremity of Culloden Moor, and opposite the Druidical temples of Clava, the same bituminous beds occur. Their upper strata consist of very fissile shales, passing into a black compact calcareous rock formerly burned for lime, extremely fœtid when struck, and having all the characters of the Caithness pavement. Of this many slabs have been employed in the erection of the Druidical circles. In some of these beds nodules occur, in several of which are found scales of fish and ill-preserved vegetable impressions of the same general character as those of Lethen. Many of the nodules are very small, appearing to have been formed around single scales, and others are studded with smaller nodules, or composed of a congeries of them. These appearances are explained by what occurs at Dipple on the Spey, where all the fish have suffered some degree of decomposition previous to their being included in the stone, and many of the nodules are studded in the same manner with little excrescences, each of which contains a scale. This fact is in accordance with the opinion of those who ascribe the fœtid bituminous character of the Caithness rocks to putrescent animal matter. These strata rest on a coarse compact conglomerate, which reposes in the usual manner on the gneiss.

This bituminous rock is no doubt continuous with that at Inches, four miles to the west, and two miles south-east from Inverness, described by Professor Sedgwick and Mr Murchison, and which they showed to be a continuation of the bituminous schists of Caithness and Strathpeffer. The relations of these strata are therefore established, not only by similarity of lithological and zoological characters, but by careful investigation of numerous sections along the shores of the Moray Firth from Caithness to the Findhorn."

Between the rivers Findhorn and Spey, except at the Scāāt Craig and at the influx of the Shoggle Burn into the Lossie, where we discovered many years ago casts of large scales in a coarse whitish sandstone, no fossils of the central division have been met with. Indeed, few of its beds appear at the surface of this wide drift-covered plain, save the cornstone itself, which is singularly devoid of organisms, none having yet been detected in it. The cornstone crops out, or is quarried, at the following places, where, so far as its beds have been laid bare, it dips at a low angle a little to the west of north. The localities are named as they succeed each other, beginning at the most westerly. All of them, save the last two, are in the immediate vicinity of the town of Elgin, which stands on this part of the system. They are Sheriffmill; Palmercross; Wood of Main; the limeworks of Bilboahall, Ashgrove, and Linksfield; Waulkmill; Stonewells, near Innes House; and the Boar's Head, a rock in Spey Bay. The cornstones of the province of Moray, although burned and used both for building and agricultural purposes, are not properly limestones. They are rather to be regarded as concretionary sandstones. —the matrix being sand and marl, and the concretions of lime being largely developed throughout such of the beds as have been quarried for the kiln. Some of the lower beds have so little lime that they are used for dykes, fences, and even for the inferior sort of housebuilding. The debris of these limestone quarries is admirably adapted for binding the loose metal, whether of the public road or garden walk. The cornstone, unlike the rocks with which it is associated, maintains, even in its most widely separated localities, a striking lithological character, so that the description of one escarpment or quarry may serve for the rest. Generally of a yellowish grey colour, the solid portions are compact or sub-crystalline. They are seldom of great extent, but are mixed with and pass into masses which are less coherent, and have a greenish, reddish, or variegated colour, derived from the marls with which they are associated. Where the softer parts are wasted away, the forms become so irregular as to give the rock a brecciated appearance. Some parts of the beds are cherty, containing chalcedonic veins and small flattened cells, coated over with mammilated reddish chalcedony. Dendritic stains are not unfrequent, of some size, and of beautiful tracery. Crystals and radiating concretions of calcspar are abundant. Agaric mineral, iron pyrites, and galena (the last at Sheriff-mill), may be mentioned as some of the accompanying minerals. The pieces of calcspar that have long been lying near the surface of the rock are not unfrequently found decomposed into a dark powdery substance which leaves stains not unlike plumbago. For fuller particulars of this portion of the series, we refer to the paper by Messrs Sedgwick and Murchison, already noticed, and published in vol. iii., second series, of the Geological Society's Transactions.

The fish-beds of Dipple, on the left bank of the Spey, where the great north road crosses the river at the bridge of Boat o' Bog, lie on the inferior great conglomerates which are seen so largely developed on the opposite or right bank. These conglomerates extend from near Fochabers to near where the railway now crosses the Spey, and where they rest upon the quartzy beds of the still older rocks. The fish nodules are found at Dipple imbedded in a soft unctuous argillaceous schist, containing a good deal of iron and very little lime, and which has proved injurious to the soil to which it was applied as a manure. Although several species have been determined, yet this locality does not invite the collector for the cabinet, as its specimens of fishes are ill preserved, compared with those at Tynat and at the Nairnshire localities. We have here, however, a fine section of the beds that overlie the ichthyolites, running down to and passing the bridge, and sinking under the gravel and river terraces about half a mile to the north. These overlying beds consist chiefly of thick bands of red sandstone passing into conglomerate, with some thin layers of red and grey micaceous shales. The harder and more compact varieties, although quarried to some extent, do not well withstand exposure to the weather, and hence, for purposes of building, are greatly inferior to the white and yellow silicious sandstones around Elgin.

"Following," says Dr Malcolmson, whose views we have chiefly adopted in the two foregoing paragraphs, "the strike of the Dipple beds into Banffshire, we discovered at the burn of Tynat, four miles from Fochabers, another series of beds containing ichthyolites. They consist of thin bands of shale, interstratified with red sandstones and conglomerates, which dip to the north in the usual manner. The fossils occur usually in small, flat, compact, nodules of the same outline as the fish. Fragments of the tuberculated bones have also been found in the finer conglomerates. There are two beds containing ichthyolites, separated by about twenty feet.

"The burn of Buckie, descending from the hills near Letterfurie, passes through great beds of northern drift, containing many angular fragments of the Morayshire sandstones and cornstones, and at the mains of Buckie runs over strata of gneiss and fine micaceous chloritic schists, dipping to the south at a high angle. A little lower down, a thin vein, resembling serpentine, crosses the strata (of which it contains fragments) at right angles. On the sharp edges of these underlying rocks, and filling up the depressions between the projecting ledges, a coarse hæmatitic red conglomerate rests, inclined to the north at a low angle. Near high-water mark some of its beds pass into a coarse limestone, which is occasionally worked. The conglomerate does not exceed thirty feet in thickness, and the only strata seen resting on it are a few patches of a red schistose sandstone, in which we found a distinct fragment of a tuberculated bone, and some scales."

The following list, drawn up from Agassiz's monograph, gives the names and the provincial localities for the fish chiefly imbedded in the strata just described. Although but one locality is mentioned for a species, yet we believe that Clune, Lethenbar, Dipple, and Tynat hold many of them in common.

Pterichthys latus, Lethenbar.
Pterichthys Milleri, Clune.
Pterichthys productus, Lethenbar.
Pterichthys cornutus, Lethenbar.
Pterichthys major, Findhorn and Scäät Craig.
Placothorax paradoxus, Scäät Craig.
Coccosteus oblongus, Lethenbar.
Coccosteus maximus, Lethenbar and Boghole.
Acanthodes pusillus, Tynat.
Cheiracanthus microlepidotus, Lethenbar.
Diplacanthus striatalus, Lethenbar.
Diplacanthus longispinus, Lethenbar.
Cheirolepis Cummingiæ, Lethenbar.
Osteolepis major, Tynat and Lethenbar.
Diplopterus macrocephalus, Lethenbar.
Stagonolepis Robertsoni (a reptile ?), Lossiemouth.
Holoptychius giganteus, "Dans le couches de Old Red en Escosse à Elgin."
Holoptychius nobilissimus, Elgin.
Actinolepis tuberculatus, Findhorn.
Dendrodus latus, Scäät Craig and Findhorn.
Dendrodus strigatus, Scäät Craig.
Lamnodus bifurcatus, Scäät Craig.
Lamnodus Panderi, Scäät Craig.
Lamnodus sulcatus, Elgin.
Cricodus incurvus, Scäät Craig.
Asterolepis Asmusii, "Environs de Elgin."
Asterolepis minor, "Environs de Elgin."
Asterolepis Malcolmsoni, Elgin.
Bothriolepis favosa, Elgin.
Bothriolepis ornata, Monachtyhill, and also near Nairn.
Cosmacanthus Malcolmsoni, Scäät Craig.

The silicious sandstones and conglomerates form the third or upper division that has heretofore been commonly made of the Devonian or Old Red Sandstone formation, as it appears within the province of Moray. But we must here premise that it is not yet finally settled that they are really superior to the cornstone beds. Mr Duff, in his "Sketch," p. 24, says, "Great difference of opinion exists among geologists as to the exact position in the scale of this bed (cornstone)—some thinking that it passes under the yellow sandstone, in the usual manner, with cornstone, and I believe I stand single in maintaining that it does not do so; and I am so far safe in my assertion of the fact, that no instance can be pointed out in Morayshire of its passing under the sandstone, while it certainly overlies and passes into it. The town of Elgin stands on this limestone; and it is to be traced following the undulations of the surface two miles to the south of that town in a continuous scurf, and three miles to the eastward, without a single particle of sandstone covering it. At Cothall again, it is to be seen cut through by the course of the River Findhorn, and lining it northwards for at least a mile, during which stretch no sandstone rests on it." Mr Martin, also, in his

"Essay," takes the same view, and states that, "above the sandstone an extensive deposit of limestone is found. Its structure is sub-crystalline, compact, and of a bluish grey colour. It inclines with the sandstones to the north." Even Dr Malcolmson himself did not reckon it a fixed point, for on 2d March 1840 he writes to Mr Duff,—"I own the force of your remarks on the abstract (of his paper); yet I think I am entitled to speak with the hesitation I do on the relation of the silicious sandstones to the cornstone. I own it to be the weak part of my paper, and fortunately it is the part of least consequence." Although it be a question not to be settled by names or numbers, yet, following Messrs Sedgwick and Murchison, and the late Mr Robertson of Inverugie, we would here venture to state an opinion long held, that it is far more probable that the silicious sandstones of Bishopmill and Quarrywood do rest on the cornstones of Elgin. The strike and the dip of the beds clearly indicate this position, which is one not the less likely, from the absence of any apparent disturbance or fault from trap dykes or otherwise, to alter the appearance of the order in which we suppose them to have been deposited. The beds that lie under the cornstones of Cothall have few visible representatives in the neighbourhood of Elgin save at Scāāt Craig, while the silicious strata above the cornstone so largely developed in the eastern parts of the county may be represented in the west by the sandstones of Moy, and, possibly, of Boath, near Nairn.

The first, the most extensive and valuable escarpment of these silicious sandstones, lies immediately to the north-west of the town of Elgin. It runs from Bishopmill westward, continuously for four or five miles, to the moor at Alves. The joints, false bedding, and cleavage of the strata are apt to mislead the unpractised eye. But wherever the real surfaces of the strata appear, and are distinctly seen, they take the usual dip at a low angle a little to the west of north. This large and elevated ridge or escarpment, in its various beds, exhibits every degree of consistence, from the hard, pebbly, quartzy sandstones of the Millstone quarry, to the friable yellow beds of Bishopmill; and of colour, from the dull yellow brown of the latter place, to the rosy tints of the quarry at the foot of the Knock of Alves. Mr Duff justly remarks, "As building materials, the sandstones of Moray are unrivalled; nothing, for instance, can exceed the beauty of the masonry in the ruins of the Elgin Cathedral, where the finest and most minute carving has preserved its edge during four hundred years of exposure to the weather, and its warm cream colour in the landscape gives it a peculiar charm in the painter's eye." Of this part of the geology of the province, Dr Malcolmson says, "Resting on these Elgin cornstones, a series of very beautiful white and yellow silicious sandstones occurs, associated with a very hard conglomerate, composed of a paste of silicious grains, through which many completely rolled pebbles of white quartz, and a few of gneiss and granite, are scattered. This silicious conglomerate and sandstones, which appear to form the upper division of the Old Red system, extend over a considerable part of the north-east district of Moray, the great fertility of which depends on the rich alluvium within the ancient coast-line; the soil derived from these rocks being for the most part very sterile. Within the limits assigned to these sandstones a limestone, resembling the cornstone of Elgin and Cothall, occurs, which is extensively worked at Inverugie. On the coast, near Lossiemouth, it is in a great part composed of silica, which is often finely crystallized. At Inverugie and Lossiemouth a great deal of galena, with which, at Stotfield, Mr Gordon found specimens of blende, is disseminated through the rock. The galena is most probably of contemporaneous formation, although in one or two places the ore is most abundant along the lines of fracture. A shaft was recently driven through the limestone at Inverugie into the white silicious sandstones below; but no ore was found in the inferior rock." Two large isolated masses, apparently identical with the sandstone of Quarrywood, and which we believe are *in situ*, are to be met with, the one on the south-east flank of the Hill of Pluscarden, the other at Rinninver, about three miles south-west from the Pluscarden Priory. They have been both worked for building-stone. It were curious to ascertain the cause of their isolation from the great deposit of the same nature. The supposition of a vast and repeated denundation going on during the depositing of the sandstones of Moray seems a probable explanation.

Few fossils, and these chiefly casts or scales of Holoptychius, have been found scattered throughout the various beds of these silicious sandstones that form the lengthened and elevated ridge from Bishopmill to Alves. We however no sooner leave these beds in what we believe to be the ascending order of the strata, than we arrive at that portion of the provincial deposits which at the present excites so much interest in the geological world. Ever since the discovery of the *Telerpeton Elginense*, Mantell (*Leptopleuron lacertinum*, Owen), a strong suspicion has arisen, and prevails with many, that between the Holoptychius-bearing beds of the above-mentioned ridge, and the sandstone of Spynie, there must here exist a wide hiatus or blank in the great geological scale of the earth's crust, filled up in other areas of its surface by the whole of the Carboniferous and Permian, and no small portion of the Triassic, formations. It may be so. Still, this we affirm, that, so far as has yet appeared from repeated and careful inspection of the strata where accessible, they conform so closely in their strike, dip, position, and lithological character, as would, in the absence of these reptilian remains, have induced the most practised observers to infer, with little doubt or hesitation, that the sandstones of Spynie, Lossiemouth, and Cummingston, were but the upper beds of one and the same formation as the sandstones of Bishopmill, Quarrywood, and Alves. Another circumstance, which certainly tends to show at the same time a marked difference in the age of these beds is, that, so far as has yet been ascertained, as soon as the reptilian remains appear, those of fishes disappear,—no impression of Holoptychius, or, indeed, any other organism, has hitherto been found associated with them.

About a couple of years ago, lying on the surface of the Bishopmill silicious sandstones, near the east entrance to Findrassie House, and among the debris of a pit opened up for road material, Alexander Young, Esq., Fleurs, found a most interesting and valuable slab containing casts of bones and scales. He presented it to the Elgin Museum, where it is now to be seen. Although not actually taken from the living rock, the lithological features of the stone, and the freshness of its angles, lead us to infer that it had not travelled far from its original bed. The scales seem to be generically, if not specifically, the same as those of the specimen from Lossiemouth, which Agassiz considered to belong to a fish, and to which he gave the name of *Stagonolepis Robertsoni.* The casts, however, of the bones, which lie in such close juxtaposition to the scales as to leave no doubt of their belonging to the same animal, give good ground, we think, for raising it to the higher class of reptiles. The surface of the slab is about eighteen inches square. One bone measures three inches across the two condyles, and the scales $2\frac{1}{4}$ inches by $1\frac{1}{2}$ inches. But a verbal description here is of comparatively little use. We trust that at least a cast of this slab, and that other fossils from this now so interesting a locality, will be sent to Aberdeen, by the time the British Association meets in that city, for the inspection of those able to decide as to the character and position which these animals should have assigned to them among the vertebrata. Dr Taylor, H.E.I.C.S., at the same locality, subsequently found some casts of vertebræ, which are now in the cabinet of Mr Duff.

The Hill of Spynie, which we would suggest as coming next in order, stands about two miles to the north-east of that part of the Bishopmill sandstones which disappears under the alluvial deposits and drift. Between the two the drift, as is so frequently the case in this district, prevails and hides their junction. The hill itself, the site of the far-famed and still unique Telerpeton, rises from a sea of this drift, or from the deep sedimentary deposits of the Loch of Spynie, so that at no point in its whole circumference is any actual connection to be traced with any other rock. On the north-east corner of the hill, and close by the ruins of the Episcopal palace, there are masses of a hard, flinty, concretionary, sandstone, pervaded by decomposing iron pyrites, not otherwise differing from the cornstones at and around Elgin. Whatever may be said of the Stagonolepis at Findrassie, there can be no doubt as to the *Telerpeton Elginense* being found *in situ.* It was extracted from the living rock, deep in a quarry opened on the west end of the hill, and as yet is the only organism that the Hill of Spynie has yielded, although the workmen have had their eyes open ever since to any similar appearances that might present themselves.

After those now described, the nearest out-cropping rock to Spynie are the strata at the Coularthill, or Lossiemouth, about three miles distant, nearly north. They have all the same dip as the sandstones of the interior of the country, and do not, when taken as a whole, differ in their lithological nature. The lowest beds, as seen near the back of Rockhouse garden, are of a shaly nature, approaching to a red unctuous clay. They soon pass through a yellowish soft sandstone to a hard, whitish, compact rock, which extends down to the new harbour of Branderburgh, and which has been extensively quarried. It was immediately under this hard silicious sandstone, in a quarry half-way to the new harbour from Rockhouse, and in the face of the wall of rock that overhangs the houses fronting the old harbour, that Mr Martin, to whose discoveries in the fossil geology of the county science is already so much indebted, detected last week (1st September 1858) a bone, possibly the scapula of a reptile. This discovery will tend to throw much light upon our provincial geology. It was near the same place that Mr Duff's specimen, now in the Elgin Museum, of *Stagonolepis Robertsoni* was found, and we trust that those two interesting relics are but an earnest of what are to follow from the same locality. Overlying these beds of hard, compact, white silicious sandstone, we find at the new harbour, and thence extending as far as Burra Westra Cottage at Stotfield, a singular flinty or agaty rock well worthy of attention. At Stotfield it is seen to rest on a thin bed of limestone resembling the cornstones. Portions of the same deposit are seen to underlie it, or pass into it on the shore within high-water mark. At first sight this rock seems to be a series of strata set on their edges; but a more close inspection will show that this appearance is caused by the bed being pervaded by numerous perpendicular rents or fractures. Galena and other minerals, as noticed in the extract from Dr Malcolmson's paper, are found in this rock, which also yields beautiful small rock crystals, often in drusy cavities, and having an amethystine tint. It is this rock which Williams, in his "Mineral Kingdom," calls a composite granite. At least two attempts, both abortive, have been made by miners from the south to work the galena profitably. The ore is said to be a rich one ; but being in a hard rock, in small disseminated masses and not in veins, the labour of extracting it would be expensive. Moreover, the matrix bed itself being of no great depth, even had the disseminated masses been larger and of more easy extraction, the whole would have been soon exhausted. For there is no appearance of the lead ore extending to the underlying sandstones. The strike of this bed, which in some respects resembles the cornstones of the interior, if prolonged, would pass near to Inverugie, some six miles to the westward. At all events, at this place (Inverugie), we have a well-developed and an undoubted cornstone, which has been quarried to a considerable extent. It has the usual dip, so often noticed in the other cornstones and sandstones of the country, and has galena disseminated throughout it. The occurrence of the Inverugie cornstone, as well as that which lies on the sandstones of Spynie, becomes another element, indicating that the whole of the beds lying between it and the cornstones of Elgin are but subordinate to one great formation—the Devonian or Old Red Sandstone.

We had thus far written, when Sir Roderick Murchison (7th September 1858) visited this district. His views regarding it will probably be communicated to the Geological Section of the British Association now sitting at Leeds, and published in the third edition of his "Siluria," just about to issue from the press. With these materials before us, we shall be enabled to speak more fully and confidently of the geological order of the whole, and specially of the age of the upper or reptilian-bearing beds of Spynie and Lossiemouth, than could have been done in the absence of his unequalled experience and acknowledged authority in all that relates to the Old Red Sandstone system. We shall, therefore, reserve the description of the few remaining beds that lie along the shore, from Covesea to Burghead, including those of Cummingston, that contain the singular foot-prints already referred to, for an appendix to this paper, in which we hope also to give the result of this most recent and most authentic examination, and, at the same time, to add to and correct some of the statements advanced in the foregoing pages. Therefore, in the meantime, we turn to the next or highest system, in the province of Moray, which we were provisionally to regard as coming after that of the Old Red Sandstone, namely,

The Northern Drift or Boulder Clay.

Throughout the district under consideration, particularly its eastern half, there have been found many masses of fossiliferous shales and clays, which have been assigned to the Liassic, Oolitic, and Wealden formations. However, as suspicions have arisen in the minds of local observers, that even the largest and best stratified mass—of Wealden at Linksfield—is not *in situ*, it is better, in the meantime, to treat them as all lying in the same category, namely, the Drift or Boulder Clay. At various times, specimens from Linksfield have been laid on the table of the Geological Society of London, and papers on this deposit read before its learned members; but no hint was given, or doubt expressed, regarding its being a transported mass. Hence, when the Telerpeton was found at Spynie, the natural idea was entertained by not a few, that the reptile must belong to some system lying between the widely separated Wealden and the Devonian, the two acknowledged formations of the district. If it then turn out, as we think it will, that the Linksfield Wealden owes its present locality to glacial action (icebergs), the opinion, if any further proof be necessary, is the more confirmed, that the Telerpeton, the Stagonolepis, and the foot-prints of Cummingston, are of the Old Red Sandstone era.

On the 25th April 1838, Dr Malcolmson read a paper "On the Wealden beds at Linksfield," before the Geological Society of London. Mr Martin having favoured us with his manuscript copy of it, we give the following extract:—"The principal beds at Linksfield, in the ascending order, are,—1. Immediately above the cornstone, and unconformable to it, a bed, several feet thick, of red, nearly incoherent, sandy marl, effervescing with acid, and abounding with rolled pebbles of granite, gneiss, &c. I also detected unrolled fragments of the fine-grained yellow and gray sandstones, forming the hills to the west. This sand appears to be less inclined than the upper beds, and it becomes more argillaceous, and of a redder colour above. 2. Laminated green clay, with a network of fibrous carbonate of lime. 3. Compact gray limestone without shells, with clay between the laminæ and strata. The central parts of these bands are mostly broken across the planes into rhomboidal masses, preserving their parallelism. 4. Blackish clay or shale, some specimens very black, others turning green on exposure, not bituminous. Between one and two feet thick. 5. Narrow bands of limestone and clay. 6. Blue clay, with thin bands of compact limestone, mostly composed of bivalve shells, of a dark-green colour, occasionally tinged with pyrites. The blue clay abounds with crystals of selenite and argillo-calcareous nodules, and its lower laminæ are intermixed with satin spar. The fossils have been found principally in the lower part of the bands. The shells are rarely well preserved, and cannot be separated from the rock. They consist of few species, but the individuals are very numerous, constituting nearly the whole rock. The most remarkable is a Cyclas that cannot be distinguished from the *C. media* of the Wealden in the Isle of Skye. With them are mixed a few individuals of a new species of Avicula, fragments of Astarte, and *Venus elegans*, and a microscopic univalve. The clay below the limestone is full of the valves of a species of Cypris, ascertained by Mr J. D. Sowerby to be new. A saurian bone, and numerous scales and teeth of fish, have also been found. The character of these beds differs so much from the Lias, to which they had been referred, that I was reluctant to admit the conclusion, that this rock has assumed so different an appearance, not only from that exhibited by it in England, but from the same strata on the opposite side of the Moray Firth. This suspicion was confirmed by none of the chambered or other remarkable shells so abundant at Ethie having been found at Linksfield, and by the discovery of the fresh-water shells and Cypris. Having stated my belief that the deposit belonged to the Wealden beds, the gentleman who had discovered and collected the specimens kindly favoured me with them; and Mr Murchison was immediately struck with the similarity to the lower part of the Purbeck beds at

Swanage, between which and the several variety of clays and limestone bands at Elgin there appears to be a perfect identity. That this does not extend to all the species of fossils might be expected from the distance of the locality, the beds having been probably deposited in different estuaries."

In Mr Duff's "Sketch," Plate III., there is a coloured section of this deposit, which distinctly exhibits the order of the strata, and to which we would refer our readers. Mr Duff divides and enumerates the beds thus, in the ascending order. Lying on the cornstone—1, A red till, the same as again occurs at the top of the Wealden strata; 2, Green-clay; 3, Limestone; 4, Dark blue clay, with fossils; 5, Green-clay; 6, White-band; 7, Limestone; 8, Green-clay; 9, Red till, same as No. 1; 10, The surface soil. He says (p. 61),—"The remarkable alluvial stratum (No. 1) of red till forming the bottom of the series, being easily worked, enables the labourers to undermine the tenacious clay and marl beds above, and to bring them down in masses; were it not present, it would be almost impossible to remove the upper beds from the limestone below." The late Mr Robertson of Woodside and Inverugie, in his valuable note in "Anderson's Guide to the Highlands," 3d edition, p. 348, states, that "the remains obtained from these strata are,—a femur of Trionyx (Prof. Owen); vertebræ of *Plesiosaurus subconcavus*; scales of a species of Semionotus, Lepidotus, Pholidophorus, and Eugnanthus; teeth of *Hybodus Lawsoni*, Duff, and *H. dubius*, Agass.; and of *Sphenonchus Martini*, Agass.; and an Acrodus. The shells are of the genera Melanopsis, Paludina and Planorbis, Ostrea, Avicula, Modiola, Mytilus, Astarte, Unio and Cyclas. There are also valves of Cypris, fragments of carbonized wood, and two or three species of Ferns."

Such, then, being the nature of the deposit itself, and of its contents, a most interesting point is, to determine the character of the red sandy clay stratum (No. 1) on which the undoubted beds of Wealden rest. Dr Malcolmson seems not to have been aware of its differing so much as it does from the beds that lie immediately upon it, and inferred that it was of the same series; and some still continue to think that it is contemporaneous with, and is here the base of, the Wealden. Mr

Duff, however, in 1842, stated that it appeared as if it had been interjected between the Wealden beds and the cornstone. "This bed at first sight might be held to belong to the Wealden, but, on minute examination, it is found to contain not only rounded masses of the cornstone below, but also water-worn portions of the Wealden beds above, thus giving undoubted proofs of its having been an alluvium gathered from both deposits, and introduced between them by means difficult to account for" ("Sketch," p. 16). Mr Robertson, in the note already quoted, says of the same stratum,—"Between the Wealden beds at Linksfield and the subjacent 'Old Red' Limestone, a mass of boulder-loam is intercalated. The surface of the limestone is scratched and polished, and the thickness of the loam varies from an inch or two to about five feet. Besides the usual boulders, the loam contains nearly angular fragments of both the subjacent limestone and overlying Wealden beds, and sometimes includes considerable seams of the clays and limestones of the latter. The Wealden beds have suffered considerable disturbance, and are irregularly curved. In explanation of these appearances, it is supposed that the terminal portion of a vast glacier, in the course of its resistless march, inserted itself between the surface of the underlying limestone and the yielding beds of the Wealden, scratching the former, elevating the latter, and introducing a mass of subglacial detritus (the boulder-loam) beneath them. On the melting of the ice, the Wealden beds would fall down in flexures, force the plastic loam to accommodate itself to their sinuosities, and finally rest upon it, as they actually do. It may be mentioned that M. Agassiz gives his sanction to this hypothesis."

Captain Lambart Brickenden adopts much the same hypothesis. In the "Proceedings of the Geological Society" for June 1851, he gives a ground-plan and sections of this interesting locality. After affording data to show that the intercalated stratum of boulder-clay extends over an area of about twenty acres, and stating that the height of the beds above the limestone is about forty feet, he writes—"That the drift has been forced into the place it now occupies is the opinion generally entertained by those who have examined it; and this appears to be fully sustained by certain peculiarities which the bed discloses, though it is not very easy to conceive the exact manner in which such an extensive and marvellous intrusion was effected. The surface of the boulder-clay, and also the strata between which it has been propelled, is hardened, abraded, and marked with polished striæ, indicating the direction in which the mass has moved." "We can imagine a mass of yielding clay, arrested at the base of an escarpment or outcrop of strata, might have been injected between them, in much the same manner as igneous or molten masses between some of the stratified formations, provided that certain conditions were fulfilled." "I therefore presume that the boulder-clay, having originally accumulated at the base of the oolitic outcrop at Linksfield, and having gained an entrance into the position held by its softer and subjacent beds, had been subjected to the action of vast and extensive masses of ice, which, by continuing to press onwards, the accumulations of clay retained beneath it had, by superior force to that which the oolitic beds could offer in resistance, eventually produced the phenomenon at Linksfield." Since these views were published by their respective authors, another has occurred to some local observers,* namely, that the whole mass of this Wealden at Linksfield, and all the Lias and Oolites found on the southern shores of the Moray Firth, as well as the chalk flints of Peterhead and Delgaty, are but so many boulders transported hither by icebergs from some northern locality. This hypothesis is not only of more general application, but one which, we think, with all its attending difficulties, meets the phenomena at Linksfield as fully as any that has been propounded. Meantime, we trust we have said and quoted enough regarding this interesting locality to arrest the attention of geologists from a distance when they visit this part of the country, and to draw out their opinions, not only of the formation itself, but of the causes that have placed it where it now lies. Small patches, the same as the Linksfield beds, were long ago seen at the edge of the Loch of Spynie near Pitgavenny, and at Waulkmill. In addition to these, Mr Duff mentions, "the bank at the west end of the

* See Mr Martin's paper on the "Northern Drift," vol. iv. p. 223, October 1856.

town of Elgin, on which the house of Maryhill stands, and the bank on which the ruins of the castle of Spynie are situated."

Inverugie, Duffus House, Coulart Hill, and Lhanbryde, are given as localities of the inferior oolite. To the last of these, at the west end of the village, and some hundred yards below where the turnpike road crosses the burn, we well recollect being conducted nearly thirty years ago by the venerable Mr Leslie, late minister of the parish. Having observed some ammonites in a stone used in erecting an adjoining farm-house, and ascertained whence it had been taken, he thus, from his well-known observation and spirit of inquiry, became its discoverer. "Although," writes Mr Duff, "the oolite appears *in situ* only at Lhanbryde, isolated masses are found strewed over the plain, formerly the Loch of Spynie. About twenty-five years ago, the workmen, in cutting the canal intended to drain the lake, touched on a bed of bituminous shale, of which they threw out large quantities, with fragments of that kind of coal called lignite, and in the shale numerous belemnites and ammonites, and occasionally masses of the oolite." Immediately below the church of Urquhart, on the flat between it and Innes House, the same formation has been met with in several spots. From one of them the Rev. Mr Morrison has extracted as fine a suit of fossils as has yet been made from the oolites in this quarter. They are of such number and quality as will enable those versed in this department of science to say whether they more resemble the oolitic forms of the south of the island, or those of more northern regions, as the flints, &c., of Aberdeenshire are said to do.* For this purpose we trust that Mr Morrison will have a series of his specimens ready for inspection by the savans who are to meet next year at Aberdeen. Many of the oolitic masses are unquestionably boulders. It were well that the bases of others of a more doubtful substratum were thoroughly examined, as we think there is much

* "There has also been made an important discovery in Aberdeenshire of Neocomian fossils. It appears that flint and greensand, containing greensand fossils, have been found in that county; and what is still more remarkable, some of the fossils resemble more those of Scandinavia than of Britain. This points to a connection between the northern cretacious system and that of Scotland."—Lord Talbot de Malahide's "Address to the Geological Society of Dublin," 1857.

truth in what that accurate observer, the late Mr Robertson, says,—"Nor is it certain that any of the oceanic members of the oolitic series occur absolutely *in situ.* Detached blocks belonging to several of the divisions, from the superior oolite to the Oxford clay, both inclusive, are found in the boulder loam, as well as in the overlying stratified deposits; and in some places, as near Lhanbryde, they are associated with a sandy gray clay. Their angles are in general but slightly rounded, and they are very abundant in certain localities, from which circumstance it may be inferred that their parent sites are not far distant from the spots where they now rest. The fossils, which have been extracted from these masses, include many new shells; (*Hybodus undulatus*, Ag.), erroneously stated in "Poiss. Foss." to be from Linksfield, and another undescribed tooth of another species of the same genus."

Mr Martin having, so lately as October 1856, laid before the readers of this Journal full and graphic details regarding what is, strictly speaking, the Northern drift, so largely developed in the province of Moray, we need only here remind them that he represents it as ranging from the sea-shore level to the height of 900 feet. He divides it into three portions, —1. In the ascending order, immense deposits of very coarse gravel, chiefly to be seen in the elevated slopes of the hills to the southward. 2. The till, of a reddish colour, very tenacious, and is void of the least appearance of stratification; it is composed of fragments and comminuted parts of the older rocks, and also contains boulders, many of them of immense size. 3. The beds of sand which accompany and overlie the till, and which present undoubted marks of stratification. This last portion, chiefly in the lower parts of the country, forms extensive elongated ridges and wide-spread plateaux. "The remains of no animal or plant, supposed to have been alive when the drift was being deposited, have yet been found in any of its subdivisions in this district." Several distinct and far-extending terraces, or old sea margins, are seen on the surface of the drift, as on the northern slopes of the Manoch and Quarrywood hills. In almost every gorge or valley, through which water has flowed, the debris of the drift, increased by fresh materials from the newly-worn channels, has been moulded and shaped into bluff banks or river-terraces. Shell marl occurs in many places where modern improvement has drained off the fresh waters in which the mollusca that formed it disported themselves; and the bed of the Loch of Spynie, in its alternately showing strata of fresh and marine remains, records the changes that have taken place in bygone eras, when at one time it was an arm of the sea, and at another an inland lake. "All the different kinds of peat," says Mr Robertson, "with the exception perhaps of the maritime species, are met with in Morayshire. In some elevated and exposed mosses, as those of the Brown Moor, which are from 600 to 1100 feet above the sea, the stools and trunks of oak and other trees are found of a size which the climate now existing at such heights in this district does not admit of." "In the autumn of 1849, the horn cores and part of the frontal bone of a large *Bos primigenius* (Boj.), together with the shed horn of a stag, were found in cutting a drain at Westfield. These specimens are now in the Elgin Museum. A little to the west of Burghead there is a submarine forest, which must, from the circumstance of trees being occasionally dragged up by the anchors of ships riding in the bay, extend for a considerable distance beneath the sea. Part of it is exposed at low water. It is a combination of forest, lake, and marsh peat." "Ventose accumulation of sand or dunes are largely developed at Culbin, to the west of the bay of Findhorn, where they have buried an extensive area of what was once the most fertile cultivated land in the county, and attain a height of 113 feet above low-water mark. Similar deposits, though on a less conspicuous scale, are found all along the seaward zone of the district, the sand in some cases, as at Inverugie (as also at Culbin), alternating with seams of vegetable soil."

The extent to which this paper has now reached admits but the simplest notice of these superficial deposits; but we must not close it without giving Mr Robertson's observations on the shingle beaches which have often been remarked as a striking peculiarity of the southern shores of the Moray Firth. "Where the coast is not rocky, as is the case from the western extremity of the county to Burghead, between Craighead and Stotfield, and from Lossiemouth to the Spey, the present beach is bounded by a series of ridges, externally of shingle, but showing rudely saddle-shaped alternations of gravel and shingle when a transverse section is made. The ridges vary in size, and the distances between them are unequal. The breadth to which they extend inland is sometimes, as near Inchbroom, a mile and a half, and their number is occasionally from twenty to twenty-five, as near the Blackhill of Spey. They are in general nearly parallel with the existing coast line; but at Culbin and Speyslaw they are so contorted as in some some places to run at right angles to it. The ridges are due to the piling action of waves during storms. From their mode of distribution they may be regarded as rings of growth, showing the intermittant nature of the elevation of the land. To the east of Hopeman Lodge, and also on a terrace about half a mile west of Craighead, similar series of ridges, though on a smaller scale, are found about forty feet above the present high-water mark." That these ridges are the effect of causes similar in their action to those now in operation, distinctly and strikingly appears from the manner in which the debris, excavated from the harbour at Branderburgh, has been carried westward, laid down and arranged on the shore within the last quarter of a century, by the currents of the Moray Frith. These newly-formed ridges are of such extent and regularity, become gradually more and more water-worn and rounded as we trace them westwards, and at the place where they encounter and cross a spur of hard, flinty, and concretionary sandstone, are so much raised above the level of high water, that they must delight, as a fit study, all who in geology explain past effects by an appeal to present forces, even not excepting their able and acknowleged leader, Sir Charles Lyell.

At the late meeting of the British Association at Leeds, Sir Roderick J. Murchison laid before the Geological Section "The results of his researches among the Older Rocks of the Scottish Highlands;" and in noticing the yellow sandstones of Morayshire, in which the *Telerpeton Elginense* was found, stated his conviction that they are part and parcel of the Old Red or Devonian series. "In exploring the coast range from

Burghead to Lossiemouth, he observed that the strata had been thrown up on an anticlinal, trending parallel to the more inland ridge with the *Telerpeton;* and that whilst the inland ridges are associated with hard sub-crystalline cornstones (limestones) first described by Professor Sedgwick and himself as analogous to the Old Red cornstones of England, so the coast ridge, folding over dips on the sea-shore beneath another band of similar cornstone, which in its turn is overlaid by flag-like deep red sandstone, clearly seen in reefs at low water. In this Morayshire series there is not a trace of a carboniferous plant, and the strata are so bound together by mineral characters and fossil remains that they must be all grouped as Old Red or Devonian."

Since this paper was read at Leeds, we have been fortunate enough to secure and forward to its learned author many specimens of impressions or casts from Findrassie, of footprints from Mason's-haugh quarry, near Cummingston, on the property of C. L. Cumming Bruce, Esq. of Roseisle, &c., M.P., and of veritable plate and bone from Lossiemouth. These specimens are now in the hands of Professor Huxley, who, we understand, has expressed an opinion that they belong to reptiles of a high order. We must still, however, wait for the further elucidation of these interesting relics, and for more details regarding the Old Red formation, as developed on the southern shores of the Moray Firth, until the publication of Sir Roderick's additional memoir, about to be laid before the Geological Society of London.

Having thus brought down the history of discovery to the present day, and stated the opinions now entertained regarding the geology of the lower or northern part of the province of Moray, it remains but to enumerate some of the points which still call for inquiry from resident observers and scientific visitors.

1. What are the geological position and extent, &c., of the crystalline rocks that underlie the undoubted Old Red conglomerates?

2. What relation, if any, does the limestone near Grantown in Strathspey bear to these crystalline rocks?

3. To which of the sections in the Old Red system do the

conglomerates near Tomintoul (Banffshire), and the sandstones of Auchindoir (Aberdeenshire), belong ?

4. The same question may be asked regarding the sandstones of the Nairnshire coast.

5. What account is to be given of the outlying masses of yellow sandstones at Rinninver in Dallas, and on the south-east flank of the Hill of Pluscarden ?

6. What proof is there that our (boulder) oolites, &c., are of the same nature as those of Sutherlandshire, and not of the Scandinavian formations ?

The chief purpose of this paper has been to record what Dr Malcolmson had, twenty years ago, accomplished in the geology of the province of Moray, and to point out to those who may visit this now interesting district the several localities where the different strata can be best studied, and where the various fossils are to be met with. Much remains to be done, for the queries above given could easily be multiplied; and some others have no doubt already suggested themselves to our readers. But of a more local and urgent nature would it be to procure complete, or at least better, specimens of the many singular creatures of which as yet only fragments have been discovered and collected. Of the multitude of scales, bones, and casts, &c., that have been extracted from the Scāāt-Craig, the Findhorn, the Meikle Burn, Findrassie, and Lossiemouth, not a single specimen has appeared or been constructed so as to show in full outline the animal itself.

Even in this utilitarian age, when the exercise of the bodily or mental powers, while not followed by direct and profitable, if not pecuniary, results, is too often regarded with coldness, disrespect, or ridicule, a claim may be urged on this low basis for the support and countenance of the community of the provincial capital for the further elucidation of the local geology. Thus, many foresee that the smaller towns will not be so enlarged and improved by the railway trains running up to and passing them as was at one time anticipated ; and some regard even Elgin in this respect as for the present in a problematical state. Neither a terminus in itself, nor the source of large or varied manufacture, it has mainly to depend on its climate, its society, its schools, its cathedral, for securing for a few

[The following Note, with reference to the foregoing Paper, has been communicated by Sir Robert I. Murchison.]

Additional Notice on the Old Red Sandstone of Morayshire.

From the forthcoming edition of "Siluria," by Sir Roderick Murchison. *(Appendix.)*

Already in 1828 the tract was so far described by Professor Sedgwick and myself, that we not only united into one geological group its lower red conglomerate and sandstone, intervening cornstones, and superior light-coloured sandstones of Elgin, but we further showed that the fish-bearing zone of Caithness was traceable to the south-east of Inverness as a thin course of shale; though we there detected no fishes in it. (Trans. Geol. Soc. Lond., 2 Ser., vol. iii., pp. 147, 150, *et seq.*)

The remains of fishes were not discovered until nine or ten years afterwards; in the first instance, I believe, by Lady Cumming Gordon, so well known to all the readers of the works of Hugh Miller and Agassiz. About the same time, my zealous and able friend Dr J. Malcolmson, then on leave of absence from the East Indies, detected several of the Caithness fishes at Clune and Lethen Bar, in Nairnshire; and, having followed up his discoveries into Morayshire, presented to the Geological Society a detailed memoir descriptive of these tracts in 1839, as stated p. 558. This valuable paper was recommended by myself to be printed in the Transactions of that body; but, as the author spoke doubtingly respecting the genera and species of his fossil fishes, and did not feel himself competent to describe them, it appears, by a reference which I have just made to the records of the Society, that the order for the publication of the memoir was deferred by the Council until Agassiz, the great authority on ichthyolites, should have determined the specific characters of the fossils. In the meantime a clear abstract, giving the main features of the labours of Malcolmson (above referred to, p. 558), was published (Proceedings Geol. Soc. Lond., vol. iii. p. 341); and shortly afterwards that accomplished man, having returned to India, fell a victim to his zeal in pursuing geological researches in the jungles of the Bombay Presidency. Doubtless it is to be regretted that the original memoir was not completed for publication; but the absence of the author, the want of a scientific description of the fossils, and my own occupations during the next five years, when pursuing my researches in Russia, seem to have combined to let the period pass when justice ought to have been done to the field-labours of poor Malcolmson. Every effort will be made to honour his memory.

My respected friend the Rev. G. Gordon, who explored parts of Morayshire and the adjacent country with the deceased, having recently put into my hands the article on this subject before alluded to, which will appear in the January number of 1859 of the "Edinburgh New Philosophical Journal," and in which he gives most of the data ascertained by Malcolmson, as taken from a copy of his memoir, and from letters addressed to him, and, further, expostulates with the Geological Society for their remissness in respect to that memoir,—I take this opportunity, now that I have looked into the subject, and have seen the original paper with its illustrations, of explaining thus fully the circumstances which led to the memoir never having been printed.

In mentioning those persons who, in addition to Hugh Miller, Malcolmson, and others, have done good geological service on the north-east coast of Scotland, I am bound to go as far back even as my own earliest researches of 1826, and to state, that my friend Mr George Anderson, of Inverness, has thrown much light upon parts of his native country, and has been of great use to many an explorer besides myself. Mr Anderson is well known to all tourists as the author of the "Guide to the Highlands," in the third edition of which (pp. 344 to 349, &c.) the reader will find an able summary, by the late Mr Alex. Robertson, of the Geology of the Moray Firth.

days or hours the sojourn of the traveller, and perhaps for ultimately fixing him as a permanent resident. To these attractive objects and motives may now be added the circumstance, that the country around Elgin is yearly rising in the estimation of the scientific world as a good field for the study of an important part of that series of rocks of which the crust of the earth is formed, as well as of other departments of learned research. If a Murchison and an Egerton this autumn deemed their time well spent in examining it, there are doubtless many more to follow on the same instructive ground. The chief object of attraction, or the starting point for such visitors, is the museum, where they naturally expect to find in its specimens not a heterogeneous mass of objects from foreign lands, but rather an outline or epitome of the surrounding country ;—hence a strong reason why this institution, in its local department, should have a large share of civic patronage. We can here but barely hint at other reasons, of a more powerful, lasting, and ennobling nature, such as the diffusing of a taste and affording materials for one of the most rational and laudable recreations to which a person's spare hours could be devoted,—expanding the powers of the mind, and cultivating the habit of correct observation, enlarging the views of creation, and for bringing more fully before the eye the power, the wisdom, and the goodness of Him in whom we live, and move, and have our being.

On the Rude Unsculptured Monoliths, and Ancient Fortifications of the Island of Arran. By Mr John M'Arthur, Partick.

The single erect, and circles of upright stones, so numerously scattered over the Western Islands and mainland of Scotland, England, and Ireland, are to be found in most of the countries of the eastern and western continents.

Of the *single columnar structures* there are many specimens in Arran. Four at one time existed near Brodick Bay, one of which, measuring 14 feet in height, may still be seen by the roadside, and another in a neighbouring field.

On the bank of the river near Slidry, there is a long grave-like mound, distinguished by two large erect stones standing, the one at the head, the other at the foot, at an intervening distance of about 30 feet. This is supposed to be an elongated trench, in which the warriors slain in battle have been buried; tradition claims it as the grave of one of Fingal's heroes.

On the south side of Kirkmichael River there is an erect stone, upwards of 15 feet in height; near its base there was dug up a stone coffin filled with human bones. Similar structures exist at Sannox, Largiemore, Glen Shant, Glen Iorsa, Blairmore, and other parts of the island.

The monolithic *circles* are even more numerous in Arran than the *single* structures. The most remarkable of the former is a group near Tormore, towards the south-west of the island. During the past summer I traced here eight circles, all more or less complete, each consisting of from four to fourteen columns of rude, unhewn sandstone. The stones measure from 3 to 18 feet in height, with an average circumference of 8 feet; the diameters of the circles range from 15 to 30 feet; one of the largest embraces an inner circle of eight stones, the outer consists of fourteen stones, through one of which a small hole has been perforated. Several of these perforated stones have been found in Scotland, and in modern times have been regarded with the most superstitious reverence. Stone *circles*, similar to those above described, existed or imperfectly still exist, in Arran, at Blairmore, Monquil, Glen Sherrig, Monymore Glen, &c.

The *single monoliths* are frequently referred to both in sacred and profane history. Beneath a pillar Jacob buried his beloved Rachel, and Joshua set up a stone in Shechem as a witness of the covenant he there made with the people of Israel.

In primitive times, it was the custom for the newly-elected chief to stand beside a large upright stone, and swear fidelity to the trust reposed in him; thus, "Jehoash was crowned king, standing by a pillar as the manner was." One of these rude Scottish tanist stones (*tanaista*, a thane or lord) not more remarkable for its great antiquity than for its singular history, forms a part of the coronation chair of the British sovereign in Westminster Abbey. In old deeds and charters, erect stones are sometimes referred to, as boundaries or landmarks; and Mr Ure, in his "History of Rutherglen," mentions that it was an old custom for the magistrates of that ancient borough to ride round the *march stones*, which formed the boundaries of the royalty, followed by a pompous procession of councilmen and people.

The erecting of stones to mark the spot of some bloody battle-field; to distinguish the grave of the warrior slain in conflict; and to commemorate some friendly compact between rival chiefs and people, were also ancient customs common to many primitive nations.

Much extravagant speculation has been expended in attempting to assign to the *monolithic circles* the period and object of their construction, whilst the uncertainty and obscurity which still attend the inquiry have been much increased by many antiquaries mistaking for, or confounding with, the *origin* of these circles, the purposes to which they may have been applied in succeeding ages.

The circles in Arran exhibit the three following characteristics, which appear to furnish unquestionable evidence of a *sepulchral origin* :—

1*st*. Their occasional connection with the cromlech (a sepulchral monument) which they enclose.

2*d*. In their neighbourhood, urns and cistvaens have been dug up.

3*d*. The cairn-like peculiarity of their construction.

On removing the moss and earth which covered the areas of the *circles* at Tormore, large stones and boulders were exposed. These I removed to the depth of about 3 to 4 feet, without arriving at the original soil. Farther investigation convinced me that these stones had not been placed there *beneath* the surface soil, but *over* it, and that the accumulating moss had gradually grown up around, until it had reached the level of the superincumbent mound enclosed. Their singular resemblance, indeed, to the British encircled barrow is at once apparent, and it is extremely probable that future systems of archæology will embrace these and other similar *monolithic* *circles* within the class of *sepulchral monuments*, and within the division of encircled tumuli.

Many of the *single* stone structures of Arran possess, in the urn and stone chest, the accompanying proof of their sepulchral origin. Contemporaneous with the custom of rearing the single stone in honour of the distinguished hero, was that of raising over the grave of the illustrious warrior as many stones as he had slain of the foe on the field of battle; and we may not far err in referring to this ancient custom the origin of not a few of the monolithic circles. In comparatively modern times, Ossian indicates the sepulchral circle, when he makes the dying Foldeth exclaim, "Raise the tombs of those I have slain around my narrow house; often shall I forsake the blast to rejoice over their graves, when I behold them spread around with the long whistling grass."

The Ancient Fortifications of Arran.—The most important of these ancient strongholds has been that of Drumidoon, situated on the shore at the south-west of the island. Towards the sea, the cliffs rise to a perpendicular height of about 300 feet. On the land side the ascent is steep, and near the summit there still exist the ruins of a wall, which appears to have surrounded the top from cliff to cliff. Within the enclosed area are the remains of this interesting structure, which are still considerable, though a great portion of the stones have been carried away for the building of dikes and other purposes.

Further south, and near to Slidry, there are the ruins of another fort, known as Torcastle, situated on an artificial mound of about 50 feet in height. The walls are about 4 feet in thickness, and enclose an area of 54 feet in diameter. A small outwork protects the narrow entrance from the land. On some of the stones which fill up the area of the fort being removed some years ago, several human bones were discovered. The natives in the neighbourhood have a tradition, that, in early times, a great battle was fought here.

On the Eastern shore of the island, at Kingcross, Dunfiun, Dounan, Glen Cloy, and North Sannox, there are forts of smaller size; their central area ranging from 15 to 20 feet in diameter, and their walls from 3 to 4 feet in thickness.

These structures (with the exception of Dunfiun) are situated upon low natural or artificial mounds, compactly built, though without cement, of rude unhewn stones.

Many writers indiscriminately assign a Danish origin to these and other primitive strongholds of the Western Islands. That the Danes, during their occupancy of the islands of Scotland, erected several of these buildings is more than probable, but, on the other hand, there is abundant existing evidence to prove that, long ere Roman or Norseman set his foot on Caledonian soil, the rude fortress of the early Britons crowned many of its hills and eminences.

The rudeness of their materials, and the simplicity of their construction, claim for the forts of Arran, or at least for those on its eastern coast, a very early antiquity.

Starting from this position, I have been led to adopt the following theory of their origin, and which may apply in principle to many of the ancient fortifications of the Western Islands and Highlands of Scotland.

The necessity of strongholds as places of defence and attack would naturally arise, when, consequent upon the advance of civilization, the scattered inhabitants of our island formed themselves into communities or tribes.

When invaded by Agricola in the year 81, North Britain was divided into twenty-one tribes, connected by no political tie, but animated towards each other by feelings of jealousy and hostility, which frequently broke out into feuds and open warfare.

The island of Arran and the south-west of Argyleshire were inhabited by one of these tribes called the Epidii, whilst the neighbouring coast of Ayrshire was occupied by a rival and powerful tribe called the Damnii.*

The necessity and advantage, therefore, of a line of forts along the *eastern* coast of Arran are obvious, and an examination of their position proves that they command almost every spot on this side of the island where a landing could be safely effected. Besides, at Clachland promontory, the most easterly point of Arran, there rises from the shore the

* Chalmers's Caledonia.

Hill of Dunfiun, about 1000 feet above the sea-level, upon the summit of which are the remains of a fort, the stones of which bear evidence of vitrifaction. It was scarcely possible for the ancient Epidii of Arran to have selected a more advantageous outpost from which to watch the movements of their unfriendly neighbours, whilst, from its elevation, the "Baal-" fire of alarm lit upon its summit would be observed over the greater part of the island.

The two forts of Drumidoon and Torcastle, already referred to, are the only traces of fortifications to be discovered along the western coast of Arran. They are of larger dimensions, and apparently of modern construction compared with those on the other side of the island.

Whilst the occupation of Cantyre by the same tribe would render the erection of forts on the western coast of Arran unnecessary, the entire absence of such remains is strongly confirmatory of the soundness of the theory which I have above suggested.

The origin of the forts of Drumidoon and Torcastle may belong to the period when the western islands were swayed by the fierce marauders of the north, or they may have been erected, as tradition reports, to repel the landing of the Scoti-Irish, who invaded Cantyre about the beginning of the 6th century.*

What foreign foe may have failed to accomplish, the inroads of time have effected. These early strongholds, which once bristled with the spears and arrows of the ancient islanders, have long since fallen into ruins. "A green mound of earth, a moss-clad stone, lifting through it here and there its gray head, are all that preserve their memory."†

* Skene. † Ossian.

Some Ethnographic Phases of Conchology. By DANIEL WILSON, LL.D., Professor of History and English Literature, University College, Toronto.

The existence of a singular class of rude primitive weapons and implements, made of stone, shell, or bone, in nearly every quarter of the globe, has excited a very general interest of late years among the archæologists of Europe. Made, as these simple relics of primitive art are, of the most readily wrought materials, and by the constructive instincts rather than the acquired skill of their rude artificers, they belong to one condition of man, in relation to the progress of civilisation; though pertaining to many periods of the world's history, and the most widely severed areas of the globe. In one respect, however,—and not in this one alone,—such relics possess a peculiar value to the ethnologist, when searching into the primeval condition of our race. The materials of such infantile processes of manufacture have within themselves most frequently the evidences of their geographical origin, and in some of them also of their chronological eras. Among such relics as serve to fix the geographical centres of ancient arts, the sources of early commerce, or the birth-places of migrating races, might be noted the tin and amber of the Old, and the copper of the New World. So also in minuter analysis, we recognise among primitive American relics the local origin of various favourite materials: as the Mexican obsidian, the clay slate of the Babeens, and the favourite red-pipe stone of the *Couteau des prairies.* But it is to a more widely diffused and greatly varied class of natural products that I now refer, alike in their bearings on the chronological and geographical relations of ancient and living races, and on the affinities traceable between primitive and modern arts and customs.

Among the productions of nature employed as materials for ornament and use, scarcely any have commanded more universal acceptance than the shells which abound, under such varied forms, on every sea coast, as well as in the deposits of fresh-water lakes and rivers. To the conchologist they present an interesting and singularly beautiful department of nature, inviting to research amid their seemingly endless forms, and to inquiry into the habits of the "living will" that once tenanted each lovely cell.

> "Did he stand at the diamond door
> Of his house in a rainbow frill?
> Did he push, when he was uncurl'd,
> A golden foot or a fairy horn
> Thro' his dim water-world?"*

To the geologist the shells of the testaceous molluscs offer a department in palæontology of very wide application and peculiar value. They constitute, indeed, one of the most important among those records which the earth's crust discloses, whereby its geological history can be deciphered. But to the ethnologist and the archæologist also, they have their phases of interest, not unworthy of attention.

Like the precious metals, shells have been used, both in the Old and New World, not only for ornament, but as a recognised currency. Of such the *Cypræa moneta* is the most familiar. The cowry shells used as currency are procured on the coast of Congo, and in the Philippine and Maldive Islands. Of the latter, indeed, they constitute the chief article of export. On the Guinea Coast, and throughout a considerable portion of Central Africa, the cowry is still the current coin. In many parts of India, in Siam, and throughout the Burmese empire, it is universally employed as small change, and has a recognised though fluctuating value. About the middle of last century, 2400 cowries were equivalent, in Bengal, to one rupee, but increasing facilities of intercommunication have tended to multiply them and depreciate their worth. The influence of European civilisation, under British rule, has in many districts displaced the primitive cowry by a copper and a silver currency, while the increasing monetary transactions of the most favoured districts lead to the circulation even of the gold mohur, so that now, in Bengal and similar centres of commercial exchange, it requires nearly an additional thousand cowries to make up the value of the silver rupee.

Corresponding to the cowry currency of Asia and Africa, is

* Tennyson's Maud.

the use by the American Indians of the North West, of the ioqua, a shell found in the neighbouring shores of the Pacific, and employed by them both for ornament and as money. The Chinooks and other Indians wear long strings of ioqua shells as necklaces and fringes to their robes. These are said to be procured only at Cape Flattery, at the entrance of the Straits of De Fuca, where they are obtained by a process of dredging, and have a value assigned to them increasing in proportion to their size. This varies from about an inch and a half to upwards of two inches in length. They are white, conical, and slightly curved in form, and taper to a point. Their circumference at the widest part does not greatly exceed the stem of a clay tobacco pipe, and they are thin and translucent. Mr Paul Kane, writes to me in reference to them: "A great trade is carried on among all the tribes in the neighbourhood of Vancouver's Island, through the medium of these shells. They are valuable in proportion to their length, and their value increases according to a fixed ratio, forty shells being the standard number required to extend a fathom's length. A fathom thus tested is equal in value to a beaver's skin, but if shells can be found so far in excess of the ordinary standard that thirty-nine are long enough to make the fathom, it is worth two beavers' skins, if thirty-eight, three beavers' skins, and so on: increasing in value one beaver skin for every shell less than the standard number."

No evidence has yet appeared to indicate the use of the marine or fresh-water shells of Europe as a species of currency during the era of its primitive barbarism; but it is interesting to notice the fact that the same simple mode of employing the spoils of the sea for personal decoration, as is found prevalent among the rude Indians of the North-West at the present day, prevailed among the primitive occupants of the British Isles in that dim dawn of their primeval history revealed by the disclosures of their most ancient sepulchral deposits. Among the personal ornaments found in early British graves, seemingly pertaining to a period long prior to the acquisition of the simplest metallurgic arts, are necklaces formed of the small shells abounding on the neighbouring coasts, such as the *Nerita littoralis* the *Patella vulgata*, and others equally common at the present day. These are perforated, like the ioqua shells of the Chinook Indian, apparently by the simple process of rubbing the projecting point on a stone, and thus converted into shell-beads, they were strung together with a fibre or sinew. It may also be noted that, as among the savage Indians of the American continent such personal ornaments are not confined to the squaws, but more frequently adorn the person of the brave, and mingle with the scalp-locks and other war trophies of the most celebrated chief: so was it with the allophylian savage of Britain's primeval centuries. Bead necklaces occur alongside of the stone war-hatchet and flint lance-head, as the property of the warrior, and one of his most prized decorations. Possibly, indeed, they may have constituted symbols of rank, and the special badge of office, as considerable variety marks their forms. An Orkney stone cist, for example, contained about two dozen of the common oyster-shells, each perforated, and in all probability designed to be strung together as a collar, abundantly noticeable for size, if not for beauty. In some cases, these shells, as well as those of the limpet (*Patella vulgata*), and the cockle (*Cardium commune*), are taken advantage of to form a novel shell-ornament. They are rubbed down until they are reduced to rings, which were either strung together, or attached, as ornaments, to the dress. Underneath a large cromlech, accidentally discovered in the Phœnix Park at Dublin, in 1838, in the process of levelling a mound, which thus proved to be an ancient tumulus, two male skeletons were found, and beside each skull lay a quantity of the common littoral shells (*Nerita littoralis*). "On examination," it is noted in the report of the Royal Irish Academy, "these shells were found to have been rubbed down on the valve with a stone, to make a second hole, for the purpose, as it appeared evident, of their being strung to form necklaces; and a vegetable fibre, serving this purpose, was also discovered, a portion of which was through the shell." Alongside of these also lay a knife, or arrowhead, of flint, and a small fibula of bone, but no traces of metallurgic arts.

Sir Thomas Brown has remarked in one of his quaint, beautiful fancies: "Time conferreth a dignity upon the most trifling thing that resisteth his power;" and as the uses to which the primitive British savage applied the commonest and least attractive of the shells of his island coasts, for the purposes of personal adornment, confer an interest on them for us, as illustrations of the universal prevalence of certain innate ideas which may almost be characterized as instincts in man: so, too, may we discover, even in the rudest traces of primeval culinary arts, some glimpses of forgotten truths, that will help to illuminate the past history of the human race. Amid the widening clearings of the American continent, where the natural forest still bounds the horizon, and the rude Indian savage who once found in it his free hunting-grounds, has not entirely disappeared, it requires no great stretch of imagination of the colonist to picture to his own mind what the researches of the archæologist have disclosed relative to Europe's primeval human era. From evidence of a very varied kind, it has been deduced that, many ages prior to the earliest authentic historical notices, the British Islands were occupied by a human population, even more imperfectly furnished with the means of coping with the difficulties and privations of savage life than the rude tribes of the north-western wilds. Nor was it man alone that then existed in a savage state. Searching amid the records of that debatable land to which the geologist and the antiquary lay equal claim, we learn that vast areas of the British Islands were covered at that remote era with the primitive forest; that oaks of giant height abounded where now the barren heath and peat-bog cumber the land; and that even, at a period recent when compared with that primeval era, the fierce Caledonian bull, the wolf, and the wild boar, asserted their right to the old forest glades. The scanty human population was thinly scattered along the skirts of this continuous range of forest, occupying the coast and river valleys, and retreating only to the heights, or the dark recesses of the forest, when the fortunes of war compelled them to give way before some more numerous or warlike rival tribe. Thus confined to the open country along the coasts and estuaries, the products of the sea, and especially the edible mollusca, formed no unimportant source for their precarious supplies of food.

Among the interesting illustrations of that common transitional ground on which the geologist and the archæologist meet, few have attracted greater attention than the celebrated Kent's Hole Cave, near Torquay, Devonshire. It has furnished many of the latter palæontological specimens which now enrich the collections of the British Museum; and to its disclosures both Buckland and Owen have acknowledged their obligations for some of their most important data. The roof of the cave is clustered with pendant cones of stalactite, and the floor thickly paved with concretions of stalagmite, the accumulations of many centuries. Beneath, and embedded in this, have been found numerous relics of primitive savage life, intermingled with the remains of the rhinoceros, the hyena, and great cave-tiger, *Felis* and *Hyena spelæa*, the *Ursus spelæus* or cave bear, along with those of other extinct mammals. Among these, though in more superficial deposits, lay traces of the rude culinary practices, illustrative of the habits and tastes of the primeval British savage. These are minutely described in the notes of the Rev. J. McEnery, by whom the cave was first explored. Fragments of sun-baked primitive pottery of the rudest description, rounded slabs of slate of a plate-like form, broken and calcined bones, charcoal and ashes, all served to show where the hearth of the old barbarian Briton had stood; and along with these lay, dispersed, flints in all conditions, from the rough pebble as it came out of the chalk, through the various stages of progress, on to the finished spear and arrow-heads and hatchets of flint—indicating that the ancient British troglodyte had here his workshop as well as his kitchen, and wrought the raw material of his primitive manufactures into the requisite tools and weapons of the chase. Other articles, including lance-heads, bodkins, and objects of unascertained uses,—hair-combs or netting tools,—all made of bone, lay amid the accumulated chips and splinters of flint and bone; while nearer the mouth of the cave lay a larger collection of shells of the mussel, limpet, and oyster, indicating that the ancient British aborigines found their precarious subsistence from the alternate spoils of the chase and of the sea. Nor were indications wanting of just such applications of the pearly inner laminæ of the oyster and other shells for the purposes of ornament, as may be observed in the grotesque inlaid carvings of the Polynesian savage at the present day. The like traces of the primitive habits of the aboriginal allophyliæ of the northern parts of the British mainland and the neighbouring islands have been noted. On exploring one remarkable example of the subterranean stone dwellings of the ancient population of the Orkneys,—opened by my friend Lieutenant Thomas, R.N., and a party of the Admiralty Survey Service in 1848,—the remains of the charcoal and peat-ashes of the long-extinguished hearth lay intermingled with bones of the horse, ox, deer, and whale; and also with some rude implements illustrative of primitive Orcadian arts; while a layer of shells of the oyster, escallop and periwinkle, the common whelk, the purpura, and the limpet, covered the floor and the adjacent ground, in some places half a foot deep. Of these, the limpet, though common on the coast, formed only a very small proportion of the whole; while the periwinkle was the most abundant. The relative accumulations of the other shells,—differing as they did from the present ratio of the various mollusca on the neighbouring shores,—in like manner furnish some slight index of the culinary taste of the aboriginal Briton in those long-forgotten centuries.

It is curious and instructive thus to note even so small a matter as the tastes of the rude barbarian Briton of these past centuries, for they supply a means of comparison between the very diverse races of the British Islands in remotely ancient and modern times. The periwinkle is now annually shipped in large quantities from the Scottish coasts to supply the markets of the British metropolis; and at the recent meeting of the British Association at Dublin, Mr Patterson read a paper before the zoological section, tending to show that such is the demand for that favourite mollusc that it is in danger of being extirpated on the Irish coasts. The quantity of Littorina, (littoral periwinkles) shipped at Belfast during the four previous years, according to the returns of the Secretary to the Harbour Commissioners of that port, amounted in 1853 to 1034 bags, containing 181 tons; in 1854 to 2626 bags, or 459½ tons; and in 1855 to 2286 bags, or 400 tons; while in 1856 it fell off to 786 bags, or 137 tons. The diminished exports of the last year have not arisen from any decrease in the demand. Such of the mollusca as are not procured for this export trade in the Bay of Belfast are principally collected on the coasts of the county of Down; but the banks from which they were formerly derived are no longer capable of supplying the market, and the deficient quantity is at present brought from Stranraer to Belfast, and thence re-shipped to London. But the attention of the scientific zoologist must now be turned to the habits of these and others of the favourite mollusca, and to the circumstances and seasons in which their ova are developed, otherwise they will speedily be classed among those extinct species which have owed their extirpation to the presence and influence of man.

By such facts the remote past is brought once more into intimate relation with the present; and even in matters so apparently trivial as the nice discrimination of the palate between the *Patella vulgata* and the *Turbo littoralis,* we thus detect a correspondence between the tastes of the rude aboriginal savage of primeval centuries, and the civilized Anglo-Saxon of the British metropolis; though now, as then, it is as a popular favourite, and not as a coveted delicacy, that the periwinkles, and also the larger *Buccinum undatum* or waved whelk, are imported into London, and gathered on the Scottish and Irish coasts.

At Skara, near the House of Skaill, in the west mainland of Orkney, one of a singular class of stone structures, designated *Picts' Houses,* is remarkable for an immense accumulation of ashes around it, several feet in thickness, plentifully mixed with shells, and the horns and bones of deer and other animals. The building itself has been only very partially explored, but many curious relics have been recovered from the surrounding debris. Among these are circular discs of slate, similar to those found in Kent's Hole Cave, a large tusk of a wild boar, horns of the red deer, and numerous implements made of horn. But not the least curious of these primitive relics was a box—already referred to—constructed of stones laid together, in the form of a miniature cist, within which lay about two dozen oyster shells, each pierced in the centre with a hole about the size of a shilling. Oysters, it may be remarked, are rare in

Orkney. They now occur only at two places, Deersound and Frith, the nearest of which is eight miles distant from Skaill; while the osteological remains which accompanied them are those of long extinct Orkney mammals. There is no tradition of the presence either of the deer or the boar in the Orkney Islands, unless the names of the Deerness headland and the neighbouring sound be assumed as topographical memorials of the presence of the former within Norse or Saxon times. It is scarcely possible, indeed, to conceive of the existence of such *feræ naturæ* for any length of time, within so small an area, after the occupation of these islands by a human population.

At a period which may be assumed as greatly more modern than the era of those singular subterranean dwellings of primitive centuries, we once more meet with extensive accumulations of oyster shells, with those of the cockle and mussel, among the miscellaneous remains on Romano-British sites of the first centuries of the Christian era, alongside of bones and tusks of the British boar, and of other extinct animals, deer and oxen—the latter the *Bos longifrons,* which appears to have been the domesticated ox of early Celtic times. But such Roman deposits of the shells of British mollusca are no longer confined to coast stations; as indeed might be anticipated when it is remembered that the voluptuous Roman esteemed the oysters of the British seas so great a delicacy, in comparison with those of his own Mediterranean shores, as to transport them to Italy to add a new zest to his luxurious board. Pliny records the high estimation in which the British oyster was held at Rome; and Juvenal has satirized the excessive refinement of the epicurean taste which could discriminate between the oyster of the Kentish coast, and those of Circæan sands or rocky Leucrine shores:—

> "Circæis nata forent, an
> Lucrinum ad saxum, Rutupinove edita fundo,
> Ostrea, callebat primo deprendere morsu;
> Et semel adspecti littus dicebat echini."—Sat. IV., l. 140.

It may also be noted that the shell of the common snail is found in such quantities on Roman sites, and occasionally also in Anglo-Saxon graves, as to lead to the belief that it constituted another choice delicacy at the tables of those successive colonists of Celtic Britain.

Considerable interest has been excited among Danish antiquaries, in recent years, by the explorations of large accumulations of the shells of mollusca, met with at various points on the coast of Denmark. These, which were at first regarded merely as natural deposits, the remains of the abundant fauna of the neighbouring seas, have proved on examination to come within the province of the archæologist, and special steps have been taken to secure their thorough investigation. Within them have accordingly been found implements of bone, pottery, hatchets formed of stags' horns, &c.; and in one examined by the distinguished Danish antiquary, Mr Worsaae, chiefly consisting of oyster-shells, he found numerous skulls and bones of animals, flint celts and arrow-heads, bones broken, as has been supposed, for the purpose of extracting the marrow, charcoal, and other traces of the early occupants of the Danish coasts.

Similar accumulations of the shells of a species of *Ampullacera*, largely eaten by the New Zealanders, have been observed, along with various marine and other debris, including relics of native art, on deserted sites along the New Zealand shores, although they have not hitherto attracted more than a passing notice. But a greater interest has been excited by extensive deposits of marine shells on different points of the North American coasts, accompanied with evidence of artificial accumulation, not likely to escape the attention of those who in the New World watch with so keen an eye for the slightest traces of an ante-Columbian history. The abundant and large-sized edible mollusca of the North American sea-coasts could not fail to attract the notice of an improvident and savage people, dependent on the precarious products of the chase. Large banks of fossil shells occur in many localities, where the changes in the relative levels of sea and land have left these at considerable elevations, and far removed from the modern beach. On such a bed of shells, of the *Gnathodon*—formerly a favourite food of the Indians—the city of Mobile is built; and amid these natural accumulations of older centuries, occasional indications of the former presence of the American aborigines have been met with on the site of the modern city. But the following narrative, by Sir Charles Lyell, in his second tour in the United States, furnishes an interesting illustration of primitive American traces of ancient culinary tastes and habits, analogous to those of Europe already referred to. Describing his journey through a part of Georgia, and his explorations of the lagoons of the Altamaha, Sir Charles remarks: "We landed on the north-east end of St Simon's Island, at Cannon's Point, where we were gratified by the sight of a curious monument of the Indians, the largest mound of shells left by the aborigines in any one of the sea islands. Here are no less than ten acres of ground, elevated in some places ten feet, and, on an average, over the whole area, five feet above the general level, composed throughout that depth of myriads of cast-away oyster shells, with some mussels, and here and there a mediola and helix. They who have seen the Monte Testaceo, near Rome, know what great results may proceed from insignificant causes, when the cumulative power of time has been at work, so that a hill may be formed out of the broken pottery rejected by the population of a large city. To them it will appear unnecessary to infer, as some antiquaries have done, from the magnitude of these Indian mounds, that they must have been thrown up by the sea. In refutation of such an hypothesis, we have the fact that flint arrow-heads, stone axes, and fragments of Indian pottery have been detected through the mass. The shell-fish heaped up at Cannon's Point must, from their nature, have been caught at a distance, on one of the outer islands; and it is well known that the Indians were in the habit of returning with what they had taken, from their fishing excursions on the coast, to some good hunting ground, such as St Simon's afforded." This remarkable "Monte Testaceo" of the New World is interesting to us as one of the melancholy memorials of its aboriginal races, already vanished, or hastening to extinction; while in this case the edible treasures of the deep, unlike those of the cleared forests, still remain to supply the means of subsistence, or to furnish coveted luxuries for the tables, of the old Indian's supplanters.

Another interesting class of illustrations of the subject in hand might be derived from tracing, in the diverse applications of convenient or graceful univalve and bivalve shells to purposes of ornament or use, affinities in the tastes and ideas of man under the most diverse social conditions, and in ages widely remote from each other. In the mother-of-pearl work, and other applications of shells in modern ornamentation, we have examples of art which find their analogous types in the rudest traces of primitive taste and artistic skill. Still further, in the adaptation of many beautiful marine shells as brooches, jewel cases, drinking cups, bowls, and lamps, and even as reliquaries and fonts, we may study the matured development of such applications of these spoils of the ocean to the purposes of personal adornment or of convenient use. But it would tempt us into too wide a field to illustrate all such economic and artistic adaptations of shells from the *Fusus antiquus*, still used as a lamp in the humblest cottages of the Zetlanders, to the varieties of the exquisitely graceful, and often richly jewelled, nautilus cup, or to the *Tridacna gigas* employed in churches for benitiers or holy water stoups, and the still larger bivalve, the *Chama gigas*, which may be seen tastefully adapted, not only as the basin for the ornamental garden fountain, but even as the singularly appropriate and beautiful baptismal font.

Among the charges of medieval heraldry, the scallop shell (*Pecten Jacobæus*), plays a prominent part as the ancient badge of pilgrimage. Fuller, in his *Church History*, repeatedly refers to such heraldric bearings; noting, for example, in his own quaint way, in reference to the arms of St James' Abbey, Reading—*azure, three scallop shells, or*,—"Here I know not what secret sympathy there is between St James and shells, but sure I am that all pilgrims who visit St James of Compostella in Spain (the paramount shrine of that saint), returned thence *obsiti conchis*, all beshelled about on their clothes, as a religious donative there bestowed on them." On another occasion the old Church historian suggests no unlikely origin for the escallop as the pilgrim's badge, noting in reference to the Dacres Arms (*gules, three scallop shells argent*),—"Which scallop shells (I mean the nethermost of them, because most concave and capacious), smooth within, and artificially plated without, was ofttimes cup and dish to the pilgrims in Palestine, and thereupon their arms often charged therewith." But though the scallop undoubtedly came to be adopted as the general badge of the palmer, its true heraldic symbolism is referred to St James the Great; whence its designation as St James's cockle shell, *coquille de S. Jacques*, and *Pecten Jacobæus;* and its strict ecclesiastical significance was as the memorial of pilgrimage to the shrine of St James of Compostella. Southey has translated from the *Annales de Galicia*, the ancient legend of the *Sanctoral Portugues*, relative to the origin of St James's cognizance, and the miraculous conversion of a Paynim knight of Portugal to the Christian faith; the truth of which legend is avouched by the bulls of three successive Popes, which empower the Archbishops of Compostella to excommunicate all who sell the scallop shells to pilgrims except in the city of Santiago. A still more extraordinary and miraculous legend of "Saint Cock and the Holy Hen of Compostella," derived from the *Acta Sanctorum*, and other equally authentic sources, forms the subject of the metrical tale to which the poet Southey has appended the notes above referred to in vindication of Santiago of Galicia's exclusive right to the scallop badge.

> "The poor with scrip, the rich with purse,
> They took their chance for better or worse,
> From many a foreign land,
> With a scallop shell in the hat for badge
> And a pilgrim's staff in hand.
>
> "For the scallop shows, in a coat of arms,
> That, of the bearer's line,
> Some one in former days hath been
> To Santiago's shrine."

For the adoption of the cognizance of St James of Compostella as the general badge of pilgrimage, the scallop not only took its place in the arms of various religious houses, as well as of individual palmers and crusaders of rank; but it was adopted among the insignia of more than one medieval order, and as such re-appeared in a form analogous to the more ancient collars and necklaces of primitive British graves. The Knights of the Order of St Louis, instituted by the royal crusader, Louis IX., received, from their escallop badge, the title *Du Navire et des Coquilles*;" and those of St Michael, another French order instituted by Louis XI., wore a golden collar of scallop shells, and thence were styled "*Chevaliers de la Coquille*."

To the absence of all knowledge of the metallurgic arts among primitive nomade tribes, or to the want of the metals themselves, as among the natives of the Australasian Archipelago, may be ascribed many of the economic uses to which sea shells have been so widely applied. They illustrate in a striking manner the adaptability of man to the most varied physical conditions of the globe, and frequently exhibit the imperfectly developed reasoning faculties of the savage, working within narrow limits, akin to the instincts of the lower animals. Thus we find curious accidental affinities between the rude primitive arts of the European savage in the dim dawn of the ancient world's prehistoric centuries, the equally rude arts of the Carib or the Guanche of the Antilles when brought to the knowledge of the old world in the fifteenth century, and the simple devices of the Polynesians occupying the volcanic, or coral islands of the Southern Ocean, first visited by Europeans in the eighteenth century. Owing to the absence, on many of the islands of the Australian Archipelago, not only of metals, but even of stone and wood, marine shells form the most important available material alike for economic utility and ornament; and the same appears to have been the case, to a great extent, among the Indians of the Antilles in ante-Columbian centuries. The extreme beauty of many of the marine productions of the tropics and the Southern Ocean, sufficiently accounts for their adoption for personal adornment, as in the case of the *Cypræa aurantia*, or beautiful orange cowry, of which specimens are rarely to be met with undrilled, owing to its use as a favourite ornament of the natives of the Friendly Islands. But these spoils of the ocean acquire an additional value, when, as in Central Africa, or among the American Indians around the head waters of the Mississippi, they have all the added virtues which rarity confers. Dr Livingston, when leaving the Belondas after a brief sojourn among them, thus records his friendly parting with their chief,—"As the last proof of friendship, Shinte came into my tent, though it could scarcely contain more than one person, looked at all the curiosities, the quicksilver, the looking-glass, books, hair brushes, comb, watch, &c., &c., with the greatest interest; then closing the tent, so that none of his people might see the extravagance of which he was about to be guilty, he drew out from his clothing a string of beads, and the end of a conical shell, which is considered, in regions far from the sea, of as great value as the Lord Mayor's badge is in London. He hung it round my neck, and said, "There, now, you have a proof of my friendship." My men informed me that these shells—a species of Conidæ—are so highly valued in this quarter as evidences of distinction, that for two of them a slave might be bought, and five would be considered a handsome price for an elephant's tusk worth ten pounds." But even more curious is it when such sea-wrought treasures are found employed not as the ornaments, but as the substitutes for dress, as among the natives of Darnley Island, an island of volcanic origin, off the coast of New Guinea, visited by Her Majesty's ship Fly in 1842–6. The natives are described as fine, active, well-made fellows, rather above the middle height, of a dark brown or chocolate colour. "They had frequently almost handsome faces, aquiline noses, rather broad about the nostrils, well-shaped heads, and many had a singularly Jewish cast of features. * * * They were entirely naked, but frequently wore ornaments made of mother-of-pearl shells, either circular or crescent-shaped, hanging round their necks. Occasionally, also, we saw a part of a large shell, apparently a cassis, cut into a projecting shield-shape, worn in front of the groin." Among these islanders also, the larger sea shells have to perform the functions which are so abundantly provided for, in the Western Archipelago, by the calabash. Their adaptability for this purpose, indeed, naturally suggests such an application of them wherever they abound, as in the case of the *Buccinum dolium*, frequently in use by the fishermen and mariners of the tropics as a convenient utensil with which to bale their boats. So in like manner the graceful trumpet-like form, and richly variegated colours, of the larger species of the

Tritons, such as the beautiful *Triton variegatus*, render their early and independent application as horns or musical instruments, alike by the islanders of the Pacific and the Carribean Sea, sufficiently natural and obvious.

Though the rude natives of the Antilles, when first visited by the Spaniards, possessed some natural advantages over the inhabitants of the volcanic and coral islands of the Pacific, yet the large marine shells with which the neighbouring seas abound, constituted an important source for the raw material of their primitive implements and manufactures. The great size, and the facility of workmanship of the widely diffused *Pyrulæ*, *Turbinella*, *Strombi*, and others of the larger shells, have indeed led to their application, wherever they abound among uncivilized nations, to numerous purposes elsewhere supplied from other sources. Of these the Charibs made knives, lances, and harpoons, as well as personal ornaments; while the mollusc itself was sought for and prized as food. The *Strombus gigas* is still fished for the table, off the island of Barbadoes, and numerous ancient weapons and implements made from its shell have been dug up on the island. Pearls also, of a beautiful pink colour, are occasionally formed by this shell-fish, and from their rarity are greatly valued; while the modern adaptation of the ancient cameo-engraver's art to shells, as well as their employment in the production of the finer porcelain and miniature statuary, have led to those beautiful marine products of the American tropics being more sought after in Europe for the manufacture of personal ornaments and other works in the highest class of art, even than the coveted secretions of the *Meleagrinæ*, brought from the pearl fisheries of Ormus or Ceylon, or from the Bahrein Islands in the Persian Gulf.

Thus the necessities of man in the savage state, and the ever-varying devices to gratify the luxurious exactions of civilization, have equally contributed to the ingenious application of the shells, and other products of molluscous animals, to the use of man. Under this head we might refer to the *Murex traunculus* of the Mediterranean, the source, as is believed, of the celebrated Tyrian purple of the ancient world; and to others of the genus *Purpura*,—such as the *Purpura* *lapillus*,—which have also been turned to use by the dyer. The various pearl-producing species of the *Meleagrina*, in like manner, illustrate the refinements and excesses of ancient and modern luxury. The orient pearl of the Egyptian queen, "the treasure of an oyster," and the occidental pearl of Philip II., from St Margaritas, the pearl island of the New World, which weighed 250 carats, and was valued at 150,000 dollars; or, again, the still more costly pearl of Louis XIV., brought from Catifa on the Arabian Coast, by his eccentric protégé, Jean Baptiste Tavernier, the son of an Antwerp engraver, whom the Grand Monarch created Baron d'Aubonne, and who paid for his Arabian pearl the almost incredible sum of L.110,000. Great as are the sums still annually expended on the produce of the pearl fisheries for the gratification of eastern and western luxuriance of ornamentation, the Antwerp adventurer has secured the palm for the licentious Court of Louis le Grand. The most abundant annual pearl harvest in the world is believed to be the product of the Bahrein Island fisheries, in the Persian Gulf; but the revenue of this falls somewhat short of L.100,000 sterling, even in the most prolific years. Pearls to the value of from forty to sixty thousand pounds sterling are annually imported into Britain. France and other countries of Europe also receive large annual importations of the same costly marine production; while oriental luxury absorbs a still greater amount. Ingenious means are accordingly resorted to for supplying the enormous demand. The Chinese practise one successful mode, by inserting into the living animal a silver wire with a nucleus for the pearl to form upon. Still further improving on this process of making the living pearl-mussel an obedient worker in their service, they not only produce pearls of various sizes and qualities by the introduction of pieces of wood, baked earth, &c., into the living animal, which it covers with the nacrous deposit which converts them into marketable pearls; but also small metal figures of Buddha, in the sitting posture in which the divinity is usually pourtrayed, are treated in a similar manner. These miniature pearl-encased penates are highly valued by the Chinese as charms, and produce large prices. But while thus dwelling on the prolific pearl productions of southern seas, it must not be forgotten that Britain has also her pearl-producing bivalve. The river pearl-mussel (*Unio margaritiferus*), is found in various Scottish rivers, but chiefly in the Tay. There was formerly an extensive pearl-fishery extending from Perth to Loch Tay, and the pearls sent from thence from 1761 to 1764 have been estimated in value at L.10,000. Single pearls are still procured from the Tay, which readily sell at from one to two pounds sterling.

The discovery of the economic use of the larger *Strombinæ* as an important material in the manufacture of porcelain, as well as the introduction of the practice of working camei on these shells, and the increasing demand for this beautiful and artistic class of personal ornaments, have united to create a novel trade in the gigantic tropical shells. Immense quantities of the *Strombinæ* are now annually brought to Europe; and so many as 300,000 shells of the *Strombus gigas* and *Strombus pugilis* have been imported from the Bahamas to Liverpool alone in a single year.

Theory of Linear Vibration—(concluded). By Edward Sang, Esq., F.R.S.E.

VI.—*Alligated Vibrations.*

The slightest attention to the phenomena of sound is enough to convince us that few, if any, sounds are occasioned by a solitary impulse. Sounds arise, last, and cease with their causes. As long as the string of a harp vibrates, the sound endures; so soon as the vibration of the string is arrested, the sound ceases. The continuous application of a disturbing cause, seems to be essential to the production of such aërial pulsations as affect our organs of hearing; and it seems also that the viscidity (so to call it) of the air is so powerful as to arrest the internal vibration of its particles almost as soon as the disturbing cause has passed away, while it is not so powerful as to prevent the transmission of part of the influence to the adjoining particles.

In order, then, to prepare for a discussion of the phenomena of sound, we must investigate the effects of a disturbing cause applied, not for a minute interval of time, but continuously and perseveringly to an elastic system. This we may do by supposing one or more of the points of the system to be compelled to move in some peculiar way by an extraneous influence. Such a supposition introduces an entirely new element into our formulæ, and therefore, for the purpose of rendering the investigation as general as possible, I shall resume it at the beginning.

In addition to the bodies A, B, C, ... K, L, M, which are free to obey the attractions by which they are solicited; let there be another set of bodies, R, S, T, &c., moving each according to its own determinate law, and attracting the bodies of the first set with intensities proportional to their distances, and to certain coefficients of attraction. Then the equations of motion become

$$\begin{aligned} \mathrm{A}_{2t}x_{\mathrm{A}} &= \overline{\alpha\varrho}\,(x_{\mathrm{R}}-x_{\mathrm{A}}) + \overline{\alpha\sigma}\,(x_{\mathrm{S}}-x_{\mathrm{A}}) + \overline{\alpha\tau}\,(x_{\mathrm{T}}-x_{\mathrm{A}}) + \&c. \\ &\quad + \overline{\alpha\beta}\,(x_{\mathrm{B}}-x_{\mathrm{A}}) + \overline{\alpha\gamma}\,(x_{\mathrm{C}}-x_{\mathrm{A}}) + \overline{\alpha\delta}\,(x_{\mathrm{D}}-x_{\mathrm{A}}) + \&c. \\ \mathrm{B}_{2t}x_{\mathrm{B}} &= \overline{\beta\varrho}\,(x_{\mathrm{R}}-x_{\mathrm{B}}) + \overline{\beta\sigma}\,(x_{\mathrm{S}}-x_{\mathrm{B}}) + \overline{\beta\tau}\,(x_{\mathrm{T}}-x_{\mathrm{B}}) + \&c. \\ &\quad + \overline{\alpha\beta}\,(x_{\mathrm{A}}-x_{\mathrm{B}}) + \overline{\beta\gamma}\,(x_{\mathrm{C}}-x_{\mathrm{B}}) + \overline{\beta\delta}\,(x_{\mathrm{D}}-x_{\mathrm{B}}) + \&c. \\ &\quad \&c. \qquad \&c. \qquad \&c. \quad . \quad . \quad (100.) \end{aligned}$$

and on multiplying these by the indeterminates *a*, *b*, *c*, &c., and collecting, we obtain

$$\begin{aligned} & a\mathrm{A}_{2t}x_{\mathrm{A}} + b\mathrm{B}_{2t}x_{\mathrm{B}} + c\mathrm{C}_{2t}x_{\mathrm{C}} + \&c. = \\ & x_{\mathrm{R}}\left\{a\,.\,\overline{\alpha\varrho} + b\,.\,\overline{\beta\varrho} + c\,.\,\overline{\gamma\varrho} + \&c.\right\} \\ & + x_{\mathrm{S}}\left\{a\,.\,\overline{\alpha\sigma} + b\,.\,\overline{\beta\sigma} + c\,.\,\overline{\gamma\sigma} + \&c.\right\} + x_{\mathrm{T}}\left\{\&c.\right\} \\ & + x_{\mathrm{A}}\left\{-a\,.\,\Sigma\overline{\alpha\varrho} + \overline{\alpha\beta}\,(b-a) + \overline{\alpha\gamma}\,(c-a) + \&c.\right\} \\ & + x_{\mathrm{B}}\left\{-b\,.\,\Sigma\overline{\beta\varrho} + \overline{\alpha\beta}\,(a-b) + \overline{\beta\gamma}\,(c-b) + \&c.\right\} \\ & + \&c. \qquad \&c. \qquad \&c. \quad . \quad . \quad (101.) \end{aligned}$$

The second member of this equation consists of two sets of terms; the first containing the ordinates of the extraneous bodies R, S, T, and the other containing the ordinates of A, B, C, &c.

If a, b, c, &c., be now determined so as to render the coefficients of ${}_{2t}x_A$, ${}_{2t}x_B$, &c., proportional to those of x_A, x_B, &c.; that is, if

$$a\mathrm{A}\,.\,\mathrm{R} = -a\Sigma\overline{a\varrho} + \overline{a\beta}\,(b-a) + \overline{a\gamma}\,(c-a) + \&c., \quad (102.)$$

and similarly of the others, we shall have

$$ {}_{2t}\Big\{a\mathrm{A}\,.\,x_A + b\mathrm{B}\,.\,x_B + c\mathrm{C}\,.\,x_C + \&c.\Big\} = $$
$$ x_R\,\Sigma a\,.\,\overline{a\varrho} + x_S\Sigma a\,.\,\overline{a\sigma} + \&c. $$
$$ +\mathrm{R}\Big\{a\mathrm{A}\,.\,x_A + b\mathrm{B}\,.\,x_B + c\mathrm{C}\,.\,x_C + \&c.\Big\} $$

which, in respect to its integration, may be put under the form

$$ {}_{2t}\mathrm{X} = \varphi t + \mathrm{R}\,.\,\mathrm{X} \quad \ldots\ldots \quad (103.)$$

This equation can be integrated, when the function φt contains only integer positive powers of t, and also when its derivatives recur.

Now the equations (102) are n in number, so that the equations in R, obtained by eliminating a, b, c, &c., from them must rise to the n^{th} power; there are then n ways in which equation (108) may be produced, so that we shall ultimately have as many equations as will determine all the unknown quantities x_A, x_B, x_C, &c., at any future time, when the state of the system at the instant $t=0$ has been given.

Without insisting farther on this branch of the inquiry, I proceed to apply this method to a linear series A, B, C, ... K, L, M, of which the first is attached to a body W by means of a spring, of which the coefficient of elasticity is $\overline{a\omega}$; the body W being compelled to move in a prescribed manner by extraneous influences.

The equations of motion, analogous to equations (37), are

$$ \mathrm{A}\,.\,{}_{2t}x_A = \overline{a\omega}\,(x_W - x_A) + \overline{a\beta}\,(x_B - x_A) $$
$$ \mathrm{B}\,.\,{}_{2t}x_A = \overline{a\beta}\,(x_A - x_B) + \overline{\beta\gamma}\,(x_C - x_B) $$
$$ \ldots\ldots\ldots\ldots $$
$$ \ldots\ldots\ldots\ldots $$
$$ \mathrm{L}\,.\,{}_{2t}x_L = \overline{\varkappa\lambda}\,(x_K - x_L) + \overline{\lambda\mu}\,(x_M - x_L) $$
$$ \mathrm{M}\,.\,{}_{2t}x_M = \overline{\lambda\mu}\,(x_L - x_M) + \overline{\mu\mu}\,(x_M - x_\mu) \quad \ldots \quad (109.) $$

whence, using the multipliers a, b, c, &c., we have

$$aA_{2t}x_A + bB_{2t}x_B + cC_{2t}x_C + \&c. =$$

$$a \,.\, \overline{\alpha\omega} \,.\, x_W + x_A \left\{ \overline{\alpha\omega}\,(0-a) + \overline{\alpha\beta}\,(b-a) \right\}$$

$$+ x_B \left\{ \overline{\alpha\beta}\,(a-b) + \overline{\beta\gamma}\,(c-b) \right\}$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$+ x_L \left\{ \overline{\kappa\lambda}\,(k-l) + \overline{\lambda\mu}\,(m-l) \right\}$$

$$+ x_M \left\{ \overline{\lambda\mu}(l-m) - \overline{\mu\mu}(m-m) \right\} \quad . \; . \qquad (110.)$$

and we have now to determine a, b, c, &c., so as to satisfy the conditions

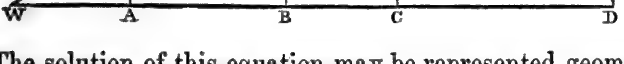
$$\overline{\alpha\omega} \,.\, 0 + (\theta^2 A \mp \overline{\alpha\omega} + \overline{\alpha\beta})a + \overline{\alpha\beta}\, b = 0$$

$$\overline{\alpha\beta} \,.\, a + (\theta^2 B \mp \overline{\alpha\beta} + \overline{\beta\gamma})b + \overline{\beta\gamma}\, c = 0$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\overline{\kappa\lambda} \,.\, k + (\theta^2 L \mp \overline{\kappa\lambda} + \overline{\lambda\mu})l + \overline{\lambda\mu} \,.\, m = 0$$

$$\overline{\lambda\mu}\, l + (\theta^2 M \mp \overline{\lambda\mu} + \overline{\mu\mu})m + \overline{\mu\mu}\, m = 0 \quad . \; . \quad (111.)$$



The solution of this equation may be represented geometrically, as was done for that of (40). Having measured off the distances WA, AB, BC, &c., inversely proportional to the coefficients $\overline{\omega\alpha}$, $\overline{\alpha\beta}$, $\overline{\beta\gamma}$, &c., we begin with two ordinates erected at W and at A, but in this case the ordinate at W is zero. If θ^2 were zero, the line Wabc, &c., would be straight, but on giving to θ a small value, that line bends down to become more and more nearly parallel to the axis; and when such a value of θ is reached as makes the part mm' parallel to MM′, we have the first root of the equations (111). If the value of θ go on increasing, the line W*abc*, &c., will come to cross the axis between A and M; becoming concave upwards when on the under side of the axis, the line may have its last portion *mm'* again parallel to MM', and this will indicate the second root of the equation. In this way, by augmenting θ, we shall obtain altogether as many roots as there are bodies A, B, ... L, M.

For each one of these values of θ we shall have equation (110) under the form—

$$_{2t}X = a \,.\, \overline{a\omega}\, x_{W} - X\theta^2 \quad . \; . \; . \; . \; . \quad (112.)$$

When the series of bodies is uniform, the coefficient $\overline{a\omega}$ being supposed equal to $\overline{a\beta}$ or to e, the equations become

$$-a\theta^2 = \frac{e}{w}\left\{0 - 2a \;+ b\right\}$$

$$-b\theta^2 = \frac{e}{w}\left\{a - 2b \;+ c\right\}$$

$$. \; . \; . \; . \; . \; . \; . \; .$$

$$-l\,\theta^2 = \frac{e}{w}\left\{k - 2l \;+ m\right\}$$

$$-m\theta^2 = \frac{e}{w}\left\{l\; - 2m + m'\right\} \quad . \; . \; . \; . \quad (113.)$$

Here if we put $2 - \frac{w}{e}\theta^2 = 2\cos 2\varphi$, and if we assume the first ordinate a to be $\sin 2\theta$, which is allowable since one of the multipliers may be arbitrarily assumed, we have

$$\begin{aligned} a &= \sin 2\varphi \\ b &= \sin 4\varphi \\ c &= \sin 6\varphi \\ &. \; . \; . \; . \; . \; . \\ m &= \sin 2n\varphi \\ m' &= \sin \overline{(2n+2)}\varphi \quad . \; . \; . \; . \; . \quad (114.) \end{aligned}$$

and therefore the solution is obtained whenever $m = m'$; that is, when

$$\sin 2n\varphi = \sin\,(2n+2)\varphi,$$

which can only be when $(2n+1)\varphi$ is an uneven multiple of $\frac{\pi}{2}$;

therefore, for the first root of the equation we must have

$$\varphi=\frac{1}{2n+1}\,\frac{\pi}{2}$$

and the values of φ for the succeeding roots must be odd multiples of this, so that for the ν^{th} root we must have

$$\varphi_\nu=\frac{2\nu-1}{2n+1}\,\frac{\pi}{2}$$

$$\theta_\nu{}^2=4\frac{e}{w}\,(\sin\varphi_\nu)^2.$$

The aggregate equation of motion thus becomes

$$_{2t}\left\{\sin 2\varphi\,.\,x_{\text{A}}+\sin 4\varphi\,.\,x_{\text{B}}+\sin 6\varphi\,.\,x_{\text{C}}+\&\text{c.}\right\}$$

$$=\frac{e}{w}\,.\,\sin 2\varphi\,.\,x_{\text{W}}-4\,\frac{e}{w}\,\sin\varphi^2\left\{\sin 2\varphi\,.\,x_{\text{A}}+\sin 4\varphi\,.\,x_{\text{B}}+\&\text{c.}\right\}$$

or as, for convenience, it may be more shortly written

$$_{2t}\text{X}=\frac{e}{w}\sin 2\varphi\,.\,x_{\text{W}}-4\frac{e}{w}\sin\varphi^2\,.\,\text{X}.\quad .\quad .\qquad (115.)$$

If we now suppose that the point W is compelled to oscillate, by some influence foreign to our system, and that the law of its oscillation is

$$x_{\text{W}}=r\sin(\varrho t+\sigma.)\quad .\quad .\quad .\quad .\quad .\quad .\qquad (116.)$$

equation (115) becomes integrable.

The general equation

$$_{2t}\text{X}=\text{P}\sin(\varrho' t+\sigma)\mp\text{Q}^2\text{X}\quad .\quad .\quad .\qquad (117.)$$

has its integral of the form

$$\text{X}=\text{X}_0\cos\text{Q}t+{}_{1t}\text{X}_0\frac{\sin\text{Q}t}{\text{Q}}$$

$$+\frac{\text{P}}{\varrho'^2-\text{Q}^2}\left\{\sin\sigma\,.\,\cos\text{Q}t+\frac{\varrho'}{\text{Q}}\cos\sigma.\sin\text{Q}t-\sin(\varrho' t+\sigma)\right\}\ (118.)$$

in which X_0 and ${}_{1t}\text{X}_0$ are the values of X and of its first derivative at the instant of time $t=0$.

This value of X represents the compound of two oscillations, viz., one made with the angular velocity Q, due to one of those vibrations of the system

M, L, ... B, A, W, A, B, ... L, M,

in which the middle body W remains at rest: the other, made with the angular velocity ϱ, belonging to the motion of the compelling body W.

This integral, however, is inapplicable when the two velocities of oscillation are equal to each other, for then the denominator $\varrho^2 - Q^2$ is zero. In this particular case, the equation is

$$_{2t}X = P \sin (Qt + \sigma) - Q^2 X \quad . \quad . \quad . \quad . \quad (119.)$$

and its integral takes the form

$$X = X_0 \cos Qt + {}_{1t}X_0 \frac{\sin Qt}{Q}$$
$$- \frac{P}{2Q^2} \left\{ Qt \, . \cos (Qt + \sigma) - \cos \sigma \, . \sin Qt \right\} \quad (120.)$$

which represents an oscillation augmenting in extent with the lapse of time. Whenever, then, the time of oscillation of the compelling body W happens to agree with one of the alternate oscillations of the system,

M, L, ... B, A, W, A, B, ... L, M,

the extent of the vibrations of the system goes on augmenting without limit.

The leading phenomena of such alligated oscillations may be best studied by taking the cases in detail.

Case I.—*One Alligated Body.*

To begin with the simplest possible case, let the single body A be attached to the oscillating mass W; and, for the sake of comparison, let the law of oscillation of W be expressed by the equation

$$x_W = r \sin \left(t\varrho\sqrt{\frac{e}{w}} + \sigma \right)$$

then the equation of motion of A becomes

$$_{2t}x_A = \frac{e}{w} r \sin \left(t\varrho\sqrt{\frac{e}{w}} + \sigma \right) - \frac{e}{w} x_A \quad . \quad . \quad (121.)$$

which gives, in all cases when ϱ is not equal to unit, the integral

$$x_A = \left\{ x_0 + \frac{r \sin \sigma}{\varrho^2 - 1} \right\} \cos \left(t\sqrt{\frac{e}{w}} \right) + \left\{ {}_{1t}x_0 \sqrt{\frac{w}{e}} + \frac{r\varrho \cos \sigma}{\varrho^2 - 1} \right\}$$
$$\sin \left(t\sqrt{\frac{e}{w}} \right) - \frac{r}{\varrho^2 - 1} \sin \left(t\varrho\sqrt{\frac{e}{w}} + \sigma \right) \quad . \quad . \quad . \quad . \quad (122.)$$

From this it is seen that the motion of A is composed of two oscillations, one of them in the time due to the elasticity of the spring, and the other in unison with the oscillation of the compelling body. The magnitude and epoch of the first oscillation depend partly on the condition which we may suppose the system to have been in at the epoch $t=0$, and partly on the magnitude of the oscillation of the body W. If the body A had been at rest in its mean position, when the oscillation of W came to act upon it, the two terms x_0 and ${}_{1t}x_0$ would both be zero, and the remaining terms would exhibit purely the effect of bringing suddenly such an oscillation to bear upon A. That part, then, of the motion of A which is due to the impulse of the oscillating body W is expressed by

$$(x_A)=\frac{r}{\varrho^2-1}\left\{\sin\sigma\cos\left(t\sqrt{\frac{e}{w}}\right)+\varrho\cos\sigma.\sin\left(t\sqrt{\frac{e}{w}}\right)\right.$$
$$\left.-\sin\left(t\varrho\sqrt{\frac{e}{w}}+\sigma\right)\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (123.)$$

If we assume λ such an angle that

$$\varrho\tan\lambda=\tan\sigma$$

$$(x_A)=\frac{r}{\varrho^2-1}\left\{\sqrt{\left(\sin\sigma^2+\varrho^2\cos\sigma^2\right)}\sin\left(t\sqrt{\frac{e}{w}}+\lambda\right)\right.$$
$$\left.-\sin\left(t\varrho\sqrt{\frac{e}{w}}+\sigma\right)\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad , \quad . \quad (123.)$$

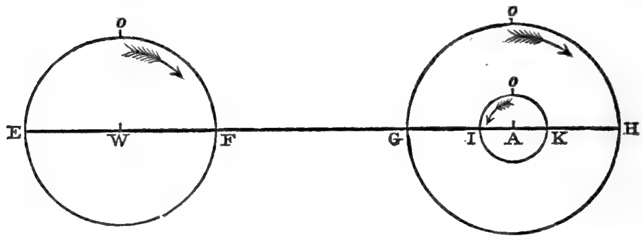
The most remarkable feature of this formula is, that the extents of the oscillations are inversely proportional to ϱ^2-1; so that when ϱ is unit, that is to say, when the time of oscillation of the compelling body W is equal to that of the oscillation of A, the extents of the resulting oscillations become infinite, and although, in this very case, another form of integral must be taken, still when ϱ is very little different from unit, the extents of the oscillations must be very large; and we are naturally led to inquire how the alligation of the moving body W to the end of the spring which is attached to A can, all at once, as it were, communicate a motion to A much more extended than the motion of W.

The phases of the phenomena depend, to a certain extent, upon the value of σ: let us begin by assuming $\sigma=0$; that is to say, let the body W impinge, with its full velocity, upon the end of the spring. Then

$$\sigma = 0$$

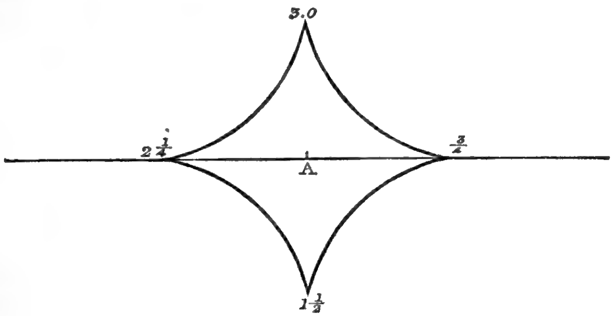
$$[x_A] = \frac{r}{\varrho^2 - 1} \left\{ \varrho \sin\left(t\sqrt{\frac{e}{w}}\right) - \sin\left(t\varrho\sqrt{\frac{e}{w}}\right) \right\} \quad . \quad (124.)$$

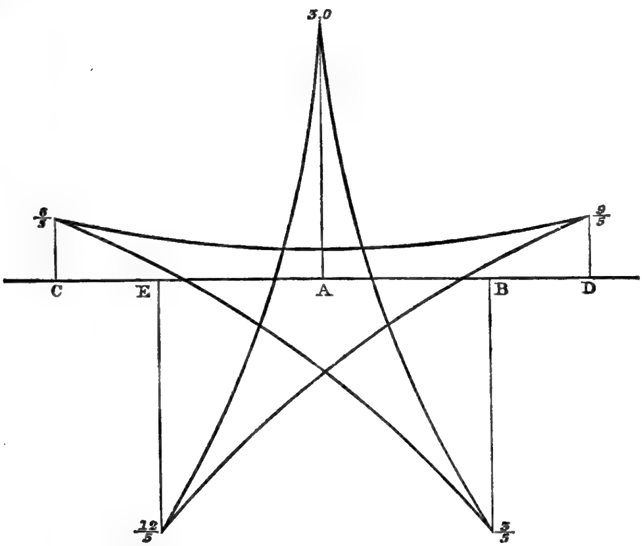
so that the motion of A is, in this case, composed of two oscillations, the extents of which are inversely proportional to the angular velocities with which they are performed, or are directly proportional to their periodic times.



Let A be the mean position of the body A, AW the length of the spring to which it is attached; let also E, F, on either side of W, be the extreme limits of the oscillation of W, so that having described round W a circle with the radius WE, the uniform motion of a point in the circumference of that circle may represent, being transferred to EF, the oscillations of W. The time of a complete oscillation of the body A, when urged by the spring WA (supposed to be held fast at W), being taken as a standard, let the time of oscillation of W be $\frac{1}{\varrho}$, then if we make $AG = WE\frac{1}{1-\varrho^2}$, and $A1 = WE\frac{\varrho}{1-\varrho^2}$, the circles described round A with the two radii AG and AI will represent the two oscillations of which the motion of A is compounded; W and A being the positions of the two bodies at the instant, $t=0$; W having then its full velocity, and A being at rest.

When ϱ is less than unit (in the above figure, ϱ is taken as $\frac{1}{3}$), the motion in the several circles are as represented by the arrows. Now the angular velocities in the two circles GH and IK being inversely as the radii, it follows that the linear velocities must be alike: and therefore, two points starting from 0 and 0 in these circumferences, the one to the right, and the other to the left, will have at first equal velocities, estimated in the directions AH and AI, so that the sum (algebraically) of the two will be zero. If we transfer the centre of the circle IK to the circumference of the circle GH, supposing the motions to be carried on as before, the abscissæ of the epicycloid produced by the combination of the two motions, will represent the successive positions of the vibrating body A.





$\Upsilon=1,\ \varrho=\frac{3}{5},\ \sigma=0,\ {}_{1t}x_0=0;\ x_0=0.$

Since the linear velocities in the two circumferences are alike, the epicycloids must be cusped, and the apices of the cusps must lie in a circle having its radius equal to the sum or to the difference of the two radii, according to the arrangement of the figure.

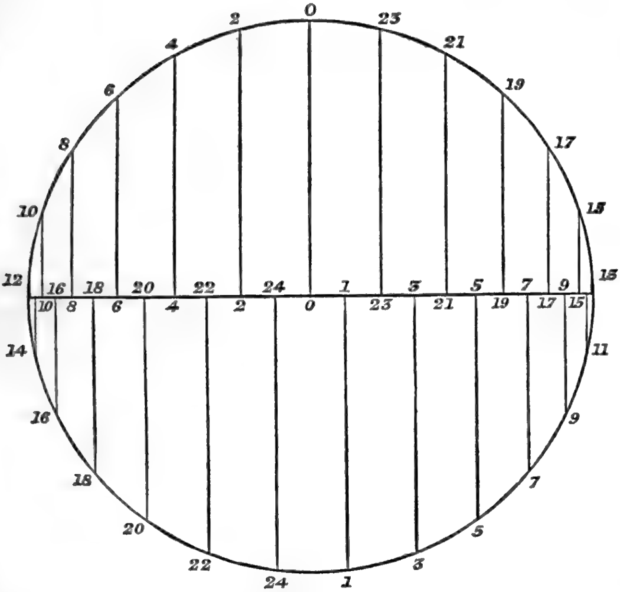
The first of the adjoining figures represents the epicycloid for the value of $\varrho = \frac{1}{3}$. Starting from the point marked 0, the tracing-point passes along the first branch of the curve, reaches the point marked $\frac{3}{4}$, after a lapse of time equal to $\frac{3}{4}$ of the time of the fundamental oscillation, or to one-fourth of the time of the oscillation of W: thence it proceeds along the second branch in the same way—its velocity augmenting from the cusp to the middle of the branch, and then decreasing to zero at the next cusp. The body A, then, accompanying the ordinate of the tracing-point, oscillates from the point marked $\frac{3}{4}$ to that marked $2\frac{1}{4}$, but not smoothly; it makes, as it were, a halt in the middle.

The second figure shows the phases of the vibration of A when $\varrho = \frac{2}{3}$: the radii of the partial oscillations are, in this case, $\frac{9}{5}r$ and $\frac{6}{5}r$, and the cusps are reached at intervals equal to $\frac{3}{5}$ of the time of the fundamental oscillation, or $\frac{2}{5}$ of the time of the oscillation of the compelling body W. Starting from its mean position A, the oscillating body reaches B, where its velocity is zero; thence it starts across to C, where it is again brought to rest, having made a much larger oscillation than before. From C it takes a still longer sweep, reaching D as far on the other side of its mean position; thence it goes to E, whence it returns merely to pause at A on its onward progress to B.

When the value of ϱ approaches to unit, the radii become greater, and each branch of the epicycloid stretches over nearly one-half of the circle; and thus we see how, when ϱ is almost unit, the very extensive oscillations indicated by the formulæ are reached to by successive steps.

Thus when $\varrho = \frac{12}{13}$, the successive resting-places of the body A are obtained by dividing the circumference of a circle into 25 equal parts, and by following the chords of 13 of those parts, as shown by the successive numbers in the adjoining figure, and then by letting fall ordinates from these points.

When ϱ comes to be exactly unit, we must use the form of



integral given in equation (120). In this case (121) takes the more simple form

$$ {}_{2t}x_A = \frac{e}{w} r \, . \sin\left(t\sqrt{\frac{e}{w}} + \sigma\right) - \frac{e}{w} x_A, \quad . \quad . \quad . \quad (125.) $$

and its second integral becomes

$$ x_A = x_0 \, . \cos\left(t\sqrt{\frac{e}{w}}\right) + {}_{1t}x_0 \sqrt{\frac{w}{e}} \, . \sin\left(t\sqrt{\frac{e}{w}}\right) $$

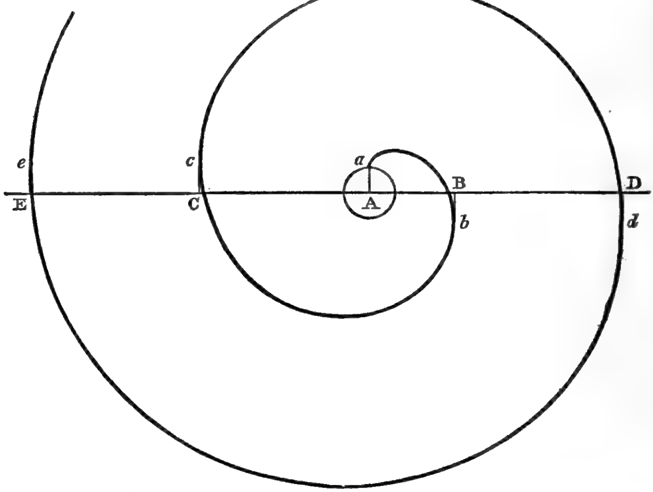
$$ - \frac{r}{2} \, . \, t\sqrt{\frac{e}{w}} \, . \cos\left(t\sqrt{\frac{e}{w}} + \sigma\right) + \frac{r}{2} \cos\sigma \, . \sin\left(t\sqrt{\frac{e}{w}}\right) \, . \, . \quad (126.) $$

and this, adapted to our present case, in which x_0, ${}_{1t}x_0$, and σ are all taken as zeroes, becomes

$$ [x_A] = \frac{r}{2} \left\{ \sin\left(t\sqrt{\frac{e}{w}}\right) - t\sqrt{\frac{e}{w}} \, . \cos\left(t\sqrt{\frac{e}{w}}\right) \right\} \, . \, . \quad (127.) $$

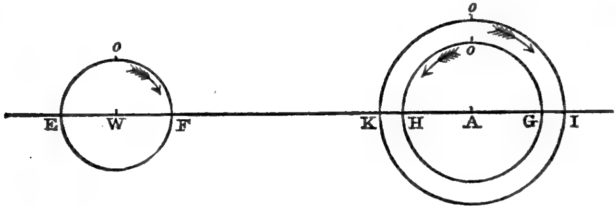
which is the equation to the involute of a circle having its radius $\frac{r}{2}$, and its involved arc $\left(t\sqrt{\frac{e}{w}}\right) \times \frac{r}{2}$.

Having described a circle with the radius A*a*, equal to half the radius of the oscillation of the body W, construct the involute of that circle, then the ordinates B*b*, C*c*, D*d*, &c., applied to touch the curve at its successive half turns, mark out the limits of the successive oscillations of the point A.



The motion thus indicated is the limit to which that shown by the preceding figure tends as the value of ϱ approaches more and more closely to unit; and the infinite magnitudes of the radii are represented by the endless extension of the involute. In such a case, the oscillations of A would go on increasing without limit, being continually instigated by the oscillation of W.

When the value of ϱ exceeds unit, that is, when the oscillation of W is more rapid than that which the spring would induce in A, the sign of the denominator ϱ^2-1 changes, so that the bodies A and W are on opposite parts of the oscillation represented by $r \sin\left(\varrho t\sqrt{\frac{e}{w}}\right)$: as ϱ continues to increase, the radii AG and AI of figure, page 66, decrease, while AI has be-



come the greater of the two. The adjoining figure shows the arrangement of the motions when $\varrho = \frac{4}{3}$.

As the vibration of W becomes very rapid, the radii AG and AI become minute, AG more particularly so; and thus we see that the intervention of a soft spring WA almost destroys the effects which a rapid vibration in W has upon A.

I have hitherto only considered minutely those cases in which the epochal angle σ is zero, and might now proceed to consider the results of giving different values to it; but there is hardly any general principle to be illustrated by such a proceeding; it may be enough to remark, that when the sine of σ is not zero, the linear velocities in the two circumferences are not alike, and that, therefore, the epicycloid cannot be cusped—it must either be nodated or waved; and also to indicate, that when $\sigma = \frac{\pi}{2}$, the two circles have equal radii for all values of ϱ.

When a series consisting of two or more parts is acted on by an oscillating body W, the investigation of the various movements becomes much more intricate on account of the superposition of vibrations having their periodic times incommensurable. The investigation, however, of the separate vibrations is more simple, and leads to the detection of a very beautiful general law.

On substituting for x_{w} its value

$$x_{\text{w}} = r \sin\left(t\varrho\sqrt{\frac{e}{w}} + \sigma\right)$$

in equation (115), and then taking the integral, we obtain

$$\begin{aligned} \mathrm{X} = \mathrm{X}_0 \cos\left(2t \sin\varphi\sqrt{\frac{e}{w}}\right) &+ \frac{{}_{1t}\mathrm{X}_0}{2\sin\varphi}\sqrt{\frac{w}{e}}\,.\sin\left(2t\sin\varphi\sqrt{\frac{e}{w}}\right) \\ + \frac{r\sin 2\varphi}{\varrho^2 - 4\sin\varphi^2}\Bigg\{ &\sin\sigma\,.\cos\left(2t\sin\varphi\sqrt{\frac{e}{w}}\right) \\ &+ \frac{\varrho}{2\sin\varphi}\cos\sigma\,.\sin\left(2t\sin\varphi\sqrt{\frac{e}{w}}\right) \\ &- \sin\left(t\varrho\sqrt{\frac{e}{w}} + \sigma\right)\Bigg\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (128.) \end{aligned}$$

which represents one of n similar conditions which must subsist among the n quantities x_A, x_B, &c. These equations (128), then, are just sufficient to determine the positions of the bodies A, B, C, &c., at any future time, if the condition of the system at the time $t=0$ be given. Each one of these equations indicates an oscillation performed with the angular velocity due to the particular value of ν, combined with another oscillation synchronous with that of the compelling body W.

From the form of these equations, it is obvious that all these oscillations, the periodic times of which depend on the elasticity of the system, are distributed among the various members of the series, precisely as they would have been if the body W had been kept at rest.

But each of these equations contains a term

$$-\frac{r \sin 2\varphi}{\varrho^2 - 4\sin\varphi^2} \sin\left(t\varrho\sqrt{\frac{e}{w}} + \sigma\right),$$

of which one factor, viz., $\sin\left(t\varrho\sqrt{\frac{e}{w}} + \sigma\right)$, is common to all, but of which the other factor varies from one equation to another, according to the value of ν; therefore this oscillation is not distributed among the several bodies in the same manner as any of the others is.

The true character of this vibration may be best studied by returning to the more general form of the problem.

Suppose that B, C, D are three bodies of the series, connected with the springs $\overline{\beta\gamma}$, $\overline{\gamma\delta}$: that the body B is kept oscillating according to the law

$$x_B = b \sin(t\theta),$$

it is required to investigate the conditions necessary that while D is also kept vibrating in a similar manner, C may also oscillate synchronously with them.

The elementary equation of motion

$$C \,.\, {}_{2t}x_C = \overline{\beta\gamma},\ (x_B - x_C) + \overline{\gamma\delta}\,(x_D - x_C)$$

at once takes the form

$$\overline{\beta\gamma}\, b - (\overline{\beta\gamma} + \overline{\gamma\delta} - \theta^2 C)\, C + \overline{\gamma\delta}\, d = 0,$$

by help of which any one of the three quantities b, c, d, may be found from the other two; and into which the only weight which enters is that of the middle body C.

Let the motion of the body W be given by the equation and $x_w = r \sin(\theta^t)$, suppose that the extent of the oscillations of A is also given; then from these two, r and a, we can obtain b, from that c, and so on, until we arrive at m, which represents the extent of the oscillation of M, the last body in the series. If, while W is kept oscillating according to the above law, M is also made to oscillate so that $x_M = m \sin(\theta t)$, then, provided the intermediate bodies have been all started properly, the elasticities of the intervening springs will keep them ever after oscillating synchronously.

If, now, it happen that on pushing the operation one step farther the value of m' should come out exactly equal to m, then the elasticity of the spring $\overline{\mu\mu}$ would never be called into action, so that no extraneous influence would be needed to keep M in motion.

In order to determine how an oscillation performed with the angular velocity θ must be distributed among the members of an elastic series, of which the last body is M, we have only to assume two equal values m' and m, and thence to compute backwards the appropriate values of $l, k, \ldots . b, a$, and r; and thus we ascertain the proportions which the extent of the oscillations of the various bodies A, B, C, &c., bear to that of the oscillation of the compelling body W.

When it happens that r comes out zero, the oscillations of the bodies A, B, C, &c., must be infinite in extent, as compared with that of W, and this is in accordance with equations (128), for, in such a case, one of the denominators

$$\varrho^2 - 4 \sin \varphi^2$$

has become zero.

Let, then, the body W, attached by the spring $\overline{\omega\alpha}$ to an elastic system A, B, C, &c., be made to oscillate very slowly; that is, let the value of θ be very minute: the quantities $m, k, l \ldots$ would be nearly equal to each other, and the whole system would move slowly backwards and forwards with W: but with any real value of θ, the motions of the various parts of the system would be unequal. Considering, for the moment, only that part of the general vibrations which is synchronous with the motion of W, we observe that, as the oscillation of W becomes more rapid, the extent of this vibration becomes greater, until, when θ has reached the first value which is consistent with the vibration of the system when attached to a fixed point W, the vibration becomes infinite, and is represented in kind by the abscissæ of the involute of a circle. When θ passes this limit, the extent of the vibration decreases, and the epochs of W and M are separated by half a revolution; that is, the value of x_M is maximum, when the value of x_W is minimum. This diminution reaches its limit when θ is between the first and second roots of equation (111); and as θ nears the second root, the extent of the vibration again augments to become infinite. When θ is between the second and third roots, the epochs of W and M are again coincident.

Thus it seems that whenever the periodic time of the oscillation of the compelling body W agrees with any of the odd vibrations of the double series

M, L, ... B, A, W, A, B, ... L, M,

it induces oscillations of infinite extent.

But, along with the synchronous vibration, the action of the oscillating body W creates as many other vibrations as there are bodies in the system, and the periodic times of these are, in general, incommensurable with each other; so much so, that certain very special conditions would need to subsist among the constituents of the system, in order that the ratios of these periodic times may be expressible in integer numbers. In every uniform series, these periodic times, being inversely proportional to the successive chords of the multiples of an aliquot part of the circumference, are incommensurable, and hence the periodic recurrence of any phase of vibration is impossible.

When, in order to attempt the investigation of the velocity of sound, we supposed the system to be at rest, and to receive a sudden blow on one end, the resulting formula showed that every vibration of which the system is susceptible would be called into action. The determination of the extents and epochs of these was a matter of enormous difficulty, requiring the resolution of equations involving the sines of incommensurable arcs. These extents and epochs can only be obtained, in each individual case, by the method of trial and error, and even when obtained, they leave a much more formidable difficulty behind, namely, to determine what particular phase of the motion is to be regarded as indicative of the transmission of the impulse to the other end of the series.

When, instead of receiving a solitary blow, we suppose one end of a quiescent series to be suddenly subjected to the action of an oscillating body W, the inquiry is very greatly simplified; for if, in equations (128), we put X_0, and its first derivative *zero*, the remaining terms give at once the extents and epochs of all the simple oscillations of which the actual vibration is composed, and we are able to predict the exact condition of the system at any future time by direct calculation.

These equations, with the change in the form of the integral which must be made when the periodic time of W agrees with that of any of the internal vibrations, contain the complete solution of the problem "*To determine the effects of an extraneous oscillation upon a linear elastic series,*" without either redundancy or deficiency; but they leave us quite as much in the dark as ever concerning what constitutes the transmission of an impulse from one end of the series to the other.

The methods of infinitesimal analysis yet known are quite inapplicable to this question, for if we suppose the bodies A, B, &c., to be subdivided into parts acting on each other, we multiply the number of internal vibrations, and complicate instead of simplifying the inquiry; for it is to be remarked, that not a single one of the elementary vibrations can be left out of consideration, without vitiating the conclusions. If we imagine a finite series to consist of an infinite number of infinitely minute parts, the slower vibrations, or those which we may suppose to be appreciable by our organs of sensation, will have their periodic times sensibly as the numbers 1, 3, 5, 7, &c., because the chords of very small arcs are very nearly proportional to the arcs themselves; but we cannot, on that account, neglect the infinite number of quicker vibrations, nor can we conceive of any criterion whereby to decide on what classes of vibrations may be neglected and what not, even if it were possible to neglect any.

No more can the method of development in series be brought to our aid; for, if we attempt to represent the compound motion of any one of the bodies by a series arranged according to the powers of t, we find the periodic times of the oscillations accompanying t as divisors, so that the summation of the series becomes impossible, except by help of the angular calculus.

This difficulty arises from the multitude of elementary vibrations: singly, the characters of each one of these can readily be investigated by the infinitesimal process.

On comparing the result of this analysis with the phenomena of sound, we have to remark, that if an infinite elastic series, consisting of infinitely small parts, be acted on by an extraneous oscillation, the periodic time of that oscillation will agree with that of some one of the infinite number of internal oscillations of which the series is capable, and that, therefore, the extent of the induced oscillations must go on augmenting indefinitely with the time. But we do not observe that the intensity of a note increases with the time during which a sounding body acts; or rather, it is a common matter of observation, that so long as an organ-pipe is sounded with a uniform force of wind, the strength of the sound remains the same.

Again, the ear is sensible only of vibrations isochronous with those of the sounding body: yet if the air be perfectly elastic, we cannot doubt that all manners of vibrations would be induced by the local disturbance of its repose, and among these there must be some not far different in point of periodic time from that of the note produced; yet the effects of such vibrations are not perceived. Besides, it clearly results from our investigation, that that part of the compound vibration of a linear series which is isochronous with the inducing oscillation is also synchronous with it.

Now, according to the usually received ideas, sound consists in a series of waves or pulsations proceeding from the sonorous body, so as to induce, in the successive particles, vibrations isochronous with those of the exciter, but gradually deferred as to their epochs. This, indeed, is the basis of Newton's reasoning, as well as the fundamental proposition of the Wave Theory of Light. Yet the above strict and complete analysis of the motions of a perfectly elastic linear series shows most conclusively that no such pulsation can arise from the action of an extraneous oscillation, or can be consistent with it. And although we be unable to carry the same strictness of reasoning into the case of a non-linear elastic system, we have no symptoms of any such progressive vibration, for, under all circumstances, the constituent motions of our imaginary planetary system are synchronous.

If any such pulsations do occur in air, it must be in connection with some quality altogether distinct from elasticity; there must be, in the mutual attractions and repulsions of the parts, some deviation from that law which has been supposed, and which is, indeed, the only law under which the periodic times of the vibrations can be independent of their extents.

From the suddenness with which vibrations cease, when their exciting cause is removed, we may infer that viscidity, or what may be called imperfect elasticity, has to do with the actual phenomena; and perhaps, if we could investigate the effects of this viscidity, we might find that it is sufficient to explain the known appearances, and even to account for progressive undulation. But until this investigation shall have been completed, or the hitherto unknown quality of air shall have been discovered, we can only class aërial and luminous pulsations among imagined or imaginary phenomena. And, in the present state of our attainments, we can only confess that no approach has been made to any theoretical determination of the velocity of sound, or of the characters of those vibrations which convey sound through the air.

The advocates of the undulatory theory of light imagine a highly elastic etherial medium to pervade all space, and hold that the undulations of this medium occasion what we call light. From this hypothesis the supposition of imperfect elasticity is altogether excluded; the rectilineal motion of light, as contrasted with the devious propagation of sound, being accounted for by supposing the elasticity of this fancied medium to be altogether perfect. The luminousness of a body consists in a tremor among its particles; and this tremor is communicated to the surrounding ether, just as the vibrations of a harp-string are diffused in the air. Granting all of these positions, our first step, in reasoning from them, is to investigate the manner in which the tremor of the luminous body affects the particles of the ether. Now neither this investigation, nor any approach to it, has yet been made. All the difficulties of it are overleaped at once, and we arrive at undulations or waves of light. Knowing nothing of how the vibratory motion of a single particle affects the particles around it, we yet are able, if not by reasoning, at least by bold hypothesis, to predict the manner in which one such wave influences another. We frame our suppositions to suit our knowledge of the phenomena, and then cite the coincidence as proof of the truth of the theory from which we imagine our conclusions to have been drawn.

Without denying the benefits which such fanciful hypotheses have at times conferred on experimental science, I may point to the preceding strict analysis, as affording conclusive evidence that the whole undulatory theory of light is a tissue of ingenious conjecture.

On the Origin of the Permian Breccias of the Southern portion of the Vale of the Nith. By ROBERT HARKNESS, F.R.SS.L. and E., F.G.S., Professor of Geology and Mineralogy, Queen's College, Cork.

In two memoirs I have described in detail the nature of the deposits which constitute the Permian strata of the vale of the Nith.* These have such an arrangement, owing to their lithological character, as to be naturally separated into three distinct groups. It is to the middle member of these groups which I have more immediately to refer. This middle member, which is a well-marked breccia, occupies a considerable area in the lower portion of the valley of the Nith, and, from its mineral nature, presents itself as a distinct feature in the contour of the district where it occurs. Its hardness and durability give it a ridgy form, and on its outcrop it offers steep escarpments, covering the ordinary building stone of the locality.

* Quart. Jour. Geol. Soc., vol. vi. p. 389, *et seq.*; and vol. xii. p. 254, *et seq.*

With reference to its lithological character, which is well marked, and for the most part local, it may be said to be made up of fragments of lower Silurian sandstones and shales, and these are usually sharply angular; in most instances as sharp as if only just detached from their parent rock. Some of the Silurian shales are found *in situ* to be beautifully jointed, being cut up, by these divisional planes, into rhomboids; and some of the fragments of these shales, which help to make up the breccia, have the jointed nature well exhibited. These Silurian fragments, embedded in the breccias, can be referred to their parent rocks, which are rarely at a greater distance than about three miles from any locality where the breccias make their appearance.

Silurian sandstones and shales are not, however, the exclusive components of these breccias. Angular fragments of porphyry are also common, and in many instances these are of a somewhat larger size than the Silurian fragments. These porphyries have not the same local origin as the Silurian fragments, but have been transported from a considerable distance. The porphyry consists of a purple base, including white crystals of felspar, and bears great affinity to masses of porphyry which occur on the coast of Colvend in Kirkcudbrightshire,—and this Colvend porphyry appears to be the origin of these fragments; the locality from whence they seem to have come being fully twenty miles from many of the spots where they are found embedded in the breccia; and yet, in many instances, these porphyry fragments are as sharp and angular as those of the Silurians.

There is about these breccias a general want of bedding,—their stratification is exceedingly imperfect; and although lines of this nature sometimes appear, they suddenly cease, and the mass seems almost to be united into one solid face of rock of great thickness. The mode in which the fragments are arranged shows that there has been a certain amount of freedom of motion allowed to them, as the fragments have generally their longer axis in a horizontal position. So intimately are these breccias made up of fragments, that each of these is generally in contact with its neighbour, and the whole are cemented together by a paste of very fine sandstone containing a large portion of peroxide of iron. This paste seems to have been infiltrated into the interspaces between the fragments, and affords a strong contrast, as concerns the size of its particles, with the red sandstones which support the breccias, and which in Dumfriesshire afford the fossil footprints. The latter sandstones seem to have resulted from the operation of water having a greater power of transport than that from whence the fine cementing paste, which unites the fragments of the breccias, emanated; and although these breccias are so coarse in their nature, the angular character of the fragments, combined with the fineness of the matrix, causes us to seek for some other force than the ordinary transporting power of water to account for the origin of these masses.

The structure and condition of these Permian breccias are very well exhibited in the cuttings at Dowiel, about two miles west from Dumfries, in the line of the Castle-Douglas Railway, now in the course of construction.

The late Mr D. Sharpe, when President of the Geological Society, made some notes on the memoir previously referred to (Quart. Jour. Geol. Soc., Vol. XII., p. 254, *et. seq.*), and as these notes came into the possession of his successor in the chair, and have been published in General Portlock's address, it is necessary to refer to them. Mr D. Sharpe is disposed to refer the Permian strata of Dumfriesshire to "portions of a talus of broken fragments which fell from the steep faces of the overhanging mountains into basins of water at their feet, the materials of such a talus being necessarily composed of the overhanging rock; the larger fragments are angular; the smaller, having been disintegrated by rains, and other atmospheric agencies, have obtained the condition of sand or mud." There are circumstances in connection with these breccias which militate strongly against this talus theory. The somewhat promiscuous mingling of fragments of both Silurian sandstones and shales is antagonistic to this conclusion; and the presence of porphyries, which have been derived from a considerable distance, is fatal to the opinion that these rocks have had their origin in a talus.

Professor Ramsay has described rocks appertaining to the

Permians of Shropshire and Worcestershire, which in many respects bear a great affinity to these Dumfriesshire breccias.*

On the whole, the Dumfriesshire breccias are more regularly angular, and the fragments are not possessed of certain features which characterize the Shropshire and Worcestershire breccias. These latter have, in many instances, distinctly polished surfaces, and are in some cases marked by striæ; features which are not observed in the rocks of this age of the valley of the Nith. It is owing to the polished and grooved surfaces which occur on the Shropshire and Worcestershire breccias, combined with the angular character of the fragments, and their remoteness from their parent rocks, which have induced Professor Ramsay to regard these breccias as the result of the transporting power of ice, acting in the form of icebergs during the Permian epoch.

Although the Dumfriesshire breccias do not bear about them that polishing and striation which results from the action of glaciers, yet it is excessively difficult to account for the occurrence of angular fragments, in some instances, which have been transported from a considerable distance, as in the case of the porphyries, without having recourse to the agency of ice in one form or other.

The condition in which ice exercises its influence materially affects the state in which fragments of rock transported by its means occur. Glaciers polish and groove many blocks of rock which find their way into these ice masses. Ice, formed on the shores of a frigid sea, and inclosing within it fragments of rock covering the margin of the shore, does not possess the same polishing and grooving influence. It acts, in a great measure, only as a raft for mineral matter when it becomes broken up, transporting either angular or rounded fragments, which may become embedded in it, to localities where the heat possesses sufficient power to dissolve these ice-rafts, scattering their contents on the bed of the sea, or, when these rafts became stranded, on shores. From these circumstances it will be seen that the absence of polished surfaces, or of grooves and striæ, by no means militates against the theory of ice transport, as applied to the breccias of Shropshire and

* Quart. Jour. Geol. Soc., vol. xi., p. 185, *et seq.*

Worcestershire by Professor Ramsay ; since the prevalence of similar conditions, only slightly modified, would give rise to results in some respects different from those upon which Professor Ramsay has based his conclusions. The angularity of the fragments of the Dumfriesshire breccias, and the circumstance that in some instances these fragments have been derived from distant localities, must be regarded as features sufficient to induce us to seek for the agency of that power which, so far as we know, is alone capable of transporting fragments without depriving them of their angular nature.

There are other features in connection with these breccias which appear to support this influence. In the lower portion of these rocks, where they are seen coming in contact with the underlying sandstones, the breccias often exhibit an abrupt commencement, such as would result from the stranding of an ice-raft bearing fragments of rock on a sandy shore.*

Some of the sandstones which overlie the breccias also manifest some features in support of this conclusion. Sometimes, in these, we have detached angular blocks lying in the midst of the stratum of these sandstones in the same manner as we have masses of rock occurring in the boulder clays.

The several circumstances, therefore, which we find in connection with these breccias of the vale of the Nith, justify the inference of Professor Ramsay as to the prevalence of arctic conditions during the Permian period.

Observations on British Zoophytes. By T. STRETHILL WRIGHT, M.D., Fellow of the Royal College of Physicians, Edinburgh.†

Description of Plates.

PLATE I.

Atractylis and Eudendrium.

Fig. 1. Medusoid of *Atractylis ramosa.*
2. Same at third month developed into *Bougainvillea Britannica.*
3. Tentacle of peduncle of do. further enlarged.
4. *Atractylis repens.*
5. Medusoid of do.

* Quart. Jour. Geol. Soc., vol. vi., p. 394.

† Communicated to the Royal Physical Society of Edinburgh, April 28, 1858.

PLATE II.

Fig. 1. Male polyp of *E. rameum* with double sperm sacs—*a, b*, ectoderm of unripe sperm sacs—*c*, process of endoderm—*d*, ripe sperm sac with spermatozoa, endoderm absorbed.

2. Female polyp of *E. rameum*—*a*, ovarian sac containing single ovum surrounded by *c, c*, process of endoderm.

On Atractylis (new genus).

On a former occasion I read to the Society a description of two Hydroid Zoophytes, which I placed in the genus *Eudendrium*, on account of the similarity which their polyps bore to those of the *Eudendrium ramosum* of Van Beneden ("Memoirs of Brussels Academy, vol. xvii., Plate IV."), the *Tubularia ramosa* of Dalyell, although at that time I doubted, with Johnston ("British Zoophytes," vol. i. p. 47), whether Van Beneden's zoophyte did not belong to a distinct genus. Since the publication of my paper, I have received the opinion of two of our most eminent authors, that my zoophytes were not Eudendria, and have been requested to place them in a new genus. The *Eudendrium ramosum* of Van Beneden, and *Eudendria repens*, and *sessile*, described by myself, differ from the *Eudendrium ramosum* of Johnston, in having their polyps destitute of the cup-shaped proboscis, the body fusiform instead of globular, and in the absence of the very large and distinctive thread-cells which occur on the body and within the polypary of Eudendrium. I can discover no other permanent difference between Eudendrium and Atractylis (*ἀτρακτυλίς*, from *ἄτρακτος*, a spindle), as I propose to call the first-named zoophytes. It is true, that nothing can be more dissimilar than the large-branched *Eudendria rameum* and *ramosum*, with their globular bodies, opaque from the excessive deposit of red granules in the endoderm, and the delicate polyps of the smaller species of Atractylis; but I have on more than one occasion observed an equally minute creeping species of Eudendrium, which could only be identified as belonging to the latter genus by the shape of its proboscis and thread-cells.

The last systematic writer on zoophytes, Mr Gosse, describes Eudendrium as "Inclosed; Corallum fibrous, rooted, erect, branching; Polyps protruding from tips of the branches, not retractile." This description is, however, incorrect and insufficient, as it does not notice the proboscis, and moreover, Eudendrium is not uniformly erect or branched. The reproductive system is also unnoticed. The following description will, I believe, give the characters of the genus:—

Eudendrium.—Polypary sheathed, creeping, or erect and branched. Polyps not retractile, globular, fleshy, with an alternating row of numerous filiform tentacles; proboscis cup-shaped, fleshy; endoderm of body dark; thread-cells on tentacles minute, on body large, bean-shaped, containing simple style apparent. Diœcious. Ovaries single sacs, developed from polyps or polypary. Spermaries arranged in moniliform series on pedicles, which arise beneath tentacles of polyps, or on separate stalks from the polypary.*

The characters of Atractylis are:—

Atractylis.—Polypary sheathed, creeping, erect, or branched. Polyps fusiform, incompletely retractile, with transparent filiform alternating tentacles (mouth closed by a dense muscular ring). Thread-cells inconspicuous. Reproduction by medusoids.

Atractylis ramosa (Van Beneden, Dalyell).—Polypary sheathed, erect, and branching; stem composed of many minute sub-parallel tubes; ends of branches dilated. Medusoids springing from branches and polyps; umbrella sub-globose; peduncle with four undivided capitate tentacles; marginal tentacles eight, in four pairs, each pair springing from a bulb having two eye-specks; auditory sacs absent.†

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* *Note on the reproduction of* E. rameum.—Mr Alder, in his "Catalogue of Zoophytes of Northumberland and Durham," says, "according to Sir J. Dalyell the reproductive capsules of this species are of two kinds (probably sperm and ovicapsules). Those I have met with form a cluster round the base of the tentacles, and are arranged in a linear or moniliform series, two or three on each pedicle." *The double sperm sac* consists of two ectodermic sacs placed end to end (Plate II., fig. 1, *a*, *b*), permeated by a tubular process of endoderm (*c*), and containing the spermatic gelatinous plasma. As the spermatozoa first ripen in the distal sac (*d*), the endoderm in that sac is absorbed and withdrawn. The same process afterwards takes place in the proximal sac (*e*). *The ovarian sac* (fig. 2, *a*), contains a single yellow ovum (*b*), which at an early stage is encircled by a looped tubular process of the endoderm (*c*); subsequently this loop is absorbed, and the ovum becomes a ciliated larva filling the sac. Its further change has been described by Dalyell.

† *Note on the development of* Bourgainvillea Britannica *from* Atractylis ramosa.—In August last I found *Atractylis ramosa* growing in great profusion on the Bimer Rock and on Inchgarvie, both near Queensferry, Firth of Forth. When taken, the specimens were in high condition, each branchlet possessing its terminal polyp; but after being kept in one of my tanks for a few days, I found that a great change had taken place; the polyps were all absorbed, or undergoing the process of absorption, and in their place, and also from the branches themselves, a great number of medusa buds were put forth, which

Atractylis repens (mihi).—Polypary creeping, sheathed; polyp-stalks erect, single, or bifurcate (wrinkled); ends of stalks dilated or not. Medusoids springing from polyp stalks, mitre-shaped; peduncle quadrangular; tentacles four, two very long, two rudimentary. Eye-spots and auditory sacs absent.

Atractylis sessilis (mihi).– Polyps sessile on creeping polypary, or scarcely stalked, sheathed up to the tentacles. Medusoids developed from creeping fibre, similar in shape to those of *Atractylis repens.*

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were rapidly developed into the *Medusa ocilia* of Dalyell. The zoophyte had in fact assumed its reproductive phase. It had changed from a creeping hydra-bearing zoophyte, to a multitude of free and actively swimming medusæ. It is well known that the Aphis, as long as its pasture is good and the weather is fine, will produce a continued succession of wingless and sexless individuals by internal gemmation. It will continue its phase of nutrition. But should its circumstances fall adverse—should Flora and Jove become unpropitious—then it undergoes its last change, and becomes a winged and egg-bearing creature. It assumes its phase of reproduction. So the gluttonous caterpillar, taken yet unsatisfied from his cabbage leaf and shut up in a box, becomes prematurely a chrysalis. And so, too, the medusa-bearing zoophytes, exchanging the open sea for the confined water and poor fare of a tank, become, so to speak, winged medusæ, and, instead of a continued succession of polyps, produce eggs.

The medusa of *Atractylis ramosa*, when first given off from the zoophyte, is identical with the *Medusa ocilia* of Dalyell. The orange-coloured alimentary polyp or peduncle has four unbranched tentacles, capitate at their extremities with bundles of thread-cells. The orange tentacular polyps are each furnished with two tentacles, and a black eye-speck at the root of each tentacle. In this stage a large number, then about a month old, were brought to Edinburgh. They fed on the minute Entomostracea (which swarmed in the tank), with avidity, and increased in size. But, to my surprise, I found that a further development was taking place in them. The tentacles of the alimentary polyp (peduncle) became first once, and afterwards twice, dichotomously divided, and each of the tentacular polyps put forth additional successive tentacles, until the greatest number observed amounted to six, each additional tentacle being accompanied by an additional eye-speck at its root. At the same time, genital lobes were developed, springing from the peduncle, which passed for a short distance along the lateral canals of the sub-umbrella, and ultimately contained spermatozoa. In other specimens, given off by *Atractylis ramosa* in the spring, but which never arrived at so late a stage of development, ova were found situated in four masses within the walls of the peduncle. This medusa, at its latest stage of development observed by me, bears a strong resemblance to the *Hippocrene* or *Bourgainvillea cruciata* of Forbes, and also to his *Bourgainvillea Britannica*, which I am disposed to consider as different sexes and stages of development of the same medusa. I am the more emboldened to hold this opinion, as Professor E. Forbes has already considered the *Medusa duodecilia* of Dalyell (which represents, as I have observed, one of the stages of that I am now describing) the same with his *Bourgainvillea Britannica*. (*Monograph of British Naked-eyed Medusæ*, p. 68.)—*Nov.* 22, 1858.

On the fixed Medusoids of Laomedea dichotoma.

Description of Plate.

PLATE II.

Fig. 3. Summit of reproductive capsule (female) of *L. dichotoma*—*a*, four-lobed endodermal or nutritive process of ovarian sac—*b*, ectoderm of do.—*d*, umbrella or marsupium—*e*, ectoderm of ovary ruptured, ova having escaped into the cavity of the marsupium.

4. Summit of male reproductive capsule of *L. dichotoma*.

5. Alimentary polyp of Siphonophorous Zoophyte (*Agalmopsis punctata*), and

6. Tentacular polyp of same, compared with

7 and 8. The same organs in Sarsia.

9. False medusoid (ovary with rudimentary umbrella) of *Hippopodius Neapolitanus* (Kölliker).

10. False free medusoid of *Diphyes* (Huxley).

11, 12, 13, 14. Development of false medusoid or marsupium in *Sertularia fallax*.

Under the title of *Laomedea dichotoma*, Johnston has described as varieties two very distinct zoophytes. One (the Sea-thread Coralline, *Ellis*, Corall. 21, No. 18, Plate XII., fig. *a*, A), a magnificent production, attains a height of twenty-four inches, its slender stem and branches hidden by thousands of snowy polyps, the whole forming a pyramidal mass, which sways to and fro with every movement of the waves; while from the axillæ of the branches the reproductive cells pour forth shoals of flapping medusoids, which fill the water around with a cloud of living beings. Many of these beautiful trees are joined together by anastomosing lines of creeping fibres, which wander over the rocks, and unite them as a single living being. The other variety (*the Sea-thread Coralline* of Ellis, plate xxxviii.) is very different from the last. It is a shrubby Zoophyte, of robust habit, the imperfect medusoids of which remain fixed to the top of the reproductive cells, where they serve as *marsupial* pouches for the development of the ova.

The reproductive cells are developed from the axillæ of the branches, and are at first traversed by a fleshy column, which occupies the axis of the cell, and, being dilated at its summit, closes the orifice. This column differs in no respect from the ordinary alimentary polyp at an early stage of development, and must be considered as a polyp in which development has been arrested, in order to render it subservient to the function of reproduction.

In the female (Plate II., fig. 3) we find a number of sacs developed from the reproductive polyp, each of which consists of,—1*st*, An ovarian sac formed of two layers, a four-lobed endodermal process or layer (*a*), and an ectodermal layer (*b*), between which are contained one or more ova; and 2*dly*, Of an investing capsule, which becomes converted into the umbrella, with lateral canals and tentacles of an imperfect medusoid (*d*), of which the ovarian sac is the peduncle. After the medusoid has issued from the top of the cell, the ova still remain in the peduncle or ovarian sac, but the outer membrane or ectoderm of the sac presently bursts (*e*), and the ova are discharged into the umbrella of the medusoid (*f*). There they become developed into ciliated larvæ, and are afterwards discharged, to swim away, and, after attaching themselves, become transformed into arborescent zoophytes.

The male capsules (fig. 4, first described by Lister) resemble those of the female, but the medusoid is in a still more rudimentary state. Its tentacles are very short and few in number, the lateral canals are not to be detected (Schultze and myself), and the peduncle and umbrella are imperfectly differentiated.

The reproduction in this zoophyte has been already described by Lister, Loven, and Schultze, but the anatomy of the different parts has not been well distinguished. I have brought this subject before the Society to point out the distinction between the ovarian sac and the other parts of the medusoid, organs which have been lately confounded together by Professor Allman in his papers on the Reproduction of Zoophytes, and as to the homology of which he appears to me to have arrived at inaccurate conclusions. Wherever the medusoid form of generation exists, the umbrella, with its canals, will always be found not homologous with, but superadded parts to, the ovary; which last, when single, as in the present instance, represents the peduncle of the medusa. Where several ovaries exist, as I have shown in *Campanularia Johnstoni*, and shall show in *Laomedea geniculata*, these organs are developed from the lateral canals, distinct both from peduncle and umbrella, or as bands between the tissues of the peduncle.

The umbrella of a completely developed gymnopthalmatous medusoid, with its canals, is the homologue of the swimming organ of the Siphonophora. The Siphonophora are compound medusæ of the gymnopthalmatous type, in which an aggregation of peduncles (alimentary polyps), tentacles with their bulbs (tentacular polyps), and reproductive polyps, are joined together by a tubular polypary, the whole being buoyed up, as in *Forskalia Edwardsii* (Kölliker), by a swimming organ composed of numerous conjoined umbrellas, each with four lateral canals. In this animal the umbrellas are altogether segregated from the ovaries. In *Hippopodius Neapolitanus* and others, in addition to the common swimming organ, each ovary is associated with a minute rudimentary umbrella, as in fig. 9. In *Diphyes*, again, the ovary (fig. 10), furnished with a large umbrella, a serviceable swimming apparatus, becomes freed from the polypary, and floats away as a locomotive reproductive organ, like the Hectocotylus of the Cephalopod. So, also, the fixed false medusoid of *C. dichotoma* is nothing more than an ovary with an umbrella, which last, however, exercises—not the function of a swimming organ, but rather, as does the gelatinous envelop secreted by the ovarian sacs of *Sertularia pumila, Laomedea lacerata*, &c. (see p. 113)—that of a marsupium.

We have another instance of an umbrella-shaped sac being employed as a marsupial chamber in the reproductive cell of

Sertularia fallax.

In this zoophyte (as I described to the Society, April 1857) the summit of the ovary puts forth four thick lobes, consisting of endoderm and ectoderm covered by corallum ; these are gradually developed (as shown in Plate II., figs. 11, 12, and 13,) until they form an umbrella with four or eight canals, (as in fig. 14.) The ova, after leaving the ovary, are received into the cavity of the umbrella, which, on their attaining a more mature stage, opens at the top, and allows them free exit.

On the Reproductive organs of Laomedea geniculata.

PLATE II.

Fig. 15. Medusoid of *Laomedea geniculata—a*, ovaries.

On a former occasion I described the existence of ovaries and ova in the lateral canals of *Campanularia Johnstoni*, and the production of the young zoophytes. On examining, in like manner, the medusoids of *L. geniculata*, immediately after their exit from the capsule, I discovered their ovaries with the contained ova. In some of the medusoids the ovaries were situated in close proximity to the peduncle, in others, midway between the peduncle and the marginal canal (as at fig. 15).

Laomedea lacerata.

Description of Plate III.

Fig. 1. Male polypary, with polyps and sperm-cells—*a*, unripe sperm sac—*b*, ripe do.

2. Unripe ovarian cell—*a*, reproductive polyp—*b*, sac inclosing ovary—*c* endoderm of ovary—*d*, ectoderm of do.

3. Ripe ovarian cell, ovary emerging from top of cell and enveloped in gelatinous marsupium.

This zoophyte was described by Johnston (" British Zoophytes," 2d edition), under the title of *Campanularia lacerata*, as having " cells on short stalks, ovato-conical, the upper half cleft in six lanceolate segments," the cells arising from a creeping tube. In August 1852 (" Annals of Nat. Hist."), the Rev. T. Hincks removed it from the genus Campanularia to that of Laomedea, and described it as follows :—" Stem filiform, ringed throughout; cells on short pedicles, ovato-conical, the upper portion divided into a number of deep convergent segments." He stated that the stems, which did not exceed the *sixteenth of an inch* in height, rose from a creeping fibre, and bore their cells on pedicles composed of four or five rings, somewhat irregularly disposed. And further, that this Laomedea, *in its young state*, was identical with *C. lacerata* of Johnston. He had not observed its mode of reproduction. Mr Hincks' description, also, is taken from an immature state of the zoophyte. *L. lacerata* may be found in profusion at Morrison's Haven, Firth of Forth. It attains a height of an inch and a quarter, slender and lax, but is generally about half an inch high, and bushy. Both varieties are covered with ovarian or spermatic cells in the spring. Plate III., fig. 1, exhibits a male specimen taken with the Camera lucida. The polyps resemble in shape those of *C. syringa*, have fourteen to sixteen alternating tentacles, and are capable of extending themselves to more than twice the length of the cell.

The reproductive cells are ovate, and are shortly pedicled, like the alimentary polyp cells, of which I consider them an *in-development-arrested* form. Each reproductive cell grows in close proximity to a polyp cell.

The female cell (fig. 2.) consist of a reproductive polyp (*a*), from the side of which buds a single ovarian sac inclosed within a layer of the ectoderm (*b*) of the polyp. The endoderm of the ovary (*c*) is branched or lobed, and is moulded, as it were, on and between the ova which lie between it and the ectoderm of the ovary (*d*). As development proceeds, the ovarian sac (its endodermic lobes having been previously absorbed) rises up to, and issues from, the top of the cell (fig. 3), and becomes surrounded by a thick gelatinous mass, secreted from the surface of the ectoderm. The ectoderm of the ovary now bursts, leaving the ova in the gelatinous *marsupium,* where, as in *Sertularia pumila,* &c., they become developed into ciliated larvæ.

The male cell resembles the female cell. Instead of an ovary, a spermatic sac buds from the reproductive polyp. At first a transparent gelatinous plasma is secreted between the branched endoderm and the ectoderm, as at (*a*), fig. 1. In this plasma the spermatic cells, and subsequently spermatozoa, are developed. Meantime, the sperm-sac rises to the top of the cell, is extruded (*b*), and bursts.

REVIEWS AND NOTICES OF BOOKS.

Blick pä Ethnologiens närvarande Ständpunkt, med afseende pä Formen af Hufvudskälens Benstomme. Af Anders Retzius. Christiania, 1857.

View of the Present State of Ethnology, in reference to the Forms of the Skull. By Anders Retzius.

The particular form of the skull has for some time been a recognised basis of distinction among the different races of men, by ethnologists. Among the most zealous students of this special physical feature is the distinguished Professor of Anatomy at the Carolinska Institute of Stockholm, Anders Retzius. About the year 1844, he laid before the meeting of Scandinavian naturalists assembled in that city, his proposal for arranging human races in four orders. His two chief divisions were into *Dolichocephalic* people, or those having long heads; and *Brachycephalic* people, or those having short heads. And, under each of these chief divisions he ranged a double subordinate one, according to the uprightness of the jaws or face, or the projection of the jaws; naming the first class *Orthognathous*, and the second *Prognathous.*

Retzius's investigations of this subject by travel and observation, and his study of skulls, both at home and abroad, have been diligently pursued ever since. And at the meeting of the same Society at Christiania, in 1856, he was prepared to elaborate his views upon this simple method in the paper the title of which is given above.

In this sketch he briefly arranges the nations of Europe, Asia, Australia, Africa, and America, according to the principles above mentioned. All European people are orthognathous, or free from projecting jaws. The Germanic nations, in which he includes the Scandinavians, the Normans of France and England, the Dutch, Flemings, Burgundians, Germans, Franks, Anglo-Saxons, and Goths of Italy and Spain; and the Celtic nations, which are made to embrace the Celts of Scotland, Ireland, and England, the Walloons, the Gauls of France, Switzerland, Germany, &c., the Romans, and the old Greeks and their descendants, he places among the *Dolichocephali.* The whole of these nations it will be observed belong to Western Europe. On the contrary, he arranges the nations of Eastern, and portions of Northern Europe among his *Brachycephali.* Among these he includes the people who have been denominated Ugrians, or the Samöeides, Lapps, Voguls, Ostiaks, Permians, Votiaks, Tcheremis, Morduins, Tchuvatch, Magyars, and Finns; the Turks, the Sclavonic nations, and the Letts, Albanians, Etruscans, Rhætians, and Basques.

To place the Romans and Greeks among Celtic people, it will be perceived, is an unusual arrangement. In a former memoir on the round, brachycephalic skull-form of the Greeks, Retzius had concluded that this was the proper shape of the Greek head; although he observed, that the Belvedere Apollo presented an oval head with projecting occiput, and expressed the opinion then that the latter—the long oval form—nevertheless belonged to the Greeks. He now regards it still as of only occasional occurrence, and never to have belonged to the greater number of the nation, which he notwithstanding arranges amongst his dolichocephalic Europeans.

That the Turks, the Russians, Poles, and other Sclavonic people have short lofty heads may be said to be more or less well known, and to have been confirmed by the most accurate observers, as the learned Professor of Zoology at Leyden, J. Van der Hoeven. The oriental position of the Greeks would make them an exception to the general distinction above mentioned, between the nations of Western and Eastern Europe, were the majority of them dolichocephalic. Whatever may be said of the classification of the Romans and Greeks among Celtic nations, we think it probable that the Greek skull will be found to be generally short; whether the Celtic skull itself can be properly included among dolicocephalic crania or not. We may obeserve, *en passant*, that it would be difficult to account, in a rational and satisfactory manner, by any influence of climate or other secondary causes, for this difference in the form of the head in people placed so near to each other as the Germanic and Sclavonic races, or other similar instances. The cause of such an essential difference is clearly radical and primary.

Of the Asiatic skull-forms Professor Retzius makes the Hindoos, the Arian Persians, the Arabs and Jews (all orthognathous), and the Tungusians and Chinese (both prognathous) to be dolichocephalic. Whilst the Ugrians and Turks of Asia, the people of the Caucasus, the Turkmans, Affghans, Tartars, Mandchu-Tartars and Mongols, both of Asiatic-Russia and Mongola, who are all prognathous, except the three first, he classifies as brachycephali.

This separation of the Chinese and Tungusians from the Mongols and Tartars, based upon skull-forms, is one of the peculiarities of the author, and is deserving of attention. According to this representation of Retzius, the people of the southern parts of the Asiatic continent are dolichocephalic, whilst the brachycephalic Asiatics are more generally distributed. He says, that in Asia as well as in Europe, the brachycephali are most numerous, but with this difference, that the Asiatic brachycephali are mostly prognathous.

With respect to Australian skull-forms, Retzius makes up his division of Australian dolichocephali of the Austral negroes alone, who are wholly prognathous. His brachycephalic Australians, likewise wholly prognathous, embrace the Malays, the Polynesians, and the Papuans.

The African nations, we are assured by the author, are wholly dolichocephalic. This is an extension of the view given by Professor J. Van der Hoeven, in his "Natural History of the Negro Race," in many respects the most complete work yet written on any distinct people, and worthy to be regarded as a model of ethnographic research. He dwells especially on the lateral flatness of the Negro head, and its elongation backwards, as its most distinguishing characteristics.* Whether that more thorough and complete investigation of African skulls, which we may reasonably expect to result from the great extension of discovery in that quarter of the globe, will leave them all in the category of dolichocephalic, seems at present to deserve to be regarded as somewhat dubious.

Perhaps the most important portion of this treatise of Professor Retzius is that which refers to the American races. The distinguished American craniological ethnographer, the late Professor Morton, laid it down almost as an axiom, that the aborigines of America, from one end of the continent to the other, greatly resembled each other, and were distinguished, amongst other features, by elevation of the head in the vertical region, with flatness of the occiput, producing a roundness in the skull. Still Morton admitted that the nations east of the Alleghanies, and some others, had the head more elongated than other Americans.* The further researches of Retzius have led him to the conclusion, that the short round head, described by Morton, is more limited in its occurrence; and that the dolichocephalic form is that which prevails in the Islands of the Carribean Sea, and in the eastern regions of the great American continent, from its highest northern limits to Uruguay and Paruguay.

Retzius here mentions that, in examining the collection of skulls at Stockholm, he has often been struck with the resemblance between those of the Guanches and Copts of the one side of the Atlantic, and those of the Guaranis of Brazil on the other. Besides alluding to the likeness of skull-forms in the ancient inhabitants of the Canary Islands and the Guaranis, whom he regards as allied to the former Caribs of the Antilles, he mentions the reddish-brown colour of the skin, like brownish-tanned leather, common to those races of the opposite sides of the Atlantic, and the simi-

* Bijdragen tot de Natuurlijke Geschiedenis van den Negerstam, 1842, bl. 23, 24.

† Crania Americana, 1839, p. 65.

larity of their straight hair,* from which he infers a great agreement of features and make. On these grounds he suggests a probable alliance between the people inhabiting the opposite sides of the Atlantic. Craniography is yet very far from being established on such strict and distinct grounds as to prevent hypothetical conjectures like this. The author's impression, derived from craniological observations, that the Highlanders of Scotland are descended from the Finns or the Basques, we may probably be allowed to regard as another flight of fancy, worthy of the *alchemical age* of ethnology. Mr Skene has, to the satisfaction of most inquirers, succeeded in referring the Highlanders to the *Cruithne*, or northern Picts, on reliable grounds. To derive them from either Finns or Basques, through such an ancestry, must, besides involving a great amount of vague hypothesis, have the inconvenience of a large mixture of doubt and uncertainty. We allude of course to the conjectures of Arndt, Rask, Keyser, and others. The mere fact that the Highlanders have brachycephalic heads, a remarkably short, broad face, red hair, and a freckled countenance,—if these characters were general, which is to be questioned, would almost equally ally them with other brachycephalic races of Europe or Asia.

And here we are pressed with the question, What is the true value of craniological evidence? We are disposed to doubt whether cranial investigations have hitherto been carried out extensively enough, and in a sufficiently philosophical spirit, to determine this question. Still, we are far from being willing to undervalue their importance, when we express the opinion that they have frequently been employed to decide questions out of the compass of their teachings. We are even bold enough to believe that we should not derogate from their true value, were we to point out the extravagant pretensions they have been made to assume in some hands, far less judicious than those of our author.

* The colour and structure of the hair of the American nations has been considered to be uniform, with very few exceptions; the occurrence of grey hair among the Mandans being the most striking of these exceptions. The black, coarse, and lank or straight hair of the American races may be said to be universal. Dr P. A. Browne attributes its properties to its cylindrical shape. ("Trichologia Mammalium," 1853, p. 63.) That of the Guanche mummies has also been described more than once as black and long; yet, in the Chronicles of the Conquest of the Canaries, the colour of the skin of the inhabitants of the greater parts of the islands of the western group, which Berthelot regards as of the dominant Guanche type, is described as moderately white, and that of the hair as fair, reddish, or red (*cabellos rubios, rojos, dorados*); and Berthelot informs us, that nearly all the Guanche mummies he had examined had hair *more or less red* ("Ethnografia y Anales de la Conquista de las Ilas Canarias, Santa Cruz de Teneriffe," 1849, p. 239.) The hair of a mummy derived from a cave at Taraconte in Teneriffe, in the possession of the writer, confirms this statement. It is what is called auburn, a reddish brown, without any predominance of red. Exactly the same colour appertains to that on the skull of a Guanche mummy contained in the Museum of the Anatomical Cabinet at Leyden.

The human skull is the receptacle of that great mass of brain, which is the truest exponent of man's superiority over all other creatures. It contains that organization which not only distinguishes him from and exalts him over all other animals, but which characterizes and particularizes him, *in himself*, as a conscious, intelligent, moral being, extending his aspirations over the whole universe, and all time, past and future. In whatever way this mass of nervous structure may be allied to man's highest powers, observation has taught the closeness of this alliance; and, even speaking generally and referring to races, that the special manifestation of intellect, which we will call *civilizibility*, is intimately associated with the particular development of this nervous mass. We mean that, as civilizibility, or the inherent power of improvement, is different, not only in degree but in kind also, in different races, so likewise the mass and form of the brain, *pari passu*, differ in the same degree. To take an extreme case, and premising that the skull is a pretty true representative of the diversity of size and shape of the brain, we cannot well compare the fine, large, oval, smooth, equably-developed skull of an Englishman (or of Apollo or Minerva, if we defer to M. Courtet de L'Isle's principle of beauty),* and the small, rugged, low-browed, ugly skull of an Australian, without the inference, that we have under our eyes the real and essential difference between the people themselves—that which points out the one to be inherently capable of the highest intellectual and moral cultivation, and the other to possess no such capability; or, we might say, occasions his gradual, but rapid and inevitable extinction when he comes into the presence of the former, even where the greatest pains are taken to prevent what we cannot avoid regarding as a sad calamity. When we meet with a pretty similar low development in other equally savage races, and find that, as we ascend through races of higher powers, and evolving a more lofty civilization, we perceive a more and more close approximation in skull-forms to those of Europeans, we are satisfied that our former conclusion is correct.

We therefore see that we have in this diversity of skull-form, if it can be rightly interpreted, a key to the discrimination of the most inherent and essential differences amongst human races. The study of skull-forms is probably the most valuable and assured means of discerning the diversities that exist among the races of men, and of determining their relations. The mode of study, which deals with the most especial characteristic of man, his nervous organization, as a first element of arrangement, need not restrict itself to this. Other physical characters, his moral and psychical phenomena, and the tongues he speaks, as an expres-

* "Tableau Ethnographique du Genre Humain," 1849. An essay of extraordinary merit.

sion of these latter, may all be taken into account, and will all be required for subordinate elements. And by this means only can we arrive at any adequate and comprehensive system of the natural history of man.

In this department of natural history, such is the teeming fertility we behold in the works of creation, such the almost unlimited diversity, that we are at first perplexed and lost in the profusion. And it is only after a well-selected and well-digested method that we can attain that largeness of view which will enable us to estimate the subordinate features of diversity at their proper value, as less significant features. Even then, and after every elaboration, it is believed the most perfect system will fail to reduce every individual to his place; the most perfect system—a work of human art—will not reach and embrace all the height and depth of creation. Every system must make up its account to admit of this seeming playfulness in creation—for the diversity of form which exists in every distinct race and even family of men. Diversity, within certain bounds, seems to be a rule of creation; and it is only by a judicious selection that we can attain to the proper elements of arrangement—those which touch a large number of individuals without constraining them to a rigid uniformity. Again, this apparent law of variation, within certain limits, cannot be supposed to be a result of deviation or degeneration from the original, as we behold in the relics of the oldest races,—the ancient Egyptians, the ancient Britons, and others,—that the same diversity, within moderate limits, always prevailed.

As a first element of cranial arrangement, there cannot be a doubt that the one fixed upon by Professor Retzius is the simplest and most comprehensive. The students of anthropology must be grateful to this learned anatomist for his patient and persevering researches, which tend to divide mankind into two great orders, the *Dolichocephali* and the *Brachycephali.* Admitting that arrangements of this kind must not be interpreted too strictly, that exceptions and varieties are scattered more or less through all races, we must allow that this is the first right step in, what we think will be found to be, the natural arrangement of the races of men.

Hasty deductions, from the facts brought to light by this method of Retzius, are to be guarded against. They inevitably reduce this, which we call the natural system, to the level of the wild speculations on coincidences which have rendered the laborious efforts of philologists so futile and unsatisfactory. What shall we say of the view of our author, for which he admits he has only slight grounds, based upon a resemblance which he considers he perceives between the skulls of the Esquimaux and the Chinese, that the race to which the Esquimaux belong not only constitutes the Polar race of North America, but extends itself in a thin distribution over the islands of the Polar Sea and in the northern parts of America, from west to east, over Asia to China, and there constitutes the proper Chinese population, which he allows can scarcely be separated from the Tartar-Chinese? This, we suppose, is in allusion to his peculiar ideas by which he separates the Tunguse and Chinese, as *dolichocephali*, from the Mandchu Tartars and Mongols, who are *brachycephali*. A more careful discrimination will surely result in pointing out essential differences between the very diversified races thus considered to be an extension of one and the same. Indeed, we believe skull-forms alone would be sufficient for this end, if we shut our eyes to the other physical characters of these various peoples, and took no account whatever of their diverse civilizibilities, which leads us to remark that this study of skull-forms must not become too exclusive—must not overlook the results of that organisation which it takes for its base. Whilst it is, we believe, to be justly considered the prime element of a natural arrangement, it is not the only element, and must not, we suggest, be allowed to carry us to the point of allying such diversified beings as the short, ice-bound, carnivorous Esquimaux, and the fine cosmopolite and enterprising Chinese, the originator of a civilisation even exalted, the features of which are probably the most singular and special of any of which we have any knowledge.

In a note appended to this communication, upon the curious subject of the artificial deformation of the skull, a subject which has been frequently and well elucidated before by Professor Retzius himself, he appears to consider that the custom has originated with the Mongols of Asia, been actually carried to America by these people themselves (whom he is pleased to designate "American Mongols," after Dr Latham, as if names were things), and then been spread over the "non-Mongolic" races of America, for whom Dr Latham has equally coined another designation, "American Semites." The excellent Stockholm Professor may obtain countenance for things equally strange, and having bases equally slender, from the scholars of various European countries. Still, we cannot help asking ourselves, whether such violent assumptions and liberties taken upon paper with ancient races, to all appearance as distinct in all their characters as in their places of habitation, can be reconciled with true philosophy, or be promotive of the real progress of science? If the Flathead of the Columbia River practises the custom of deforming the head of his infant, by what necessity has this custom been *imported* into the regions of North America? No necessity for such importation can be induced by designating him, in pleasant drollery, an American Mongol. Are we constrained to suppose that he has not mind enough to invent such a practice of enhancing himself in the eyes of the fashionables of his tribe? Or is the custom itself so recondite, involving such a singular combination of efficient causes, that it could only be invented *once* upon earth, amid the countless races of man, in the long lapse of ages since he first appeared on the globe? Would not a sounder philosophy resolve the problem in a simpler manner, by referring this and all similar customs to a sentiment common to the human family of all races and all climes—the vanity of distinction—seen in the Boulevards of Paris and Broadway of New York, as well as among the Australian tribes, among whom it presents itself in the form of front teeth knocked out, and wheals of different patterns raised on the breast and on the arms; seen also in the tattooing of the New Zealander, and the patterned skin-stains of the Sandwich islander? To leave out of notice the multitudinous ways in which the same feeling presents itself in all Europe of the present day, we would add—seen as clearly in the ingenious devices by which the six or eight letters of a man's name are tortured into diversity to devise a special spelling by which all the "Smÿths" of future generations may be *distinguished.* Again, if there be in the nature of things a necessity which we cannot perceive, for this strange disfiguring custom having been invented in one spot and by one race, what reason can be given by M. Thierry, or any historian, why it should have been invented by Mongol nations, rather than by his own countrymen in the south of France, among whom the custom has prevailed for ages. A sound philosophy appears to us to make short work with these riddles of ethnology, and we surely cannot err in interpreting them by the help of such a key, where the mouth of history is permanently closed.

How far the study of skull-forms can be carried, and by what means and to what extent the secondary skull-forms can be discriminated—those forms, for instance, which distinguish the different families of the *dolichocephali* and the *brachycephali* of Europe, who, we must recollect, are both admitted by Retzius to be orthognathous, have not yet been fully determined, probably because these diversities themselves have not yet been adequately studied in a right spirit. Further investigations will decide the true extent of the applicability of this method, will point out its imperfections, and the best means by which these can be compensated. We do not expect that the simple method of Retzius will solve all problems, and suffice for all adequate arrangements, or, indeed, can do more than afford the first element of a true method. Nor do we doubt that there are other and sufficient materials for a satisfactory arrangement of all the very various races of mankind.

Even if we go no further than the organization of the head, there are many elements of form to be studied besides those chosen by Retzius. The various proportions in the brain-case have all, doubtless, their value, without our being under any necessity to estimate that value by the organography of Gall. And, besides the numerous well recognised forms which serve to distinguish different races, other combinations will be perceived by further research. Especially if we embrace, which we ought to do, in the investigation of skull-forms, the bony frame-work of the whole head, both calvarium or brain-case, and face. In Retzius's system the importance of the conformation of the face is fully recognised. The phrenologists have been almost wholly absorbed in the observation of the brain-case. That older sect, the physiognomists, allowed themselves to be more especially occupied with the face, its various distinct features, and their expressions. A rational observer will very properly direct his attention to both classes of features. The one is made by nature, in some measure subordinate to the other, but both are worthy of becoming objects of study in an enlightened system of craniography, which will thus be made to combine all that is useful, in both phrenology and physiognomy, of the methods of Gall and Lavater.

We feel deeply thankful to Professor A. Retzius for this clear exposition of his system, and greatly admire the courteous and generous manner in which he appreciates the aid and contributions of every coadjutor. If, in giving an account of this system, we have found occasion to differ from some of his views and positions, we feel that we must always offer objections to such an observer with profound respect, and in a spirit of becoming humility.

A Manual of Qualitative Chemical Analysis. By A. BEAUCHAMP NORTHCOTE, F.C.S., Demonstrator to the Professor of Chemistry at Oxford, late Senior Assistant in the Royal College of Chemistry, London; and ARTHUR H. CHURCH, F.C.S. of Lincoln College, Oxford, late Assistant to Professor Brodie (*Van Voorst*).

The appearance of this excellent manual is well timed. Now that chemists are beginning to use the notation of the late deeply lamented M. Gerhardt, it is fitting that some treatise on analyses should appear, written in accordance with his system. There are several features in the one under consideration, which make it especially valuable. In the first place, the most salient reactions of the ordinary substances are condensed into tables. In the next, the entire arrangement is thoroughly systematic, and evinces care and judgment; and, lastly, the decompositions are, whenever required, expressed clearly in the form of equations. It is not only to the ordinary student that Messrs Northcote and Church's work will prove useful, for even the experienced analyst will find much information in its pages. The reactions of the rarer metals, &c., are not omitted, but are placed in smaller type in their appropriate places. Altogether we consider this manual to be a valuable addition to Mr Van Voorst's series of class-books.

EXTRACTS FROM CORRESPONDENCE.

Letter from Dr W. Balfour Baikie *to* Sir John Richardson.

Encampment near Kitsa Nápe, Central Africa,
1st *August* 1858. 6. 30, a.m.

My dear Sir John,—As I am sending off a mail this morning I shall endeavour to let you know what we have been doing since I last wrote to you. And first, as to our collections. In *Mammalia*, the principal addition has been a nearly complete skeleton of the African elephant, one having been killed here very recently. It is complete, all except the lower jaw and a portion of the tail, which was carried off by the pagan hunters as sacred. In birds, hough we have several fresh specimens, there is hardly anything new, the best things being a good skin and skeleton of the crown crane. In reptiles, I have done fairly. First, I got a false gavial (*mecistops*), differing from any described in the British Museum Catalogue, and I have also been able to ascertain several peculiarities in the habits of this little known animal. Here, three years ago, my black servant shot a common crocodile, ten feet long, which I have had skinned, and I believe it will, as I mentioned, from an examination of the skull, in a paper sent to the Zoological Society, prove a distinct species. I have also some new lizards and a snake. I have many additional fish. I have better specimens of the large scaled one I have already written to you about, and I have also a skeleton. I have one which I do not know where to place. It is soft, and with very small scales, lengthened, and somewhat cylindrical. Snout produced; eyes very small, anterior; tail tapering to a long point; dorsal fin soft, extending along whole length of back; no anal nor ventral fin; pectoral fin small. Of this fish, besides smaller ones, I have a skin upwards of five feet long. Of *Polypteri*, after examining a good many specimens, I am sure there are two varieties, if not species, differing in form of tail, in form of head, and in size of teeth. One has a more rounded lengthened head and larger teeth; the other, a flattened depressed head and smaller teeth: the dorsal fin also is situated nearer the head in the one than in the other. Among the lower orders, my additions have been principally among insects. Shells, either land or water, are very scarce. I have also got another new myriapod, and some more spiders. Our botanical collection is really extensive, and must comprise nearly 1500 species, besides seeds, fruits, woods, products, &c. Our last novelty was a Cycad, found a few days ago by Barter, on a height not more than from 250 to 300 feet above the river. We have also a good many living plants ready to be sent to Kew. We have found but one fossil here, and I am going to send it to Sir Roderick Murchison, with a description of the rocks, which are very interesting. Our fossil is vegetable, apparently a small stem—no leaves. Our river, since the 4th of this month, has been steadily rising, and we hope soon now to see our ship. It has been very much later than we even reckoned upon. This is a very dry spot, and though rain often falls within a few miles of us, we are without it; and yet we are living among rocky ridges and hills from 40 to 150 feet above the river. On the opposite side of the river, where the hills are 400 feet or upwards, showers often fall, and the attraction of these hills has often saved us from severe tornadoes, the storm clouds passing along that side. The weather is now however pleasant, the maximum in the shade seldom exceeding 90° or 92°, often lower; and the minimum varying from 71° to 74°. Now, the greatest cold is from 4 to 5.30 A.M.; but in the dry season, especially in December and January, when we had extreme heat and cold, the minimum, often 60°, was from 6.30 to 7 A.M. We all keep well and in excellent spirits, having abundant occupation to keep us employed.

I have got good living specimens of *Bos d'ante* and of the *B. taurus* of the country, and I am comparing them accurately, and drawing up a table of their characters and differences, and I am also collecting all the habits of *B. d'ante*, many of them being unrecorded.

But I must conclude, and with kind regards to Lady Richardson, believe me, my dear Sir John, very faithfully yours,

(Signed) WM. BALFOUR BAIKIE.

P.S.—If you are writing for mail of Oct. 24, please send your letter to my agents, Messrs Hallet, Maude, and Hallet, Great George Street, Westminster, and they will forward it.

Letter from DR JAMES STARK *to* PROFESSOR BALFOUR.

SCOTTISH METEOROLOGICAL SOCIETY,
EDINBURGH, 15*th October* 1858.

DEAR SIR,—Mr Angus M'Intosh, the Registrar of Lagan, in Inverness-shire, sends the following report, which I think would prove acceptable to your readers. You can make what use of it you think proper.—Ever truly yours, JAMES STARK.

"During a severe thunder-storm on the 14th of August, the top of one of the hills on the north side of the Spey was struck by lightning, and from the effects produced the flash would appear to have been of more than ordinary force. The part struck consists of a bare conical point of red granite about thirty feet in circumference, and rising about six feet above the surrounding ground. The flash seems to have descended perpendicularly,—splitting off a slice about three feet thick from top to bottom, and shattering it to pieces. Several of these, weighing two or three hundred weight, were thrown a distance of from twenty to thirty yards. After striking, the flash appears to have separated into two divisions, one of them plunging straight into the ground, excavating a hole about four feet deep and sixteen feet in circumference, the loose stones being thrown off in all directions with great force, some of them ploughing up the ground like cannon balls; the other division, branching off to the left, opened a trench down the side of the hill for about sixty yards, smashing every stone large or small with which it came in contact, and finally plunged into a deep peat-moss."

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science, Meeting at Leeds, September 22 to 28, 1858.

MATHEMATICAL AND PHYSICAL SCIENCE.

Professor Stevelly read a communication by Professor Powell, in continuation of his report of last year, on *Luminous Meteors.* It stated that no further discoveries of any note had been made during the past year. The subject of spurious discs had also engaged much of his attention. In the course of a conversation which ensued, it was stated that the altitude of meteors was between forty and fifty miles from the surface, and was the same at Greenwich or anywhere else.

Mr Balfour Stewart, of Edinburgh, read a paper *on Radiant Heat,* the result of experiments made by himself and Professor Forbes, of the University of that city. He adduced some tables, showing the different degrees of radiation arising from lamp black, plates of glass, rock salt, and other substances, at the same degree of temperature, both as regards their quantity and quality.

Dr P. A. Silgestrom's paper *on the Magnetic Dip at Stockholm,* confirmed the fact that the dip reaches its minimum in winter.

Mr W. Ladd exhibited a very fine specimen of a modification of Ruhmkoff's Induction Coil, which extended to the length of six miles.

He made some brilliant experiments to show the intensity of the electricity contained in the apparatus.

Mr J. P. Gassiot, assisted by Mr Ladd, then read notes and experimented on the phosphorescent appearance of electrical discharges in vacuum, made in tubes of flint glass, and of German glass made with potash, and on induced electrical discharges when taken in aqueous vapours. A distinction was exhibited in the flint and in the potash glasses, the former showing a bluish and the latter a light greenish tint. The glasses had been manufactured in Bonn, and at present none were obtainable in England.

Mr H. Dircks *on an Apparatus for Exhibiting Optical Illusions illustrative of Spectral Phenomnea.* A model of the apparatus was placed on the table, and Mr Dircks explained its construction as follows:—An oblong chamber is divided into two parts, which are separated by a glass screen, each chamber being twelve feet square. One of these chambers should have three of its walls solid, the other being the glass screen. The ceiling must be of different parts to let in the light. The line of vision is about 45 degrees, with respect to the glass screen. The figure placed before the screen is so strongly reflected that the spectator cannot tell whether it is an illusive or a real body. The reflection of the figure could not be seen, except by diminishing the light by degrees, until the proper point is reached.

Mr J. Park Harrison gave some *Further Evidence of Lunar Influence on Temperature,* pointing out the particular phase of the moon at which atmospheric changes occurred.

The Rev. G. Earnshaw *on the Mathematical Theory of Sound.* The author explained that the theory of sound must still be considered imperfect, in consequence of resting on an approximative step in the mathematical part of the investigation. The results were exhibited in a simple numerical form, and made use of to explain several interesting phenomena, such as the wasting away and divergence of sound; the peculiarity on which the sweetness of musical sounds depends; aud it was shown that the velocity with which a sound passes through the air depends on the rapidity and intensity of its formation, but not on the length of the sound-wave. The more violent the genesis of a wave of sound, the more rapid should be its transmission. It had been one of his greatest discouragements in comparing theory with experiment, to find that experimenters on sound appeared to agree unanimously that all sounds, whether gentle or violent, travel with the same speed. On this point theory and experiment seemed to be discordant; experimenters had said that there was no difference in the speed of the human voice, and the report of a cannon, but the mathematical theory showed that the report of the cannon should travel more quickly than that of the human voice. This point, however, was fortunately set at rest by its transpiring at the meeting that in Captain Sir J. Franklin's expedition to the north, whilst making some experiments on sound, during which it was necessary to fire a cannon at the word of command given by an officer, it was found that the persons stationed at the distance of some miles to notice the arrival of the report of the gun, always heard the report of the gun before they heard the word of command to fire, thus proving that the sound of the gun's report had outstripped the sound of the officer's voice, and confirming, in an unexpected and remarkable manner, the result of mathematical investigations.

The Astronomer-Royal said, he had made some experiments on the waves in a canal. The character of the wave changed as it went on. It was well known that at the mouth of a river the rise and fall was the same, but that farther up the rise was done in a much shorter space of time than the fall. He believed that the two peculiar characters of sound—roar and hiss—were severally analagous to the breaking of water.

The Rev. J. DINGLE, Incumbent of Lanchester, Durham, read a paper *on a New Law of Binocular Vision.* Its object was to point out a singular law by which an imperfection incident to binocular vision is obviated. It sometimes happens that, in looking at a field of view at some distance, objects considerably nearer are so interposed as to present themselves in the picture formed in one eye and not in the other. Thus, in looking at a landscape, if the finger or any other object is held before one eye, the image of it on the one retina only is superposed on a part of the landscape formed in the other eye. On mere physical principles this might be expected to blot out or greatly confuse that part of the landscape upon which it was placed in the sensorium; but upon trial this is not found to be the case, as that part of the landscape is merely a little dimmer than the rest, but is equally distinct and as truly coloured. By various experiments the author had ascertained that this was the result of a peculiar power of the will, by means of which the mind is enabled, when two different objects are superposed in the sensorium, to select whichever it pleases, to bring that object into view, and entirely to obliterate the other—it sees, in fact, whichever it wills to see, and the other image, simply by being neglected, become invisible. In ordinary vision the determination of the image to be seen is effected by the same act of the will which determines the position of the optic axes, but by certain arrangements the predisposition to select either of the images may be obviated, and it may be made indifferent which of the two that occupy the same space in the sensorium shall be seen. When these arrangements are made, it is found that mere efforts of the will can alternately bring either the one or the other into view. The importance of this law, which enables the mind to select its image, was pointed out in different cases of ordinary vision. It obviates the difficulty already adverted to, of having two different pictures on the same spot; it also, to some extent, remedies the effect of squinting, by obliterating the picture in the imperfect eye, which could not else be done without shutting it. The effect of the law in some extraordinary cases was also noticed, especially in the power of the fancy to fix images on the sight, as Sir Isaac Newton instances in his own case. The author pointed out the great interest of the subject, not only in its practical aspect, but also as having an important bearing on the connection between mind and matter.

Col. SYKES called attention to the fact of Mr Broun, the astronomer, having successfully established a meteorological and magnetical observatory in Travancore, at 6200 feet above the level of the sea; and to the result of magnetical observations at Trevandrum, as communicated in a letter from Mr Broun to General Sir Thomas M. Brisbane. Col. Sykes also spoke of the difficulties which this eminent astronomer had encountered in his endeavour to construct the observatory on the highest peak of the Ghats. He then read a communication from Mr Broun to General Sir Thomas Brisbane as to the result of magnetical observations at Trevandrum. He said that the observations he had made respecting the symmetrical and well characterised curves which represented the movement of the daily mean force from the beginning of January till the end of March 1844, and which were communicated to the scientific world by him on several occasions, had been found to agree perfectly with those made at Trevandrum. One result to which he had arrived was, that the changes of mean horizontal force from day to day were in the same direction over the globe, and were proportional to the horizontal forces at the places; the different effect of disturbance due to its diurnal period, and the different directions of the secular change being allowed for. Mr Broun further stated that he was not satisfied with the observations made at Makerstoun and Trevandrum, but he undertook the discussion of the subject at Hobarton, Van Diemen's Island, the Cape of Good Hope, and other places. The reductions were laborious, as the astronomer had to obtain the temperature coefficients, and to correct the observations by his own processes. The result, however, was, not only that the annual law was the same at Makerstoun and Hobarton, but that the changes of the individual monthly means followed generally the same law. The variations of the daily mean force from hour to hour were felt simultaneously on all meridians, and they appeared to be independent of the sun or moon. He could prove satisfactorily that the diurnal variation was not due to the sun's heating power, whether on the earth's surface or its atmosphere; but that it may be due to the sun's magnetic action on the atmosphere appeared to him to be much more probable.

Dr Lee read a paper *on the Results of the Measures of Gamma Virginis for the Epoch,* 1858, *as determined by Admiral Smyth.*—He said, that he had again the gratification of presenting results of the position of this important double star, for its last apparition, as observed at the Hartwell Observatory, with corresponding results obtained at Greenwich, by Mr Airy; at Haddenham, by Mr Dawes; at Tarn Banks, by Mr Fletcher; and at Wrottesley, by Lord Wrottesley. The discrepancies were certainly greater than might have been expected under the present easy state of the object, but on the whole a very satisfactory epoch was gained. One of Sir William Herschel's most interesting discoveries was the Gamma Virginis, whose observed and computed places have generally been found to agree within the limits assigned to probable errors of observation. This star now presents a system which affords, by actual changes, both in angular velocity and distance,—the former varying inversely as the square of the latter with the elliptical orbital elements deducible therefrom,—incontrovertible evidence of the physical connection of its constituent members. This binary star has been very assiduously watched by various astronomers, especially during the last thirty years, and the results obtained are converting probability into demonstration respecting its being subject to the same dynamical forces which govern our own system. Every advance tends to prove the universality of the Newtonian influence of attraction, obeying the Keplerian law of areas. In a word, by warranting the conclusion of the inconceivable extent of the controlling agency of gravitation, it forms a wonderful and sublime truth in astronomical science.

The Rev. Dr Lloyd called attention to the instruments employed in the magnetic survey of Ireland, and also stated some of the results. He said that the survey was nearly terminated, so that nothing now remained for its completion except the determination of some of the instrumental constants. The instruments employed were a theodolite magnetometer and a dip circle furnished with an apparatus for the determination of the earth's magnetic force in absolute measure. The theodolite differed from the instruments hitherto in use, the difference consisting in observing the sun and other celestial bodies by reflection, and transferring the transit adjustments to the axis of the mirror employed for that purpose. By that arrangement the observing telescope was always horizontal and in readiness for the magnetic part of the observation. He gave some details respecting the result of the experiment, which had been found to be somewhat similar to those discovered on a previous occasion, in which survey Dr Lloyd was also engaged.

Dr Lee submitted a paper *on the new variable Star, "R. Sagittarii,"* by N. Pogson, Esq., of Oxford.—The writer said, that on the limit of a rich and widely-spread group of stars, Professor Argelander, of Bonn, observed one of the 8½ magnitude in his F zone No. 227, on the night of August 7th, 1849. Exactly seven years later, while carefully charting in the vicinity, Mr Pogson found the assigned position unoccupied; but entertaining no suspicion of variability, he supposed an erratum to exist in the published zone, and simply noted the star as missing. On July 3d of the present year, whilst looking over his chart with the Smythian telescope, Mr Pogson was struck by finding a fine star of nearly the eighth magnitude not recorded in the chart. A micrometer was immediately applied, and an observation taken, with the aid of a sidereal chronometer kindly lent him by the Royal Geographical Society, but this observation only established its fixity, and thereby proved that it was not one of the small planets, but most probably a new variable star. Subsequent comparisons confirmed this conclusion. Combining his own observations with those of Professor Argelander, it appeared to Mr Pogson to be most probable that seven maxima occurred between August 7, 1849, and July 3, 1858, in which case the period would not differ much from 465 days, and the next maximum would fall due in September or October 1859.

Edward Joshua Cooper *on the Perihelia and Ascending Nodes of the Planets.*—The paper set forth, that the writer had, previous to 1851, made some observations on this subject which had been communicated by him to the scientific world. The last notice which he sent to the Royal Society was last year, when the number of known planets was 51. There were now 62, but no elements of the last had been as yet computed. Taking 61 of these, he stated that the perihelia of 42 are found in the semicircle of heliocentric longitude between 0° and 180°, and only 19 in the remaining semicircle. With reference to the ascending nodes of the 60 planets, 42 were likewise found between 0° and 180°, and only 18 in the remaining semicircle. But the appended table shows some remarkable results, viz., that when there were only 4 known asteroids and 7 large planets, or, if adding Neptune, there was 12 in all, the perihelia of 10 of these were found between 0° and 180°, and of the nodes of the 11, none were in the semicircle 180° to 360°. The table also shows that, adding to the first 12 those subsequently discovered in groups of 10, the number of the perihelia and number of ascending nodes in each semicircle were about almost exactly similar. It was also a subject worthy of notice that the perihelia and ascending nodes were frequently grouped together in a remarkable manner. The tables are as follow, which show the number of planets in each semicircle :—

Perihelia	0° to 180°	180° to 360°
When 12 planets, there were ...	10 ...	2
„ 22 „ ...	17 ...	5
„ 32 „ ...	25 ...	7
„ 42 „ ...	30 ...	12
„ 52 „ ...	37 ...	15
„ 61 „ ...	42 ...	19

Ascending Nodes.

Perihelia	0° to 180°	180° to 360°
When 11 planets, there were ...	11 ...	0
„ 21 „ ...	18 ...	3
„ 31 „ ...	25 ...	6
„ 41 „ ...	30 ...	11
„ 51 „ ...	36 ...	15
„ 60 „ ...	42 ...	18

Dr Gladstone read a communication by himself and the Rev. T. Pelham Dale, *on some Optical Properties of Phosphorus.*—He said that, phosphorus was known to be highly refractive and disfusive. Its refractive index had been determined at 2·125 or 2·224, a number scarcely exceeded by that of diamond or chromate of lead. This determination was made without reference to temperature, and was that part of the spectrum measured and indicated. Their own experiments, made with instruments belonging to the Rev. Baden Powell, produced numbers which showed not merely a very high refractive power, but an amount of disfusion unknown in any other substance. The disfusive power was nearly twice that of bisulphide of carbon, and largely exceeded that of even oil of cassia; its only rival was that assigned to chromate of lead, but some doubt seemed to rest on that determination. The determinations of the disfusive power of phosphorus made by persons experimenting had indicated an amount scarcely exceeding that of bisulphide of carbon, but a difficulty attending the examination of phosphorus would sufficiently explain this. Phosphorus in a liquid condition had apparently never been examined, as difficulties had arisen from its inflammability, and from the action on cement. An examination of the properties of liquid phosphorus showed a considerable diminution of both the refractive and the disfusive power, it not being in direct ratio with the diminution of density. Liquid phosphorus exhibits a greater amount of sensitiveness than had been observed in any other substance, and it was evidently greater at the high than at the low temperatures. The effect of temperatures on disfusion could not be accurately determined. A saturated solution of phosphorus in bisulphide of carbon was almost as refractive and disfusive as melted phosphorus itself. There was a certain want of clearness in phosphorus which prevented the lines being distinguished without great difficulty, which did not arise from any opacity, or from the crystalline character of solid phosphorus, or from unmelted pieces floating about, for it occurred in a solution of bisulphide of carbon. The addition of phosphorus to bisulphide of carbon rendered the spectrum seen through it misty, according to the amount of phosphorus. This was not due to the great refraction, or the great disfusion, or the great sensitiveness, though this had undoubtedly something to do with it. To what was this due? Different specimens of phosphorus differ widely in respect to this property, and it was perhaps connected with some want of homogeneity in the substance. The phosphorus experimented on was generally colourless. It was a curious circumstance that yellow phosphorus cuts off the extreme red ray—this being the opposite of what yellow bodies usually did, and was remarkable also in connection with the red modification of phosphorus.

Dr Gladstone *on the Fixed Lines of the Solar Spectrum.*—The author exhibited three maps, the first representing the fixed dark bands and lines in the extreme red portion of the spectrum, the second those in the extreme lavender rays, and the third those which make their appearance about the orange and yellow portion when the sun is close to the horizon as described by Sir David Brewster. A long span of atmosphere absorbs also the more refrangible rays, but affects in no way the angular position of these lines. The moon's light shows exactly the same lines as the sunlight, and the dark bands in the orange and yellow equally appear when it traverses much air. That portion of the spectrum which with sun-light appears violet, has a lavender or even grey colour with moon-light. Attempts have been made to determine whether these lines were entirely due to the absorbent effect of the earth's atmosphere, by observations of stars, and of distant artificial lights, but the author thought without a conclusive result. The light from the edge of the sun's disc has just the same lines as that from the centre.

Sir David Brewster said, that he had once made an experiment, and produced similar results to those shown by Dr Gladstone, but they were not so complete. His (Sir David's) experiments were made by a solar telescope given by the Royal Society, the object-glass of which was not achromatic. These experiments had not as yet been brought to a close, but he had already discovered about 1000 lines more than the German philosopher, Frauenhoff. As to where these lines were produced, he was of opinion that it was beyond the region of our atmosphere. They were not produced by the earth's atmosphere, and if they were not produced by the sun's atmosphere, they must be the result of some law of interference.

Mr John Pope Hennessy, Inner-Temple, London, *on some Properties of a Series of the Powers of the same Number.*—He announced the discovery of a general law which regulates the series of the powers of any number. For instance, in the following series of the powers of 5, the number of digits in the several recurrent series may be expressed by the powers of 2:—

5	... ...	1st.
25	... ...	2nd.
125	... ...	3rd.
625	... ...	4th.
3,125	... ...	5th.
15,625	... ...	6th.
78,125	... ...	7th.

390,625	8th.
1,953,125	9th.
9,765,625	10th.
48,828,125	11th.
244,140,625	12th.
1,220,703,125	13th.

He pointed out that a similar law existed for every other number; and he exhibited a formula by which the sum of any of the recurrent series may be determined. He concluded by submitting a regular demonstration of the theorem.

A paper from Major-General SABINE was read by one of the secretaries *on the Magnetic Survey of Great Britain.* It stated that the operation was not now completed, but that he hoped it would be so before the next meeting, in Aberdeen.

Dr LEE *on Rock Crystal Prism Micrometers.*—He said, that this micrometer consisted of a variable eye-piece, viz., one in which the second lens was moveable by a rack-work so as to vary the distance between it and the eye lens. After some general observations, the paper proceeded to say that on viewing a double star through the ocular crystal micrometer two pairs would be seen, the four members of which must be brought into the same straight line by turning the crystal round in its cell. When these four were adjusted, and the scale read off, the magnifying power employed became known, and the measured angular distance was equal to the constant angle of the crystal divided by the magnifying power. By placing the four stars at equal intervals, the double distance would be measured, and the uncertainty of a contact between two perhaps very unequally bright stars avoided, which was highly desirable. It was, therefore, of the utmost importance to know the constant angles of the prisms, also the limits of the magnifying power of the variable eye-piece with all possible accuracy. Dr Lee concluded by setting forth the advantages of this micrometer.

Sir DAVID BREWSTER read a paper *on the Vision of the Foramen Centrale of the Retina,* on which subject Sir David said:—"At the meeting of the British Association which was held in Belfast, I gave an account of a case of vision in which it was performed entirely by the choroid coat, and through the foramen centrale of the retina. The space of distinct vision, as ascertained by the number of minute printed letters which the patient could read, was 4½ deg. In this case, the paralysis of the retina was permanent, and the patient was blind, with the exception of the small amount of vision which he enjoyed through the foramen. In the case to which I now call the attention of the section, paralysis was temporary, and was accompanied with severe headaches; but as soon as the patient recovered her health, the retina resumed its usual functions. In order to find the area of distinct vision, the patient observed with care the number of small and sharply printed letters which she could read at a certain distance from the eye; and upon measuring the breadth of these letters, and their distance from the eye, I found that they subtended an angle of 4½ deg., corresponding with the size of the opening in the retina. These facts, when viewed in connection with those which I described at the Swansea meeting, may throw some light on the functions exercised by the retina as a whole or by some of its individual layers. I have placed it beyond a doubt that the membrane, whether choroid or retina, which occupies an area of 4½ deg. at the extremity of the optical axis of the eye, is, in certain cases, less retentive of luminous impressions, and in others more retentive than the retina. If the microscope proves that there is no retina corresponding to that area, we should consider the choroid coat as the seat of vision. If it should prove that any one of the layers of the retina occupies that area, while the rest are wanting, it will be manifest that that layer is the seat of vision or rather of luminous impressions."

A letter from Mr Wm. M'Craw, of Edinburgh, to Sir David Brewster, *on a new Means of preventing the Fading of Photographs*, was read. To accomplish this object, Mr M'Craw had adopted the following formula:—

1. Take the white of eggs, and add about 25 per cent. of a saturated solution of common salt (to be well beat up, and allowed to subside). Float the paper on the albumen for thirty seconds and hang up to dry.

2. Make a saturated solution of bichromate of potass to which has been added 25 per cent. of Beaufoy's acetic acid. Float the paper on this solution for an instant, and when dry it is fit for use; this must be done in the dark room.

3. Expose under a negative, in a pressure frame, in the ordinary manner, until the picture is sufficiently printed in all its details; but not over-printed as is usual with the old process. This requires not more than half the ordinary time.

4. Immerse the picture in a vessel of water in the darkened room. The undecomposed bichromate and albumen then readily leave the lights and half-tints of the picture. Change the water frequently until it comes from the prints pure and clear.

5. Immerse the picture now in a saturated solution of protosulphate of iron in cold water for five minutes, and again rinse well in water.

6. Immerse the picture again in a saturated solution of gallic acid in cold water, and the colour will immediately begin to change to a fine purple black. Allow the picture to remain in this until the deep shadows show no appearance of the yellow bichromate. Repeat the rinsing.

7. Immerse finally in the following mixture:—

Pyrogallic acid, . . .	2 grains.
Water, ...	1 ounce.
Beaufoy's acetic acid, . . .	1 ounce.
Saturated solution of acetate of lead, .	2 drams.

This mixture brightens up the picture marvellously, restoring the lights that may have been partially lost in the previous part of the process, deepening the shadows, and bringing out the detail. Rinse finally in water, and the picture is complete when dried and mounted. The advantages of this process may be briefly stated as follows:—***First***, As to its economy—bichromate of potass at 2d. per ounce is substituted for nitrate of silver at 5s. per ounce. *Secondly*, Photographs in this way can be produced with greater rapidity than by the old mode. ***Thirdly***, The pictures being composed of the same materials which form the constituent parts of writing ink, it may be fairly inferred that they will last as long as the paper on which they are printed.

A beautiful photograph of Sir Walter Scott's monument at Edinburgh, obtained by this process, was exhibited.

Sir DAVID BREWSTER read a short paper on an optical instrument constructed by Professor Petzval, of Vienna, the peculiarity of which was a new object glass for the purposes of photography. It had been tried in England and Scotland, and the results had been most satisfactory. It was made for the survey of the Austrian Imperial Government.

Mr FOLLETT OSLER exhibited a portable self-registering anemometer of his own construction. Some new improvements were introduced into this machine, which indicated the exact time of the day, and the strength, direction, and duration of a wind storm, and the degrees of longitude and latitude.

CHEMICAL SCIENCE.

The PRESIDENT (Sir John Herschel), in his opening address, said,—He could not help giving expression to his surprise at the astonishing advancement of science during the few past years, when he thought of the magnificent discoveries of Davy, Berzelius, and Faraday, and the researches of Dumas, Liebig, Hoffmann, and other distinguished men in organic chemistry, which, as it were, had been gradually interweaving the organic and inorganic systems of composition in groups such as those of the metallic ethyles, and those of boron and silicon. He objected to the system of notation now in use among chemists, as the formulæ had been gradually taking a character more and more repulsive to the algebraical eye. As sciences do not stand alone, but exist in mutual relation to each other, the language they use, and the signs they employ, should not contradict each other, but should have a free communication on their frontier points. The time may not, perhaps, be far distant when a knowledge of the family to which a chemical element belongs, and its order in that family might be predicated with confidence. A great step in advance had lately been made by Professor Cooke of the Harvard University. According to his arrangement, the elements form six groups, each group having common properties in the highest degree characteristic. The principle affords such family groups as oxygen, fluorine, chlorine, bromine, and iodine; or again, nitrogen, phosphorus, arsenic, antimony, and bismuth. It packs together in two groups all the more active and soluble electropositive elements—hydrogen, lithium, sodium, and potassium; and in another the more inert and less soluble ones—calcium, strontium, barium, and lead. This generalization appears to be a valid one. Chemists are too easily satisfied with the idea that all the atomic numbers are multiples of hydrogen. But until an almost unattainable precision in the atomic numbers is obtained, the theory ought not to be held conclusive, however seductive it may appear. If the phenomena of chemistry were ever reduced under the dominion of mathematical analysis, it would be by a very circuitous and intricate route.

Dr MACADAM read a paper, entitled *Note on the production of a Frosted Surface on Articles made of Aluminium.*—Some aluminium had a short time ago been obtained for the purpose of making medals. When the medals were struck, a peculiar grey appearance was noticed on their surface, which it was supposed arose from the uncleanness of the die. Close examination, however, showed that this was not the case. Some of these medals were subjected to the action of hydrochloric acid and nitric acid separately, without producing much effect on their surfaces. When some of them were put in a solution of caustic potash they were acted on very violently, hydrogen being evolved, and the surface of the metal becoming beautifully frosted. This phenomenon of an alkali comporting itself to a metal as acids do, was worthy of the attention of chemists. After aluminium has been frosted in this manner, it does not become tarnished on exposure to the action of the air.

F. Crace Calvert considered the greatest objection to the use of aluminium in the arts arose from the fact that it decomposed rapidly in water, at 212 deg., and indeed, at all temperatures more or less. A wire of aluminium which he had left closed in a tube of water for twelve months, had become converted into gelatinous alumina. He found the aluminium, mixed with a small portion of iron, was less acted on by water than when pure.

C. W. Bingley, Ph.D., F.C.S., *on the Effects produced on Glass, by Exposure to the Action of Mud in Water.*—Along with several other articles lately found in the lake at Walton Hall, near Wakefield, were a piece of window glass, and the remains of an antique bottle. It is supposed that they have been buried in the mud ever since the hall was attacked by Oliver Cromwell's soldiers. The interest these specimens possessed, in a scientific point of view, consisted in the remarkable appearance they presented after their submersion, possessing hues of colour rivalling those of the first specimens of pearl shells. The mud in which they had been imbedded contained a large quantity of organic matter and sulphide of hydrogen. On scraping the glass with a penknife the coloured part was easily detached in minute scales, those exhibiting the red or deep orange rays of colour coming off easily, when green or bluish scales became disclosed to view, which were with more difficulty removed. The glass underneath appeared as if it had been ground, or subjected to the action of hydrofluoric acid. The scales consisted of silicates of lime with iron, but with no potash or soda. The glass consisted of a silicate of potassa and soda, with a very slight trace of iron and lime. The glass appeared originally to have been a pure alkaline silicate. The potash originally in it appeared to have been replaced by lime and iron derived from the water, in the case of the detached scales. It has been known for a long time that water acts more or less on glass, slowly decomposing it into a soluble alkaline silicate. Scheele observed that water which had been boiled a long time in glass vessels became alkaline. Ebelman published, some time ago, an account of the strong action of water charged with carbonic acid on glass. That ammonia assists the action of moisture or water very materially may frequently be evidenced in the case of stable windows. It is possible that, in the present case, the silica of the glass after the separation of the alkali may have been left in a gelatinous state, as a condition necessary for its subsequent combination with lime and iron, derivable from the water, to form the less soluble silicate of which it is constituted. The glass, viewed by transmitted light, exhibited rays of colour complementary to the reflective rays. The various colours doubtless owe their origin to the different refractive powers of each of the scales, according to the degree of thickness, the red or deep red orange rays being produced by the thickest of them.

Mr W. Huggon *on the Alkaline Water of Leeds.*—This water is met with on boring into the rock from 300 to 400 feet from the surface. At present the water rises to a level in the bore hole about 80 or 90 feet from the surface. Formerly the water used to rise to the surface, but in consequence of its extensive use for manufacturing and other purposes, it is now as low as before stated. It marks about 8 degrees hard on Dr Clark's scale. It sometimes rises from the sandstone rock, and at other times from the blue-band or argillaceous shale. The whole amount of earthy matter in the water is considerable. The following is the analysis of a gallon of water from Ripley's Well, Holbeck :—

Carbonate of Lime, . . .	2·131
Do. Magnesia, . . .	1·023
Do. Iron, . . .	0·045
Do. Soda, . . .	45·620
Do. Ammonia, . . .	0·045
Sulphate of Potash, . . .	1·303
Chloride of Sodium, . . .	52·123
Iodide of Sodium, . . .	0·022
Sulphide of Sodium, . . .	0·740
Bromide of Sodium, . . .	trace,
Silicate of Soda, . . .	1·312
Silica, ...	0·531
Alumina, ...	0·150
Organic Matter, . . .	0·227
	105·270
Total residue by experiment, .	106·250

It will be seen from the analysis that 97 grains of the whole mineral ingredients are carbonate of soda and chloride of sodium, which form the chief characteristics of this water. It also contains a large quantity of dissolved gaseous matter, in the following proportions :—

Carburetted Hydrogen, . . .	1·45
Carbonic Acid, ...	10·50
Nitrogen, ...	2·05
Sulphuretted Hydrogen, . . .	trace.
Cubic inches, . .	14·00

Besides the gases dissolved in the water, a large quantity is continually rising to the surface in bubbles, which explode on the application of a light. The following gases are contained in 100 parts of this explosive compound :—

Carburetted Hydrogen, . . .	75·50
Carbonic Acid, ...	11·45
Nitrogen, ...	13·05
Sulphuretted Hydrogen, . . .	trace.
	100·000

This alkaline water appears to contain, judging from analyses given, a larger amount of alkaline matter than any in England. The nearest approach to it is the water of the Artesian well in Trafalgar Square, which, according to the analyses of Abel and Rowney, contains 18 grains of carbonate of soda in the gallon, and 20 grains of the whole solid matter is chloride of sodium.

Dr Lankester exhibited an instrument for measuring the constant intensity of ozone. This instrument consisted of two small rollers included in a box, which were moved by means of ordinary clock-work. Over the roller a strip of paper, prepared with iodide of potassium and starch, is allowed to revolve, the paper becoming exposed to the air for an inch of its surface, in the lid of the box. Twenty-four inches of paper pass over the rollers in the course of the twenty-four hours, and thus registers, by its colour, the intensity of the action of ozone in the atmosphere. By this instrument the intensity of the ozone for every hour in the twenty-four could be registered, and the *minimum* and *maximum*, with an average, be ascertained. The register of ozone could also be compared with that of the anemometer, and the relation of ozone to the direction and force of the wind ascertained. Dr Lankester pointed out the importance of ascertaining the presence of ozone, on account of its undoubted relation to health. He drew attention to a series of tables which had been drawn up from the registrations of the anemometer made at London, Blackheath, and Felixstow, on the coast of Suffolk. From these it was seen that the relation of these three places was as 0, 22, and 55. The instrument acted also as a clock, and the time could be accurately marked upon the ozonised paper.

Mr J. P. Gassiot, V.P.R.S., *on Electrical Discharges, as observed in Carbonic Acid Vacuo.*—For the purpose of making these experiments, a powerful modification of Ruhmkorff's apparatus for producing the electrical discharge was used. The novel and brilliant phenomena shown caused great applause. When through cold tubes, containing carbonic acid in a very attenuated state, electrical discharges were made, there appeared a very remarkably stratified luminous appearance, which, when the tube was heated, assumed a conical form. Mr Gassiot also showed, in a striking manner, the different phosphorescent appearances of electrical discharges in vacuum, made in flint and potash glasses. A number of glass bulbs, connected by tubes, were used for the purpose. When the current was passed through the apparatus, the bulbs were illuminated by a pale green light, while that in the tubes was blue. Experiments were also made to show induced electrical discharges when taken in aqueous vapour.

Dr Odling said, that a statement made by Mr Gassiot, that electricity will not pass through a tube when the vacuum is as nearly perfect as possible, verified in a remarkable manner the law laid down by Mr Grove some years ago, in his work on *The Correlation of Physical Forces.*

Mr R. J. Fowler *on a Process for the Estimation of Actinism.*—He said, that in drawing the attention of the section to the estimation of the actinic force of the solar radiations his object was rather to add what he presumed were new facts to the science of actinometry than to present a perfect and complete process in every respect. In the 9th volume of Gmelin's *Handbook of Chemistry* he found it stated that "oxalate of ammonia, mixed with aqueous proto-chloride of mercury, is decomposed under the influence of light, yielding sal-ammoniac, calomel, and carbonic acid;" it also stated that "the mixture of the two solutions remains clear in the dark, in daylight it becomes turbid in six minutes, and in the course of an hour deposits calomel, which in sunshine quickly falls down in soft flakes surrounded with bubbles of carbonic acid. The filtrate no longer contains mercury, but chloride of ammonia and undecomposed oxalate of ammonia." On seeing this he was at once struck with the idea that here might be the elements of a process for actinometry, and whether this was the fact he left them to judge from the experiments he had tried on the subject. He found it true that the solutions named might be kept unchanged for an indefinite period in the dark; that the calomel began to precipitate in from 15 to 20 seconds in full sunshine; and also that the precipitate ceased immediately the vessel containing the solution was removed from solar influence, thus showing that the action is not continued in darkness even when the change has been partially effected, and that the action of the actinism is not in this case catalytic. He had also exposed three tubes containing the mixed solutions to pretty uniform light, No. 1 for ten minutes; No. 2 twenty minutes; No. 3 forty minutes; the results being that No. 2 contained twice the bulk of precipitate of No. 1, and No. 3 twice the bulk of No. 2. When the solutions were exposed several hours the vessel containing them was found to be completely filled with a magma of the precipitated calomel. From these experiments it appears conclusive that the mixture of solutions of oxalate of ammonia and proto-chloride of mercury is very sensitive to light, and as this action of light is not catalytic, the precipitate obtained may be considered as produced by solar influence alone; and lastly, that a definite amount of precipitate is produced by a definite amount of actinic force; thus proving that there are elements of certainty and uniformity in the behaviour of the mixed solutions when exposed to solar influence, from which a certain method for estimating the actinic force may be formed. If extreme delicacy were required in the estimations, the precipitate might be collected, dried, and weighed; but, where this was unnecessary, graduated tubes might be used for exposing the mixed solutions, and from which, after standing a certain time in the dark, the amount could at once be read off. Mr Fowler stated that in his experiments he had used a nearly saturated solution of the two salts, but this was by no means necessary, as he found that, if a drop of the solution of proto-chloride of mercury, containing only 1-1500th part of a grain of that salt were added to 300 grains of the solution of oxalate of ammonia, and exposed to the light, the calomel would still be precipitated, the reaction in fact being so delicate that it might be used as a confirmatory test for the presence of the proto-chloride of mercury. He stated in conclusion that it would be interesting to know how the absorbed actinism of M. Niepce de St Victor would affect the solutions. He had made some experiments in that direction, but not with sufficient success to warrant any positive assertions.

Dr A. Matthiessen, F.C.S., submitted a paper, read by Dr Odling. It embraced a description of the very beautiful metals obtained from the alkalies and alkaline earths, and was illustrated by the exhibition of a variety of these metals, as attractive as unusual. The specimens of sodium, lithium, potassium, calcium, strontium, &c., were regarded with great interest, and their combustion in an intensely brilliant white light, elicited frequent expressions of admiration. Their extreme lightness was dwelt on, lithium being lighter than any liquid, and possessing little more than half the specific gravity of water. From magnesium the combustion resulted in an ash hollow throughout.

The reading of the paper was followed by an exhibition, by Mr R. REYNOLDS, F.C.S., of *The Practical Application of Aluminium.*—Mr Reynolds presented for the examination of the section a spoon and fork manufactured by Messrs Coulson and Co., of Sheffield. The spoon closely resembled silver in colour, having, however, perhaps a faint tinge of blue. It could be produced at about half the cost of silver. The weight was only 2½ times that of water, and one-third that of silver. The sensation of handling so light a metal was a very singular one. On the Continent the manufacture of aluminium is pretty general—brooches, studs, &c., being made of it in consequence of its offering, with an alloy of copper, a very close resemblance to gold, in all but the property of weight. Mr Coulson had stated that with from 5 to 10 per cent. of aluminium he could obtain any shade of gold. In reply to Sir J. Herschel, Mr Reynolds said that it resisted the action of sulphur.

On some Double Salts formed with Bichromate of Potash. By Professor SULLIVAN, M.R.I.A.—The paper was read by Dr Gladstone. It commenced with an allusion to Fritzche's process of preparing chromic acid; Professor Sullivan stating that the result of his experiment was the separation—not of bichromate—but of sulphuric acid. The Professor then said, that if a nearly concentrated solution of bichromate of potash be treated with sufficient oil of vitriol to convert the whole of the potash into bisulphate, but not to precipitate the chromic acid and be then set aside, an abundant crystallization of anhydrous bisulphate of potash will be formed. The crystals thus formed are often of considerable size, and beautifully exhibit the peculiar reaction of the anhydrous bisulphate with water, namely, of swelling up and becoming opaque. The crystals are always coloured yellow by the adhering solution, but sometimes they appear to contain some chromate in combination, for even after having been repeatedly dried between folds of filtering paper, they yielded a mixture of bisulphate of potash in acicular needles and orange-red rhombic needles when dissolved in water and re-crystallized. The paper went on to describe the various forms of crystals—with the most extraordinary and beautiful changes of colour resulting from various experimental conditions—the salts being apparently as endlessly varying as they were strikingly attractive. The remarkable mode of decomposition was described on the supposition that the salt contained bisulphate of potash. The determination of the sulphuric and chromic acids gave numbers which upon this view lead to the very simple formula:—

$$\text{Ko, Ho, 2 S}_3 + \text{Ko 2 Cr O}_3.$$

The strangeness of the combination led to a natural hesitancy to attribute to the result a suggested explanation of the phenomena. On the supposition that double salts were obtained, a compound had been obtained, giving, on an equal amount sulphuric acid and chromic acid respectively, the formulæ,

$$\text{KO, HO, 2 SO}_3 + 2\,(\text{KO, Cr O}_3)$$
$$\text{KO, HO, 2 SO}_3 + 3\,(\text{KO, Cr O}_3)$$

The formation of these salts afforded a beautiful example of the influence of mass upon chemical affinity. A further series of experiments led to the variation of the salts in residue, which presented combinations of a very singular kind.

Dr Gladstone, after exhibiting specimens of the purple dye obtained from coal tar, with specimens of silk dyed with it, proceeded to give the description of the dye afforded by Mr W. H. Perkins. Mr Perkins describes it as a product of the oxidation of analine with bichromate of potash. (It is not the same as that produced with hypochloride of lime.) It is a bronze-coloured substance, dissolving in alcohol with a beautiful purple colour. It is with difficulty soluble in water. Like indigo, it is perfectly decolorized by the hydrated protoxide of iron, the colour being restored again by exposure to the air. It dissolves in concentrated sulphuric acid, forming a green solution, which, upon the addition of water, precipitates the colour unchanged, when ejected with an alcoholic solution of potash. It decomposes slowly at 482 degrees Fahrenheit; so it is evidently a very stable body. It is quite applicable for dyeing—in fact, several tons of silk have already been dyed with it. It is also applicable for cotton, wool, &c. The colour is quite as good, if not better, than archil. It is exceedingly intense in colour. One pound of the sold substance will dye no less than 200 lbs. of cotton a moderately dark lilac; and it may be added that the colour dyed on fabrics with it is very permanent, standing the action of light and heat, acids and alkalies perfectly.

Sir John Herschel observed that there appeared to be no limits to the transformations effected by coal tar. After all the useful results we owed to it, it seemed that we were now to be indebted to it for the creation of the most lovely colours. What would next come of it, it was impossible to say.

Dr Pugh *on a New Method for the Quantitative Determination of Nitric Acid.*—He remarked that the fact that chemists generally were familiar with the known methods of determining nitric acid induced him at once to give the method proposed, without referring to the methods already in use. Suffice to say, that none of them yet presented all that was desirable in methods that were used as much as were those for the determination of nitric acid. The highly important part which nitrogen, in the form of nitric acid, played in the vegetable economy—the various forms under which it was constantly appearing as the product of the decomposition of nitrogenous organic matter—the presence of it in all fluids that are exposed to the air—together with its commercial value—rendered it of the highest importance, both in a practical and theoretical point of view, that we should have methods, both exact and easy of manipulation, for the quantitative determination of it. The method which he proposed answered well in his own hands for this purpose, and he hoped it might meet with equal success in the hands of other chemists. It consisted in ascertaining how much of a solution of bichromate of potash, of known strength, was necessary to convert a given amount of a solution of protochloride of tin into perchloride. The point at which the complete conversion took place was ascertained by the decomposition of iodide of potassium, and the liberation of free iodine in the presence of starch;—the intensely blue colour of iodide of starch at this point indicating the reaction. The next part of the process was heating a like quantity of protochloride of tin with the substance containing nitric acid and free hydrochloric acid, in glass tubes, to about a temperature of 300° Fahrenheit. By this means one equivalent of nitric acid, with 8 equivalents of hydrochloric acid, and 8 equivalents of subchloride of tin, form, on thus heating for half an hour, one atom of ammonia, eight atoms of bichloride of tin, and five atoms of water. The amount of nitric acid operated upon could be ascertained either by boiling the solution containing the ammonia formed in caustic potash, and collecting the vapour in an acid solution of known strength, as usual in ammonia determinations, or by ascertaining the amount of subchloride of tin left in the solution after boiling, and then subtracting this from the amount found in the original solution, and calculating the nitric acid necessary to produce the difference in accordance with the above reactions. Both methods gave very accurate results. In five consecutive trials with ·00539 grammes of nitric acid he found—

	Nitric acid		Or nitrogen
	·00541		·00114
	·00541		—
Nitric acid	·00541	Or nitrogen	·00123
	·00532		·00120
	·00546		·00118

Larger quantities of nitric acid gave equally satisfactory results. He closed by expressing his obligations to the kindness of Mr Lawes, of Rothamstead, for having placed at his disposal the very great facilities afforded by his laboratory for making the investigation, without which he could not at this time have made it.

Mr. J. B. Lawes, F.R.S., and Dr J. H. Gilbert, F.C.S., *on the Annual Yield of Nitrogen per acre in different Crops.*—The authors had stated generally at the Dublin Meeting of the Association, that the amount of nitrogen yielded per acre per annum in different crops, when unmanured, was considerably beyond that existing as ammonia and nitric acid, in the measured aqueous deposits from the atmosphere. The object of the present paper was, to illustrate the point experimentally, showing the produce of nitrogen per acre, in the case of crops, each growing for many years consecutively on the same land; namely, wheat 14 years, barley 6 years, grass 3 years, clover 3 years out of 4, beans 11 years, and turnips 8 years. It was also shown that 4 years of wheat alternated with fallow gave as much nitrogen in the 8 years as 8 crops grown consecutively, and 4 crops of wheat grown in alternation with beans gave nearly the same as the 4 grown in alternation with fallow, and consequently just about the same as 8 crops of wheat grown consecutively. In the case of the alternation with beans, therefore, the whole of the nitrogen obtained in the beans themselves was over and above what could have been obtained in wheat alone, whether grown consecutively or in alternation with fallow. Beans and clover yielded several times as much nitrogen per acre as wheat or barley, and yet their growth, taking off so much nitrogen as they did, still was one of the best preparations for the growth of wheat; and, adding nitrogenous manures, had much the same result upon the cereal crops. But over a series of years not more than about 4-10ths of the nitrogen annually supplied in manure for wheat or barley, in the form of ammonia, would be recovered in the immediate increase of crop. Was this unrecovered amount drained away and lost? Was the ammonia transformed and evaporated? Did it remain in the soil in more fixed combinations? Was ammonia, or free nitrogen given off during the growth of the plant? Or, how far there was only a further distribution of the manureal matters applied for these crops—those such as the leguminous crops, which assimilated so much more, gathering more rapidly and from a wider area of soil, and leaving largely an available nitrogenous residue within the range of collection of the cereal crops? These questions, among others, required elucidation before agricultural facts could be satisfactorily explained. Comparing the amount of nitrogen yielded by the different crops with the amount falling in rain as nitric acid and ammonia, the result of three years' analysis of rain showed that all the crops yielded considerably more, and some very much more, than so came down to the soil. The same was the case when the several crops had been grown in rotation with one another throughout two or three successive courses without manure. It had yet to be shown what was due to absorption of ammonia or nitric acid from the air by the plant itself, or by the soil; what to the *formation* of ammonia or nitric acid from the free nitrogen of the air; or whether plants assimilated the free nitrogen of the air. Several of these points were under investigation, the authors having in this the valuable assistance of Dr Pugh. There, of course, still remained the wider questions of the original source, and of the distribution and circulation of combined nitrogen in the soil, in animal and vegetable life on the earth's surface, and in the atmosphere above it.

GEOLOGY.

The President (Mr Hopkins) in opening the section said, that in compliance with a notification he had received from the secretary of the Association, he had prepared a few introductory remarks, and he then proceeded to observe:—The existence of mammalian life in its earlier stages on the surface of our planet, the condition of its existence, and the period of its introduction, have always furnished questions of the highest philosophical as well as palæontological interest. You will be aware that some geologists regard each new discovery of mammalian remains, in formations preceding the older tertiaries, as a fresh indication of the probable existence of mammalia in those earlier periods in which no positive proof of their existence has yet been obtained; while others regard such discoveries only as leading us to an ultimate limit, which will hereafter define a period of the introduction of mammalia on the surface of the earth, long posterior to that of the first introduction of animal life. Be this as it may, every new discovery of the former existence of this highest class of animals must be a matter of great geological interest. An important discovery of this kind has recently been made, principally by the persevering exertions of Mr Beckles, who has detected in the Purbeck beds a considerable number of the remains of small mammals. The whole of them are, I believe, in the hands of our President, Mr Owen, for the determination of their generic and specific characters; but Dr Falconer seems already to have recognised among them seven or eight distinct genera, some of them marsupial, and others probably placental, of the insectivorous order. I may also notice, as a matter of great palæontological interest, the recent discovery of a new ossiferous cave, near Brixham, in Devonshire, of which some account is to be brought before us during this meeting. The past year has been fruitful in palæontological researches, but it is not my purpose to notice them in detail. I proceed to one or two points of interest in the physical department of our science. The internal structure of rock masses, with reference to joints, planes of cleavage, and crystallization, is a subject of great interest to those who would study the operation of physical causes in producing all the modifications of state through which the matter now forming the outer crust of the globe must have passed in the lapse of geological time. A considerable number of observations have been made by different geologists respecting the positions of the planes of joints and of cleavage, but I confess myself little satisfied with any laws of the phenomena, unless deduced from observations of far greater accuracy of detail than that by which these observations have generally been characterized. I allude more particularly to this subject, because some progress has, I think, been made in the mechanical explanation of a part of these phenomena—those which relate to the laminated cleavage structure. Direct experiments have been made by Mr Sorby and Dr Tyndall, which leave no doubt of the possibility of producing this structure by direct pressure alone; and in certain simple cases, in which the divisional planes form a system of parallel laminæ, this mechanical cause may be sufficient to account for the phenomena. But in many other cases in which there appear to be several systems of these planes of structure, the positions of which would seem to bear determinate relations to each other, it would appear extremely difficult to account for the phenomena by the simple operation of pressure alone. It is likely, I conceive, that more complicated causes have been at work, though pressure may have exercised an important influence. Again, it has been suggested that what has been termed the force of shrinkage, or that internal tension which may be produced in extended masses by their contraction from the loss of heat or moisture, might be sufficient to account for the formation of joints, the positions of which, you will recollect, approximate more or less to verticality. But there is one curious feature in these phenomena which appears to me inexplicable on this theory. It is well known that, in conglomerate formations in which large boulders are imbedded, the joints pass completely through the boulders without any apparent interruption. According to this theory, these boulders must have been pulled in two by the force of shrinkage. It is in this that the difficulty I allude to consists; for it would appear, I think, extremely difficult to conceive how the general motion of such a conglomerate, whatever may be the force with which it contracts, should obtain a sufficiently powerful grasp on the two opposite halves of a smooth and rounded boulder, a few inches in diameter, to pull them asunder. I suspect in all their phenomena the working of some agencies more refined than those of simple compression and extension. The subject of the motion of glaciers is one of interest to geologists, for unless we understand the causes of such motion, it will be impossible for us to assign to former glaciers their proper degree of efficiency in the transport of erratic blocks, and to distinguish between the effects of glacial and of floating ice, and those of powerful currents. An important step has recently been made in this subject by the application of a discovery made by Mr Faraday, a few years ago, that if one lump of ice be laid upon another, the contiguous surfaces being sufficiently smooth to ensure perfect contact, the two pieces in a short time will become firmly frozen together into one continuous transparent mass, although the temperature of the atmosphere in which they are placed be many degrees above the freezing temperature. Dr Tyndall has the merit of applying this fact to the explanation of certain glacial phenomena. There are two recognised ways in which the motion of a glacier takes place—one by the sliding of the whole glacial mass over the bed of the valley in which it exists, and the other by the whole mass changing its form in consequence of the pressure and tension to which it is subjected. The former mode of progression is that recognised by the sliding theory; the second is that recognised by what has been termed the viscous theory of Professor Forbes. The viscous theory appeared to be generally recognised. Still, to many persons it seemed difficult to reconcile the property of viscosity with the fragility and apparent inflexibility and inextensibility of ice itself. On the other hand, if this property of viscosity, or something of the kind, were denied, how could we account for the fact of the different fragments into which a glacier is frequently broken, becoming again united into one continuous mass? Dr Tyndall has, I conceive, solved the difficulty. Glacial ice, unlike a viscous mass, will bear very little extension. It breaks and cracks suddenly; but the separate pieces, when subsequently squeezed together, again become by regelation (as it is termed) one continuous mass. After some general remarks on the cause of the laminous structure of glaciers, during which he remarked that there was no doubt Dr Tyndall was right in supposing the laminæ of blue and white ice to be perpendicular to the directions of maximum pressure, he said that it remained to be decided whether the explanations which had been offered were correct, but the actual perpendicularity of the laminæ of ice to the directions of maximum pressure within a glacier, and the probable perpendicularity to those directions of the laminæ in rock masses of laminated structure, would seem to establish some relation between these structures in rocks and glacial ice, giving an interest to this peculiar structure in the latter case, which it might not otherwise appear to possess for one who should regard it merely as a geologist.

The Rev. T. W. NORWOOD read a paper *on the Comparative Geology of Hotham, near Cave,* in which he described the lower, middle, and upper lias formations as there occurring; and exhibited animal and vegetable remains from the latter rock. He contended, on the evidence both of lithological structure and fossils, that the oolite of Hotham quarry is not Bath oolite, as has hitherto been said, but the lower part of the inferior oolite.

The Rev. E. TROLLOPE, *on the Geology of a part of Lincolnshire hitherto unexplained.*—His remarks were confined to the coast near the Wash, and he said there were abundant evidences of the alternate submergence and elevation of a large part of the district within the human period, which he attributed to volcanic causes.

Mr H. C. SORBY, *on the Currents present during the Deposition of the Carboniferous and Permian Strata in South Yorkshire and North Derbyshire.*—This was a continuation of a branch of geology, on which the author has already published several papers, pointing out how the direction and characters of the currents present during the deposition of stratified rocks may be determined. The neighbourhood of Sheffield is extremely well fitted for this inquiry, and, from residing there, the author has been able to examine minutely a large tract, and lay down the direction of the currents in many hundred localities on large maps, which were exhibited and explained. The chief conclusions to be derived from his observations are, that during the period of the millstone grit there was a very uniform general current from the north-east, slightly interfered with by a tide setting from the north-west, and by the action of waves and local wind-drift currents produced by the powerful westerly gales. This general north-east current was also present during the deposition of the lower part of the coal strata, but ceased towards that of the central and more productive portion, when in different localities and beds the currents were from all parts of the compass; but the relative amount of material drifted from different quarters bears a very striking analogy to the amount of wind that blows from various parts of the compass, as if the wind was the effective cause of the currents, and the tide and general north-east current had ceased to exist. During the deposition of the magnesian limestone the sea was subject to a very decided tide, rising and falling with great uniformity from W.S.W. to E.N.E., amongst a number of shoals, on which surface waves stranded, chiefly produced by easterly winds, as if the sea was far more open to the east than towards the west. There must, therefore, have been a very great change in physical geography between the periods of the carboniferous limestone and the magnesian limestone, since at those epochs the directions of the rise and fall of the tide were nearly perpendicular to each other, which may perhaps indicate as great a change in the distribution of the land and sea as if the tide in the English channel was to cease to flow in its present course, and was to set right over France into the Mediterranean.

Mr T. P. Teale, *on the Deposits of the Aire Valley.*—He stated that in consequence of the discovery of some bones of the hippopotamus in the valley of the Aire, near Leeds, seven years ago, the deposit in which they were found was invested with considerable interest, and with the desire to aid in determining the geological age of the deposit, he made some inquiries on the subject, which he now proposed to lay before the section. The bones which had been found included those of the hippopotamus major, of an elephantine animal, an ox, and the remains of smaller mammalia; but before coming to the deposit in which they were found, it would be necessary to describe the superficial deposits of the district. There were three distinct deposits, namely, blue clay, yellow clay, and warp; the first overlying the outbreak of the coal formation, the second overlying the first, and the third overlying the other two, and filling in the spaces caused by denudation, being sometimes found resting both on the blue and yellow clay, and occasionally on the coal. In the blue clay they found a number of stones, the characteristics of which were that they were rolled, water-worn, and far travelled. In the yellow clay the stones were angular and sub-angular, little worn, but not far travelled. In the third deposit, namely, the warp, they found the osseous remains he had mentioned. The warp also contained both angular and rolled stones, and consisted of the *debris* of the blue and yellow clays, and of the gravel brought down the valley. It continued to the surface, up to a level of about 150 feet. Such was the general character of the deposits; and the inferences he drew from the facts he had stated were, first, that the blue clay was a glacial drift of submergence; second, that the yellow clay was a glacial drift of emergence, under a more gentle current; third, that the warp was a newer deposit than the glacial drift; and fourth, that the hippopotamus major and the elephant existed in these lands subsequent to the glacial period.

The bones, of which many fine specimens have been collected, were exhibited.

Mr Travis Clay expressed his general concurrence in the remarks of Mr Teale, but added that, in the valley of the Calder, warp was found at an elevation of 200 feet.

Mr Teale explained, that in the remark he made he referred to the neighbourhood of Leeds. Where the valley was narrower, the warp was found at a much greater elevation.

Professor Phillips said that the facts which Mr Teale had brought before them would assist in determining the succession of the various mammalia, and the period when they lived, as well as in elucidating the glacial phenomena of this part of England.

Professor Ramsay said he was familiar with similar phenomena in Wales to those mentioned by Mr Teale, and remarked, that there must have been a great change in the temperature after the second glacial period, as it was well known that the hippopotamus could not live in a climate where the rivers were even occasionally frozen over. He supposed that the hippopotami had lived in the river, and that the elephants and other animals named had roamed along its banks, all occasionally being drowned by floods and inundations, and their bones becoming imbedded in the warp. He thought it of great importance that they should endeavour to ascertain the course of the rivers in the district during the geological periods referred to.

Mr J. G. Marshall, *on the Geology of the Lake District.*—The subject of the paper was purely of a speculative character, the object of the writer being to explain some of the geological phenomena of the lake district, on the supposition of metamorphic, instead of igneous, action. He gave a very minute description of the geological formations, following generally the classification of Professors Sedgwick and Phillips, and maintained that both the positive and negative evidence which these formations afforded were in favour of the hypothesis that the granites and slates of the lake district were metamorphic, and not irruptive; that what appeared to be now alternating and interstratified igneous and sedimentary or aqueous rocks, porphyries, and slates, were originally all sedimentary, but being of varying chemical composition, when all were together subjected to heat and pressure, some were changed into porphyries, whilst others were merely hardened, and remained slaty rocks. To test this theory, he had subjected samples of Skiddaw slate, green-stone porphyry, and roofing slate to a series of experiments, under great heat and pressure, and generally the results were satisfactory, but as he could not bring to bear the agency of water, they were not conclusive.

Mr W. Pengelly read a paper *on a recently discovered Ossiferous Cavern at Brixham, near Torquay.*—He described with great minuteness the structure and formation of the cavern, and the means which had been taken for its excavation and exploration, remarking, that upwards of 2000 bones of animals had been found in it, amongst which were mingled flint knives and heads, evidently made by man. Mr Pengelly concluded his paper by stating that the means at the disposal of the local committee were quite inadequate for continuing the exploration in a satisfactory manner.

Professor Ramsay read a report which had been forwarded by the local committee at Brixham to the general committee of the Association, from which it appeared that Dr Falconer had found amongst these ossiferous remains the bones of the rhinoceros, bos, horse, reindeer, cave bear, and hyena, and also several well-marked specimens of flint-knives, generally accepted as of Celtic manufacture.

Professor Owen said, he was glad that measures had been taken for the careful exploration of this cave, but it would be premature to raise any hypothesis until the whole of the facts were before them. He had not yet seen any of the bones, and indeed was entirely indebted for what he knew on the subject to the paper which Mr Pengelly had read; and he should refrain, therefore, from expressing any opinion, but he wished to caution them against coming to conclusions as to the antiquity of these remains, which were not really warranted. He proceeded to show, from the remains of tigers, elephants, and other animals found in this country, in Siberia, and other parts of the world, where the climate was much colder than was supposed to be compatible with their existence, that there was undoubted evidence that these animals could adapt themselves to cold and temperate climates as well as to torrid ones, and remarked that the conditions of animal life were not those of climate, but of food and quiet. Wherever there was the prey, undisturbed by man, there also would be the destroyer. They had evidence from the writings of Julius Cæsar of the existence in England, 2000 years ago, of three distinct species of animals, including two gigantic species of ox, and one of the reindeer, and he was himself satisfied that they had once had a native British lion, all of which, however, were now extinct in this country, and he saw nothing in the remains which had been discovered at Brixham to lead him to suppose that the animals lived before the historic period, or which was inconsistent with the concurrent existence of a rude race of barbarians. At the same time, he was open to conviction, and should be very glad to see a good fossil human being, which should prove that man had been much longer upon the earth than historical evidence led them to suppose.

Professor Phillips gave an account of *the Hematite Ores of North Lancashire*, embodying in his remarks the substance of a communication from Mr R. Baker, jun., on the Hematite deposits of West Cumberland. The districts of North Lancashire and West Cumberland, to which reference was made, were said to be exceedingly rich in valuable deposits of iron ore, and were now producing probably not less than one million tons per annum. Notwithstanding, however, their value and importance, they had not been carefully examined until a recent period, and some interesting geological phenomena had been observed, which threw considerable light on the age of the iron ore formations of West Cumberland and North Lancashire. The ironstone of these districts was found in immediate connection with mountain limestone, and many persons had been in the habit of regarding iron ore as of the same age as the mountain limestone, and as being part of the limestone series; but a careful observation of the district of North Lancashire would go far to remove this opinion. Running across the mountain limestone of that district there was a vast hollow; and it was in these hollows that the ore is found, lying between the limestone, and resting on one side, upon what was evidently a great line of fault, as well as in the fissures and hollows of the rock, with all the indications of a later deposit. The communication of Mr Baker showed that iron ore was not confined to limestone, but was also to be found in connection with the new slate formations, and that it was not a deposit peculiar to the limestone. The opinion which he had formed on this subject he by no means wished to be accepted as a positive conclusion; but the position of the ore, upon the faults of the limestone as well as in the fissures and hollows of the rock, went to prove that it was a subsequent formation. The latest date to which it could be referred was the Permian deposits. He was inclined to believe that these lines of faults and fissures were due to the action of causes which preceded the period of the Permian system, and that the iron formation might generally be referred to the age of the Permian rocks, and occasionally to a still later date, namely, that of the New Red Sandstone. He was satisfied that it would not do to refer the iron ore of Lancashire and Cumberland to the period of the mountain limestone.

Mr Page exhibited the skeleton of a seal which had been found in the Pleistocene clays of Stratheden, in Fifeshire—the only remains of the seal family which had yet been discovered in any of our post-tertiary deposits. The Springfield brick-works, where the remains were found, are about nine miles from the open sea of St Andrew's Bay; more than five from the highest influence of the tide in the estuary of the Eden; and the clay hills rise from 120 to 150 feet above the medium tide-level of the German Ocean. There are several well-marked ancient sea-margins in the valley of the Eden, whose estuary, now only about three miles long and less than a mile in breadth, must have extended fully twenty-five miles inland, and ranged from two to five miles in width. The most marked of these old sea-levels are at 20, 40, 60, 90, 150, and 200 feet above the present sea—the lowest yielding shells, &c., wholly of the existing shores, though over-lying a well-marked submerged forest of pines, oak, birch, hazel, alder, and other British trees; the second containing bones of the whale, and several shells of boreal species; the third and fourth rarely containing remains, and the fourth bones of whales and the skeleton now in question. The clay in which the skeleton was embedded is a bright red plastic clay, evidently derived from the waste of the old red sandstone of Upper Stratheden when the waves washed the bases of the present hills, and the streams brought down from the lower Ochils the *debris* of the same formation. It contains no boulders or pebbles, and appears to have been a slow deposit, in water of considerable depth, and removed from the influence of drift, either vegetable or animal, from the adjacent shores. It rests on the true boulder clay, which is there a dark blue tenacious mass of great thickness, and replete with boulders of granite, syenite, greenstone, gneiss, quartz, and other primary formations. The descending section shows—arable soil and sandy clay three feet; laminated sand one foot; from 15 to 20 feet of red plastic clay, in which the skeleton was imbedded at a depth of 12 feet—the whole being underlaid by blue boulder clay of unknown depth. From the position of the red clay, and the disposition of the associated gravel mounds, it is evident that it is younger than the boulder bed on which it rests, and that it is as old at least as the 150 feet beach, and greatly older than the silts and gravels which in the Forth, Clyde, and Tay, have yielded remains of whales, antlers of gigantic red deer, skulls of the *Bos longifrons*, wolf, bear, and beaver, and shells, many of which are of boreal species. How much younger than the boulder clay we have no direct means of determining, though evidently much older than the human occupation of Britain, which must have then been sunk to a depth of from 150 to 200 feet below its present level. As regards the skeleton itself (which is in a wonderful state of preservation), it seems to be a pretty widely divergent variety of the common seal (*Phoca vitulina*), if not a distinct species, a point, however, that yet awaits the precise determinations of the comparative anatomist. If the same as the existing seal, then it invests that creature with a high degree of antiquity; if of a different species (boreal or more southerly), then it shows the high age of these brick clays, and may assist to identify their position in other localities.

Professor PHILLIPS made a communication *on some Phenomena at the junction of the Granite and Schistose rocks in West Cumberland, and on the Slaty Cleavage in the Lake district.*—He described three orders of phenomena, all due to some form of heat-action, observed by himself in the slate district of Black Comb, and on the north-west border of that mountain. In the mountain of Black Comb the black slates, much contorted, are not in a metamorphic state. Several dykes or interposed bands of granite (elvan) lie in the slates of the north-western part of Black Comb; they very slightly affect the condition of the slates. Round a considerable part of Black Comb the green-slate series is metamorphic, and the series of changes is such that from unaltered slate at one end, new structures appear and augment (not very regularly), so as at the other end to complete a green or black porphyry. Agate concretions appear in some places in long pipes parallel to cleavage dip. This remarkable series of changes is traced with great precision in a bold narrow ridge of rock near Booth, one end of which almost touches the black slate, the other is met by a tongue of granite. Near the junction the granite is hornblendic (syenite); it enters the metamorphic series in veins of fissure, and produces on that series further small changes of colour and texture apparently proportioned to the mass of the introduced rock. Thus, in one district, possibly due to one general cause, the earth's internal heat, but operating through a long time, three distinct orders of phenomena appear, for each of which a special investigation is necessary, and to which, when fully understood, a special explanation may be applied.

Mr H. C. SORBY *on some Peculiarities in the arrangement of the Minerals in Igneous Rocks, and on a New Method of determining the temperature and pressure at which various Minerals and Rocks were formed.*—"Very often in igneous rocks," said Mr Sorby, "infusible minerals had been formed upon such as were far more fusible, which was a very unintelligible peculiarity, if they supposed that the temperature at which they crystallised was the same as their own fusing point, when heated alone. The object of this paper was to show that this fact, as well as several important peculiarities in the microscopical structure of the minerals, may be readily explained by supposing that the fused rock is simply a liquid that melts at a high temperature, capable of dissolving various minerals, in the same manner as salts are dissolved in the very fusible substance, water. On cooling to a certain extent, the crystals are deposited from solution, and thus crystallise out at a temperature which must be somewhat lower than the fusing point of the mineral when heated alone, and may be much lower than that. This supposition completely explains why a fusible mineral may act as a nucleus for one that is much less fusible; and it was shown that this peculiarity may be imitated artificially, for when saline aqueous solutions are cooled so as to solidify, crystals of very infusible salts are actually deposited on previously formed crystals of ice."—On the second part of the subject, Mr Sorby said, "If a given volume of air is enclosed in a tube, and it be taken to a place where the temperature or pressure of the atmosphere is different, the difference in the temperature can easily be determined from the change in the volume of the air, if the pressure is known; or the difference in pressure, if the temperature is known. Where crystals are formed artificially from solution in water, they catch up and hermetically inclose in their solid substance small quantities of the liquid, so as to produce fluid cavities, which are full of the liquid at the temperature at which they are formed, and can easily be seen with a suitable magnifying power. If, then, the temperature be considerably higher than the ordinary heat of the atmosphere, and there were no great pressure, when cold, the fluid contracts so as to leave a vacuity, the relative size of which can be measured with the microscope micrometer, and employed to determine the heat at which the crystal was formed. Also, if generated under great pressure, if the temperature was known, the amount of the pressure could be determined. In applying these principles to natural crystals, it was shown that the quartz of veins, and that forming the principal constituent of metamorphic schists, must have been deposited from water at a temperature of 400 Fahr. and upwards. The minerals in the blocks ejected from modern volcanoes, and the quartz forming one of the constituents of some trachytes, contain fluid cavities, which indicate that they must have been formed at a dull red heat. If it is supposed that the quartz in granite rocks also crystallized at the same temperature, the pressure under which they were formed can be calculated. In this manner the author has arrived at the conclusion that elvans were consolidated under a much greater pressure than trachytes, and granite at a still greater pressure. The actual pressure under which elvans and granites were formed, as thus calculated, is of the same general order of magnitude as that under which the lava at the force of modern volcanoes must become solid, judging from the height to which the lava rises above the bases; as if elvans and granite were the unerupted lavas of ancient volcanoes, variously protruded amongst the superincumbent strata. It was also shown that the rocks in the Highlands of Scotland were formed under a very much greater pressure than the corresponding rocks in Cornwall, there being a remarkable agreement between the results deduced from the fluid cavities in the various igneous and metamorphic rocks."

Mr Page *on further contributions to the Palæontology of the Tile Stones, or Siluro-Devonian Strata of Scotland.*—The paper was illustrated by a number of fine fossil specimens, including a land plant, fishes, (from what has hitherto been called the Old Red Sandstone), and crustacea (partly from the Old Red Sandstone and partly from the Siluro-Devonian of Scotland).

Professor Owen *on a new Genus and Species of Pterodactyle, with remarks on the Geological Distribution of Flying Reptiles.*—He exhibited a drawing of the skull and some of the wing-bones and other limb-bones of a Pterodactyle, which he had obtained during a recent visit to Lyme Regis, in Dorsetshire. The specimen in question was discovered in the lower lias of that locality, and had been purchased for the British Museum. The fore part of the cranium was preserved anterior to the orbit, measuring in length six inches. This was peculiar for the vast expanse of the long nostril, which was oval, and measured three inches by one and a half inch; the antorbital vacuity, divided by a slender oblique bar from the nostril, was triangular, one inch five lines in long diameter; the solid part of the premaxillary in advance of the nostril, measured only one inch nine lines in length, or little more than half the length of the nostril—proportions which had not been previously observed in any Pterodactyle. The largest teeth were implanted in this part of the upper jaw. One, which had been displaced, and showed the oblique basal cavity and depression, formed by a successional tooth, measured more than an inch in length. The largest exserted crown of a premaxillary tooth in place measured seven lines. A tooth situated three inches and a half behind the first tooth, had a crown five lines in length; then followed three shorter teeth, and behind these, and below the antorbital vacuity, were several small teeth, with intervals. The dentary bones of the lower jaw were preserved, measuring 6½ inches in length. These exhibited a peculiarity of dentition not previously described or figured; viz., two long prehensile teeth at the fore part of each ramus, separated by an interval of half an inch, and followed, after a similar interval, by a series of much more minute and close-set teeth, with straight, short, compressed, lancet-shaped crowns, none of which exceeded a line in length. Forty-five of these teeth might be counted in an alveolar extent of two inches nine lines, and in a part of the dentary bone averaging eight lines in depth. This character of dentition was such, that the figure published by Dr Buckland of the fragment of a jaw found in the same lias at Lyme Regis, with similar minute serial teeth, "like one another, flat, and shaped at the point like a lancet," and which he believed was "probably that of our Pterodactyle," was deemed by most palæontologists to have been rather a portion of the jaw of a fish. The *Pterodactylus Bathensis*, and *Pterodactylus Gemmingi*, distinguished by an edentulous production (*processus mentalis*), from the forepart of the jaw, had three or four large teeth next behind that process, followed by several smaller teeth; and these Pterodactyles formed the genus *Ramphorhynchus* of V. Meyer; but the hind teeth were not nearly so numerous and minute as in the specimen from the lower lias, and this had no edentulous *processus mentalis.* So marked a difference from the dentition of the species of the true *Pterodactylus*, represented by *P. longirostris*, *P. crassirostris*, as well as from the mandibular and dental characters of the *Ramphorhynchus* of V. Meyer, appeared to call for the subgeneric separation of the *Pterodactylus macronyx* of Buckland, from the later forms of *Pterosauria*; and Professor Owen proposed the name *Dimorphodon* for this new sub-genus, in reference to the two kinds of teeth, or two features of dentition, one of them borrowed, as it were, from the fish or batrachian, by this early form of flying dragon. Among the bones associated with the skull, the author defined the lower half of a radius and ulna, four metacarpals, including the very thick and strong one of the wing-finger; the first, second, and great part of the third phalanges of that finger; phalanges, including two unequal ones, of the short claw-bearing fingers. Portions of the radius and ulna, and the entire metacarpal of the wing-finger of the other fore-limb; a few vertebræ and ribs. Only three of these bones could be compared with the first specimen of a Pterodactyle from Lyme Regis, described by Dr Buckland; their respective lengths were as follows:—

Pterodactylus (Dimorphodon) macronyx.

	1st Specimen. In.	Lines.	2d Specimen. In.	Lines.
Length of metacarpal of fifth or wing finger, ...	1	5	1	8
Length of first phalange of do. do.	3	9	4	6
Length of second phalange of do. do.	4	0	4	9
Length of a claw phalange, . .	0	8½	0	9

By this comparison it was shown that the second specimen was larger than the first, but differed so slightly in the proportions of the first and second phalanges, as not, in Professor Owen's opinion, to justify a distinction of species; more particularly since, on the supposition of the portion of jaw figured by Dr Buckland having belonged to the same individual as the limb-bones figured by the same author, the first specimen of *Pterodactylus macronyx* had the same sub-generic character of mandibular teeth as the second specimen from the same formation and locality.

Some portions of thin-walled hollow bones from the upper beds of the lias of Wirtemberg might belong to the Pterodactyle genus; in which case they would indicate the oldest examples known of the flying order of reptiles. The oldest certainly known Pterodactyles were, at present, the *Pterodactylus macronyx*, Bd., of the lower lias, forming the type of the sub-genus *Dimorphodon;* and bones of Pterodactyle from the coeval lias in Wirtemberg. The next in point of age was the *P. Bathensis*, from the "Posidonomyenschiefer" of Bonz, in Bavaria, answering to the alum shale of our Whitby lias. Then follows the *P. Bucklandi*, from the Stonesfield oolite. Above this came the first defined and numerous species of Pterodactyle from the lithographic slates of the middle oolitic system; as at Solenhofen, Pappenheim, and Nusplingen, in Germany, and from Cirin, on the Rhine. The Pterodactyles of the Wealden were, as yet, known by only a few bones and bone fragments; as had hitherto been also, those of the "green sand" of Cambridgeshire. Finally, the Pterodactyles of the middle-chalk of Kent, so remarkable for their great size, constituted the last forms of flying reptiles known in the history of the crust of this earth.

Sir Roderick I. Murchison gave *the results of his Researches among the Older Rocks of the Scottish Islands.*—He commenced his observations by indicating the various steps which had been made in developing the geological structure of Scotland, from the days of Hutton and Playfair through those of Jameson and M'Culloch, to the state in which the subject was advanced a few years ago by the proofs of the existence of considerable numbers of organic remains of Silurian age in the southern Scottish counties, which, from the wild and hilly outline of most of them, had been termed the "Southern Highlands." He then gave a sketch of the knowledge progressively acquired respecting the structure of the North Highlands, pointing out, besides that which might be termed a lithological and mineral description of the oldest rocks, that little or nothing had been effected in determining their true relative order of superposition, still less the identification of any of their members by the evidence of fossil organic remains. With the Old Red Sandstone, all red conglomerates and sandstones, whether on the west or on the east coast, had hitherto been merged. Passing over the presence of masses of oolitic or Jurassic age (Brora, &c.), which he had formerly described in a memoir published in the Transactions of the Geological Society, he showed to what extent Professor Sedgwick and himself had, thirty years ago, ascertained an ascending order from gneiss covered by quartz rocks with limestone into overlying quartzose, micaceous, and other crystalline rocks, some of which have a gneissose character. They had also observed what they supposed to be an associated formation of red grit and sandstone; but the exact relations of this last to the crystalline rocks were not ascertained, owing to bad weather. In the meantime they, as well as all subsequent geologists, believed that the great and lofty masses of purple and red conglomerate of the western coast were of the same age as those on the east. In addition to the researches of Mr Cunningham, the observations which the author made in the summer of 1855, when accompanied by Professor James Nicol, were communicated to the geological section at their last meeting at Glasgow, and to the abstract of that memoir, as published in the volume of the Transactions, he referred, as indicating the then state of knowledge, and proving the existence of a lower gneiss, as being clearly superposed by a younger series of crystalline rocks, as seen in any section from N.W. to S E. across Sutherland, Caithness, Ross, Inverness, &c. The great feature, independent of the order of superposition, which has given to some of these lower rocks their most distinctive character, is the discovery by Mr C. Peach, in the crystalline limestone subordinate to the quartz rocks, of certain imperfect organic remains, which even at the Glasgow meeting he had affirmed (on the authority of Mr Salter) to be of Lower Silurian age. He was indeed convinced, from the physical position of the masses alone, and their inferiority to it, the great and diversified series of old red or Devonian age of the east coast, that such was the epoch of their accumulation. Now, although he had also observed, in company with Mr Nicol, the clear interposition of a great mass of coarse red conglomeritic grit between the older gneiss (see Memoir in Trans. of British Association) and the quartz rocks, the extent of this interpolation had not been traced; nor, again, owing to very stormy weather, had he been able to satisfy himself that this red conglomerate and grit was or was not conformable to the overlying quartzites and limestones. Aware that his friend Colonel James, R.E., was about to visit Sutherland, Sir Roderick requested him to determine this point; and this was clearly and satisfactorily accomplished by Colonel James, who traced over a considerable area a complete discordance between the red and purple sandstones of the north-west coast and the overlying crystalline rocks. Later in the same summer, Professor Nicol, revisiting Sutherland, extended the whole of similar physical phenomena from Cape Wrath down all the west coast to Lochalsh, in Ross-shire, and published his results in the Quarterly Journal of the Geological Society. So far, then, as the physical order was concerned, *i e.*, from the fundamental or older gneiss up through great mountains of purple and red conglomerate unconformable to the rocks both below and above, and then a series of quartz rocks with limestones, covered by younger gneiss, no doubt remained. But a doubt did remain in the mind of Professor Nicol as to the value of the parallel he (Sir Roderick) had endeavoured to establish between the fossils of these lower limestones and those of lower Silurian age; and, entertaining this scepticism, he suggested that the quartzites and limestones might be the equivalent of the carboniferous system of the central trough of Scotland. Wholly dissenting from that hypothesis, Sir Roderick urged Mr Peach to avail himself of his first leisure moments to re-examine the fossil beds of Durness and Assynt, and the result was the discovery of so many forms of undoubted lower Silurian characters (determined by Mr Salter), that the question has been completely set at rest—there being now no less than nineteen or twenty species of Maclurea, Murchisonia, Onceoceras, Orthoceras, &c., of which ten or eleven occur in the lower Silurian rocks of North America. Having revisited the region this summer, accompanied by Mr Peach, Sir Roderick had on this occasion good weather, and this enabled him to satisfy himself of the clear and unmistakeable grand succession of rocks as above indicated, and to confirm the views which he had laid before the Geological Society last session, although the printing of his memoir has been deferred until the results of this last survey should be added to it. Whilst the author is convinced that great crystalline and subcrystalline masses, occupying the central and eastern parts of Sutherland and Ross, are of younger age than the siliceous rocks of the north-western Highlands, he fully admits that there may be tracts in that vast extent of country where the older or fundamental gneiss may be brought to light. The succession here described is in perfect harmony with the general order in North America, as worked out by Logan in Canada, and confirmed by geologists of the United States, and by the recent visit of Professor Ramsay, for in that quarter of the world there exists a wide spread of ancient gneiss, which is termed Laurentian, surmounted by a series of stratified coarse sub-crystalline rocks, termed Huronian, and the last again followed by sandstones and limestones, some of which, classed as lower Silurian both by Logan, in Canada, and Hall, in New York, contain the very same fossils as the rocks of the west of Sutherland. The intercalated purple and red sandstones (No. 2, of the Highland series), therefore clearly represent the Cambrian rocks, and are separated from the old red of the east coast by the whole series of the quartz rock, limestone, micaceous, and quartzose schists, all of which have afforded the materials out of which the true old red series has been formed. The second part of the communication related to the Old Red Sandstone, properly so defined, and exhibited on the east coast, between Banffshire and Morayshire on the south, and the Orkney and Shetland Islands on the north, various points of which the author visited last summer. In Caithness and the Orkney Islands, accompanied by Mr Peach, the author made various interesting additions to his former knowledge. And his belief was sustained that the ichthyolitic flagstones of Caithness, and the Orkneys, with their numerous fossil fishes, constitute the central member of the old red series, the lower part of which is made up of powerful conglomerates and a very great thickness of thin-bedded red sandstone, the whole resting on the crystalline rocks, whilst the central flagstones are surmounted by other sandstones rarely red, and usually of yellow colour, which occupy the headlands of Dunnet Head, &c. In Morayshire, Sir Roderick made transverse sections, in company with the Rev. G. Gordon, of Birnie, from the edge of the crystalline rocks (there a micaceous flagstone, in part used as slates) to the maritime promontories of Burghead and Lossiemouth, and was convinced that the yellow sandstones in which the air-breathing reptile, the *Telerpeton Elginense*, was found, are truly part and parcel of the old red or Devonian series. In exploring the coast range from Burghead to Lossiemouth, Sir Roderick observed that the strata had been thrown up on an anticlinal, trending parallel to the more inland ridge in which the Telerpeton was found, and that whilst the inland ridges are associated with hard sub-crystalline cornstone (limestone), first described by Professor Sedgwick and himself as analogous to the old red cornstones of England, so the coast ridge, folding over, dips beneath another band of similar cornstone, which in its turn is overlaid by flag-like deep red sandstone, clearly seen as reefs at low water. In all this Morayshire series there rests not a trace of a carboniferous plant, and the strata are so bound together by mineral characters and fossil remains, that they must all be grouped as old red or Devonian. Where fossil plants have been found, as in Caithness, and there the formation puts on a very different mineral aspect, the plants which have been obtained, and which have been described by Hugh Miller and Mr Salter, are all distinct from those of the coal period. The chief additional data which had been gained by Sir Roderick during his last visit were owing to the discovery by Mr Martin, of Elgin, of a large bone in the beds at Lossiemouth, which had formerly afforded the huge scales of the supposed fish called Staganolepis, by Agassiz. On visiting these quarries with Mr G. Gordon, he was so fortunate as to discover other portions of this large animal, so that comparative anatomists may now determine whether it belongs to fishes or reptiles. However this point may be decided, the existence of true reptiles, during the formation of this deposit, is established beyond a doubt; since many slabs have been found in the coast quarries of Cummingside and Coveseahill, belonging to Mr Alexander Young, in which are the foot-prints of both large and small animals, each foot-print having the impression of three or four claws to it. The specimens have been sent to the Museum of Practical Geology, London. No doubt can now be entertained of the presence of large reptiles, as well as the little Telerpeton, in this upper member of the Old Red Sandstone. In respect to the great masses of sedimentary deposit lying along the eastern and southern faces of the crystalline rocks of the Grampians, which have been hitherto all classed as pertaining to the Old Red Sandstone, Sir Roderick does not pretend as yet to be able, from the slight examination he has made of these, whether at various former periods, or in returning southwards during the present year, to be competent to describe their detailed relations. On these points, however, he begs to offer the following suggestions. The true base of the Old Red Sandstone, properly so called, is seen in Shropshire to be red rock, containing Cephalaspis and Pteraspis, which rock gradually passes down into the summit of the grey Ludlow rock, and in both of these contiguous and united strata, remains of large Pterygoti, but of different species in the two bands, are found. Now, although the Arbroath paving stone, and the grey rocks ranging to the north of Dundee, much resemble the uppermost Ludlow rock, they contain the *Cephalaspis Lyellii*, and if therefore classed with the Devonian rocks, they must, under every circumstance, be viewed as the very base of that natural group. It follows, therefore, that certain great conglomerates on the flanks of the Grampians which underlie all those grey rocks with Pterygoti, can no longer be classed as they have been, with the old red or Devonian, but must represent some portion of the Silurian system. In speaking of the lowest member of the Old Red Sandstone as characterized by the *Cephalaspis Lyellii*, the author expressed his conviction that in the north-eastern Highlands and Caithness the zone is represented by a vast thickness of this bedded red sandstone and conglomerates which had been already adverted to as lying beneath the Caithness flags. The author, who had recently visited Dura Den, in Fifeshire, in the company of Lord Kinnaird and the Rev. Dr James Anderson, declared that there could be no doubt whatever that the yellow sandstones of Fife pertain truly to the old red group, are entirely subjacent to the lowest carboniferous sandstones, and are of the same age as the upper yellow sandstones of Elgin. A drawing of a splendid *Holoptychius nobilissimus*, nearly three feet in length, which was found on the occasion of this visit, was exhibited, and as this species abounds in the lower and red portions of the deposit, and also occurs in the overlying yellow sandstones, associated with *Holoptychius Andersoni* and *H. Flemingii* of the latter, the age of the deposit is clearly substantiated. In conclusion, Sir Roderick said that this communication must only be considered as a rehearsal of what was to be done with more effect next year at Aberdeen, when further observations would either confirm or modify some portion of his views, though the great fundamental reform of the North Scottish series, proving the ascent from the oldest rocks in Britain on the west coast of the north Highlands to the much younger "Old Red Sandstone" of the east coast, is firmly established.

With reference to the same subject, Professor Nicol, of the University of Aberdeen, addressed the section *On the Age and Relations of the Gneiss Rocks, in the North of Scotland.*—He expressed his regret that on one point he was compelled to differ from his distinguished friend, Sir R. Murchison. He described a section from the Gairloch to the Moray Firth, and showed that the red sandstone and quartzite resting on the gneiss of the west, were cut off by igneous rocks from the supposed overlying gneiss on the east. This band of igneous rock he had traced at intervals for a hundred miles, from Loch Eriboll to Skye, and he therefore concluded that there was there a line of fracture and convulsion, and that the cases of the overlap of gneiss on quartzite were occasioned by a slip or convolution of the strata, and did not mark the true order of superposition. Professor Nicol also pointed out that in the great central region of Scotland, from Aberdeenshire to Argyleshire, the gneiss, limestone, and quartz rock overlaid the mica slate, and did not dip under it, as is usually represented—the gneiss of the Black Mount and Breadalbane Highlands forming a great synclinal trough, resting on both sides on mica slate.

Professor Rogers *on the Discovery of Strata of supposed Permian age in the interior of North America by Mr Meek and other American Geologists.* He said that until about a year ago the Continent of North America, at least the temperate zone occupied by the United States, was not supposed to contain any rocks of a later Palæozoic or Permian age. Only two series of strata, all of an age intermediate between the coal period and the period of the chalk, were known—one, the middle secondary or mesozoic red sandstone of the Atlantic slope; and the other related more nearly to the Triassic than any other European formation. Professor Emmons, the chief of the geological survey of North Carolina, recently proposed to divide the red sandstone series of that country into two groups, the upper of which he admitted to be of the Triassic age, and the lower of which he assumed, upon the evidence of organic remains, to be of the Permian date. The fossils to which he appealed were especially certain reptiles belonging to the lizard tribe, called by Professor Owen, "thecodonts," from the circumstance that the teeth were inserted into the jaws in separate sockets, and not in a row attached to the projecting bony ridge, nor in a groove between two such ridges. Professor Emmons had also discovered, in a coal bed of this red sandstone group, a mammalian fossil, consisting of the left side of the lower jaw of a true mammal. A comparison of this interesting fossil, (of a formation which had hitherto transmitted so very few mammalian remains), with the best figures procurable of the fossil mammals of the oolitic rocks of Europe, convinced Professor Emmons that it was not even generically identical with any species previously known, and he had therefore established for it a new genus, and called it the *Dromotherium silvestre.* In general aspect it bore some resemblance to the marsupial mammalian remains of the English oolites, described by Professor Owen, and so far as any inference could be drawn from this fossil, they must take it as implying an oolitic age in the strata which included it. Professor Rogers submitted that the evidence of this fossil preponderated in favour of an oolitic, or at least Triassic age, rather than a Permian. More recently strata had been discovered by Dr Hayden further in the interior, which bore some analogy to the Permian deposits of Europe in their fossils. Dr Hayden obtained a number of fossils in the Black Hills of the Rocky Mountains, which Mr Meek pronounced to belong partly to the Jurassic formation, and partly to the Permian. One of the most important developments, however, of the supposed Permian fossils, was discovered a year ago by Major Hawn in Kansas, consisting of a variety of shells, stated by Mr Meek to be of the species characteristic of the upper coal measures, and of others which were new to him, but which he inferred to be forms representative of the Permian species of Europe. Subsequently, Dr Cooper made a collection of similar remains from a point 100 miles to the north-east of the locality examined by Major Hawn, which were also submitted to Mr Meek, who, from both, arrived at the conviction that we have evidence, for the first time, of true Permian rocks in North America. None of these fossils were absolutely identical with the well-known Permian species of Europe, but some of them approached to European types very nearly, whilst others belonged to species not hitherto discovered below the Permian formation, occurring occasionally in still more modern strata. The most important fact connected with these fossils, was the presence of some well-known species of the upper coal measures, and it was significant that these species were far more numerous and populous than the new species which showed Permian affinities. It appeared from this evidence, from the absence of any well-defined physical horizon in separating the supposed Permian from the coal formation, and from the intermixture of both Permian and carboniferous forms of life, that these upper rocks were either a prolongation of the coal-bearing strata, or the products of a period intermediate between those of the coal formation and the genuine Permian strata of Europe. It was for geologists to decide which.

Mr Salter expressed a general concurrence in the views of Professor Rogers, that these deposits in Kansas seemed to be related more nearly to the coal formation, as an extension of the upper coal measures, than to the true Permian of Europe.

(*To be continued in next Number.*)

Papers read before the American Association for the Advancement of Science, at the Meeting held at Baltimore, May 1858.

(*Continued from page* 276 *of* vol. viii.)

Mr George Habich *on the Production of Animal Heat by the Formation of Cells.*—It is a general doctrine of organic chemistry, that the decomposition of sugar by alcoholic fermentation is always accompanied by a production of heat, but what the agent is that produces the heat has never been established. Mr G. Habich has succeeded in tracing out this agent in the following manner:—

In a solution of pure cane sugar, which did not contain any proteinous substance, he started the alcoholic fermentation by stirring in yeast-cells. Fermentation took place, but no heat was developed; on the contrary, the temperature of the solution sank below that of the surrounding medium. According to the doctrine mentioned above, the temperature should have risen. From this strange phenomenon Mr Habich concludes thus: In that pure solution of sugar there were no materials for the formation of new yeast-cells; the latter wanting the materials of proteinous substance, which is not contained in the sugar, therefore no new yeast-cells could be formed there; on the contrary, in every such solution of sugar which contains material for proteinous substance,—viz., nitrogen,—we find an exuberant new formation of yeast-cells; and, as Mr Habich established a production of heat proportionate to the mass of cells produced, he infers that the formation of cells is the origin of the heat produced during the fermentation, and that therefore the general doctrine alluded to above,—viz., that in every alcoholic fermentation heat is produced, must be changed thus:—that only in such an alcoholic fermentation, where new yeast-cells are formed, heat is produced. Animal physiologists know well that respiration alone can hardly account for the organic heat constantly produced by living animals. We recognise now a new fountain of heat in the formation of cells, which is constantly and so extensively going on in all living animal organism. The same law will find its application in relation to the heat which we know is produced in the fructification and germination of plants, because also in this case always an extensive formation of cells takes place. The circumstance that young seeds can live and grow under a cover of snow; further, that our trees in winter, though often exposed to an excessively low temperature, yet never freeze, will probably be accounted for in the same way.

Professor Henry thought that the production of heat and the formation of cells were the concomitant results of molecular change. The question was very important, and the main fact should be settled with great care.

Professor Leidy thought it doubtful whether the main fact could be established. He instanced the rapid growth of the fungi, and also the growth of the young branches of plants, as not accompanied by a development of heat. The heat of muscles, nerves, &c., he thought was opposed to the theory.

Primary Divisions of the Vegetable Kingdom.—Professor ARNOLD GUYOT, of the College of New Jersey, Princeton, read a paper upon "the character, natural relations, and relative rank of the primary divisions of the vegetable kingdom, founded on difference of structure; and especially upon the true rank of the class of Gymnosperms."

The grand primary divisions of plants founded upon structure, and now universally admitted by all botanists, are essentially the Dicotyledons, with seeds composed of two seed leaves; the Monocotyledons, with one seed leaf; Polycotyledons or Gymnosperms, with many seed leaves; and Acotyledons, without seed leaves, the seed of which is only a germinative cell subdivided into Acrogens or vascular Cryptogams. and cellular Cryptogams. The first three classes are flowering plants or Phanerogams; the last two are flowerless. The seed being the last effort and the climax of the development of the plant—a plantlet itself—its structure is found to be the best criterion of the structure of the whole plant; and plants which agree in the structure of their seeds, are found also to agree in the structure of all their principal organs.

But while fully admitting the correctness of these primary divisions, we have to determine their true meaning—their organic reactions, as well as their relative rank and perfection, which is so obviously different. Such a view becomes especially important when we try to understand the laws of the development of vegetation in the geological ages. In order rightly to appreciate these relations, we must look beyond the simple fact of the structure, and consider these various structural characters as *means* and not *ends*, and as expressive of functions of the life of the plant. The life of the plant, and the phases of its growth, are the primary facts which are typified by the grand classes of the vegetable kingdom.

The essential organs of the plants are the cellular tissue, the material of which every other organ and the whole plant is made; the leaf, or the respiratory organ, elaborating the raw sap under the influence of the rays of the sun; the stem, supporting the increasing foliage and regulating the circulation of the sap; the flower and the seed, which are the most perfect product of the plant,—the climax of its life. The same predominance of each of these organs characterizes the successive phases of the life of the vegetable.

In the germinative phase the cellular tissue alone is represented; in the next phase the power of the plant is expended in developing the leaf; the formation and consolidation of the stem come next; last of all the flowering and seeding process which terminates the life of the plant, and provides for the perpetuation of the species. The grand classes above mentioned seem closely to correspond, as to the structural character which distinguishes them, to the several organs with a predominance of one of these organs.

The life of the plant, as that of every organism, starts from a germ or undeveloped unit, develops successively every essential organ, which are united at last and harmoniously combined, in their normal subordination, in the perfect plant. Now the grand classes above mentioned seem to represent by their structural character and predominant organs each of these grand phases of the growing vegetable.

The cellular Cryptogams with no true leaves, no stem, no flower, no true seed, evidently correspond to the germinative undeveloped phase.

The vascular Cryptogams, or Acrogens, of which the ferns may be an example, are eminently characterized by the predominance of the leaf. The plant itself is but a leaf, or a bunch of leaves without flower or proper seed, but a beautiful, highly developed leaf, almost equalling the perfection of the dicotyledonous leaf.

The Gymnosperm is distinguished by a highly developed stem as that of the pines, by branches having nearly all the characteristics of the dicotyledonous tree, and still the true vessels fail. The flower is reduced to its indispensable elements; the leaf is linear and poorly developed; the seed has an indefinite number of seed leaves. By all these essential characteristics it stands lower than the Monocotyledons, though apparently higher, judging by the less important organ of the stem.

The flower and seed of the Monocotyledon come to perfection, but the leaf is inferior to that of the Acrogens, and recalls that of the tree ferns. It is still but a partial progress.

In the Dicotyledon at last all the organs attain perfection, and they are, moreover, combined in the normal subordination—leaf, stem, flower, seed, all are more perfect than in any one of the lower classes. It is *the plant*—the harmonious type of the true vegetable.

The rank of each of these classes is that given by the life of the plant itself, and it is the same order which is observed in the successive appearances of those great groups of plants in the geological strata. First, the cellular cryptogamia, water plants; then the acrogens and the ferns, &c. The leaf formation predominating in the coal epoch; the gymnosperms in the secondary formations; and for the tertiary alone, the monocotyledons and dicotyledons predominate, and impart to vegetation its character of perfection.

Arabic Work on Physical Science.—Professor W. D. Whitney read a notice of an Arabic Work on Physical Science of the twelfth century.

The American Oriental Society has lately received from one of its correspondents, the Chevalier Nicholas Khanikoff, Russian Consul-General at Tabreez in Persia, an analysis, with copious extracts from an Arabic work on the Water Balance and its use, within the twelfth century, and which has not hitherto been brought to the knowledge of the learned world. The author is not named, but it appears from data contained in the work itself, that he was a kind of secretary of the treasury to one of the Sultans who ruled in the country beyond the Caspian Sea. He writes professedly to furnish a means to the Treasury whereby pure metals, especially the precious, may be distinguished from their alloys, or precious stones from their imitations. He was conversant with the labours upon the subject of other Arabian authors, and with those of the Greek philosophers. His work is accordingly a picture of the state of Arabic science in the extreme East at that period, and of its relations to the science of the Greeks and Romans. The work is calculated to add not a little to our hitherto imperfect apprehension of the details of Arabic science.

It is virtually a treatise on specific gravities, and the means of ascertaining them, with a statement of results, with full reference to authorities, and with a description and representation of the various instruments employed, and the manner of their use. The author describes and figures five or six different balances and other instruments for determining specific gravity, crediting each to its inventor (among them appears the honoured name of Archimedes), and giving instructions for its manipulation. He also gives a table of specific gravities, as determined by him (the standard being water, like our own), for about sixty different substances, including eight metals, various precious stones, and many animal and vegetable productions, down even to human blood, and the refuse of the digestic processes. Nor are these determinations of a contemptible character for accuracy, considering the rudeness, comparatively speaking, of the instruments made use of, and the want of attention to the various modifying circumstances of temperature, atmospheric pressure, and the like, which are now so carefully taken into consideration. Our author's results are surprisingly accurate, not unfrequently differing by less than a thousandth part from the values obtained by the best modern experiments. They are, for instance, as remarked by M. Khanikoff, more close to the truth than the results of Bayle, the famous French philosopher and physicist, of five centuries later date.

The work is now about to be published by the American Oriental Society, forming a portion of the forthcoming sixth volume of the Society's Journal, with all its tables and illustrations, and I am confident that it will be examined with pleasure by all who are interested in the history of physical science.

SCIENTIFIC INTELLIGENCE.

BOTANY.

The Big Trees of California.—Among the many remarkable natural curiosities of California, not the least is that solitary group of gigantic pines known as the " Big Trees of Calaveras County." Many may have seen the sections of bark taken from one of the group, which are exhibited in the Crystal Palace, and which excite the wonder of all beholders.

The group in Calaveras County are solitary specimens of that race. There are no others of their kind or size on the known globe. It is a singular fact, that the group, consisting of ninety-two trees, is contained in a valley only one hundred and sixty acres in extent. Beyond the limits of this little amphitheatre the pines and cedars of the country shrink into the Lilliputian dimensions of the common New England pine —say a hundred and fifty feet, or thereabout. They are situated in Calaveras County, about two hundred and forty miles from San Francisco, but may be reached in a couple of days by railroad and stage-coach.

A few hunters, in 1850, were pushing their way into the then unexplored forest, when one of them, who was in advance, broke into this space, and the giants were then first seen by white men. Their colossal proportions, and the impressive silence of the surrounding woods, created a feeling of awe among the hunters; and after walking around the great trunks, and gazing reverentially up at their grand proportions, they returned to the nearest settlements and gave an account of what they had seen. Their statements, however, were considered fabulous, until confirmed by actual measurement. The trees have been named *Wellingtonia gigantea.* The basin or valley in which they stand is very damp, and retains here and there pools of water. Some of the largest trees extend their roots directly into the stagnant water, or into the brooks. Arriving at "Murphy's Diggings' by one of the daily lines of stages, either from Sacramento or Stockton, or by the Sonora coach, you are within fifteen miles of the celebrated grove; and from hence there is a pleasant ride to the "Mammoth Tree Hotel." This has been erected within a year or two, to accommodate the many visitors; for the "big trees" have now become objects of general interest.

Adjoining the hotel, with which it is connected by a floor, stands the stump of the "Big Tree," which was cut down three years since. It measures ninety-six feet in circumference. Its surface is smooth, and offers ample space for thirty-two persons to dance, showing seventy-five feet of circumference of solid timber. Theatrical performances were given upon it by the Chapman family and Robinson family in May 1855. This monster was cut down by boring with long and powerful augurs, and sawing the spaces between. It required the labour of five men twenty-five days to effect its fall, the tree standing so nearly perpendicular, that the aid of wedges and a battering-ram was necessary to complete the desecration. But even then the immense mass resisted all efforts to overthrow it, until in the dead of a tempestuous night it began to groan and sway in the storm like an expiring giant, and it succumbed at last to the elements, which alone could complete from above what the human ants had commenced below. Its fall was like the shock of an earthquake, and was heard at "Murphy's Diggings." This great trunk, it is said, in its fall, buried itself twelve feet deep in the mire that bordered the little creek hard by. Not far from where it struck stand two colossal members of this family, called the "Guardsmen:" the mud splashed nearly a hundred feet high upon their trunks. As it lay on the ground, it measured three hundred and two feet. Large trees had been snapped asunder like pipe-stalks, and the trees around were splintered and crushed to the earth. On its levelled surface are now situated the bar-room and two bowling-alleys of the hotel, the latter running parallel a distance of eighty-one feet.

One of the most interesting of the group is that called the "Mother of the Forest." It is now the loftiest of the grove, rising to the height of three hundred and twenty-seven feet, straight and beautifully proportioned, and at this moment the largest living tree in the world. It is ninety feet in circumference. Into this trunk could be cut an apartment as large as a common-sized parlour, and as high as the architect chose to make it, without endangering the tree or injuring its outward appearance.

A scaffolding was built around this tree, for the purpose of stripping off its bark for exhibition abroad. This was accomplished in 1854, for a distance of something over one hundred feet from the ground. Such was its vitality, that, although completely girdled and deprived of its means of sustenance, it annually put forth green leaves until the past year, when its blanched and withered limbs showed that nature was exhausted.

But the dimensions of the whole group sink before those of the prostrate giant, known as the "Father of the Forest." This monster has long since bowed its head in the dust; but how stupendous in his ruin! The tree measures *one hundred and twelve feet in circumference* at the base, and *forty-two feet in circumference* at a distance of three hundred feet from the roots, at which point it was broken short off in its fall. The upper portion, beyond this break, is greatly decayed; but, judging from the average size of the others, this tree must have towered to the prodigious height of at least *four hundred and fifty feet!* There is a chamber or burned cavity in the trunk, broad and high enough for a person to ride through on horseback; and a vast quantity of water accumulates in this great excavation during the rainy season. Walking on the trunk, and looking from its uprooted base, the mind can scarce conceive its astonishing dimensions. Language fails to give an adequate idea of it. It was, when standing, a pillar of timber that overtopped all other trees on the globe. "To read simply of a tree four hundred and fifty feet high," observes a contemporary, "we are struck with large figures; but we can hardly appreciate the height without some comparison. Such a one as this would stretch across a field of twenty-seven rods wide. If standing in the Niagara chasm at Suspension Bridge, it would tower two hundred feet above the top of the bridge, and would be ninety feet above the top of the cross of St Paul's, and two hundred and thirty-eight feet above the Monument. If cut up for fuel, it would make at least *three thousand cords*, or as much as would be yielded by sixty acres of good wood-land. If sawed into two-inch boards, it would yield about three million feet, and furnish enough three-inch plank for thirty miles of plank road. All this, too, is the product of one little seed, less in size than a grain of wheat."—*Cassels' Family Paper.*

ZOOLOGY.

Geographical Distribution of the Trout, Salmo fario.—A very interesting account is published by M. Aug. Duméril, in the September number of the "*Revue et Magasin de Zoologie*" of the discovery of a trout in the rapid streams of Algeria. That form of non-migratory trout of which *Salmo fario* is typical has hitherto been found only in the colder or temperate regions of the Old World, becoming more unfrequent as we reach southern Europe and the East,* and hitherto, we believe, is unknown in Africa. When contemplating the introduction of useful fishes into the colony of Algeria by means of the "*Societé Impériale Zoologique d'acclimàtation*" it was first thought advisable to discover what fresh-water fishes the colony itself possessed; and in these investigations trout were discovered in abundance by Colonel Lapasset commander of the Circle of Phillipville, in the clear rapid streams of the Oued-el-Abäich in Kabyle, whence specimens have been sent to the museum in Paris. M. Valenciennes places it in his genus *Salar*, but states that he cannot refer it to any known species. It is easily distinguished externally by large black and rounded spots regularly arranged upon the sides, and

* Kashmir may also be an exception.

from that circumstance he has named it "Truite a grandes taches" (*Salar macrostigma*). The other distinctions are thus stated :—"Ainsi, aucune n'est aussi trapue ; ses formes en effet, sont ramassées ; les nageoires paires latérales et l'anale on hypoptère sont plus rapprochées les unes des autres qu'elles ne le sont chez ses congénères ; la dorsale ou epiptère, un peu plus haute qu'elle n'est longue, est située plus en arrière, car ses premières rayons dépassent à peine l'origine des catoptes ou ventrales. La caudale ou uroptère, beaucoup plus fourchue que chez aucune truite, se termine per des lobes effilés, dont la longueur est presque double de celle de la portion centrale de cette nageoire."

The formula of the fins is given as follows :—

$$D. \frac{3}{10\text{–}11} - A. \frac{2}{9} - V. \frac{1}{8} - P. \frac{1}{12} - C. \frac{6}{\frac{19}{5}}$$

The general colour has a great resemblance to that of other trouts, and the sides are covered with round dark spots placed in a pale or bright field. The dorsal and anal fins are bordered with black anteriorly; the former covered with small black spots. Along the lateral line on each side is a regular series of large rounded black spots. These become quite distinct opposite the dorsal fin, and from that to the tail are eight in number, gradually diminishing in size.

This short notice is illustrated with a clear and well-drawn lithographic figure, and judging from this, and the description given, we think the trout in question is nothing more than an Algerian form of *Salmo fario*, or common river trout of Britain. The variety may be found in a hundred Scotch localities. The black spots in a clear field are extremely frequent. The markings on the dorsal and anal fins are found in almost every trout, and the large black spots or blotches, from which the name *macrostigma* has been taken, are the remains of the markings common to most young salmonidæ, and which often remain coloured through all stages of growth. The tail is by no means so much forked as in many varieties; the figure, in fact, is a very good representation of a very frequent variety of *S. fario*. This is our opinion, formed from the description and figure; a comparison of specimens may lead us to another; but whether distinct or identical, we are much indebted to the French naturalist for the discovery of this form in Algeria, and the description now communicated by M. A. Duméril.—(W. J.)

GEOLOGY.

Fossils from the Crimea.—The temporary occupation of the Crimea during the war led to some interesting geological discoveries. Specimens of fossils from the various strata were sent to England, and with these, including some formerly sent from St Petersburg, seventy-four specimens have been added to the published lists of fossils from that country. These fossils, with one exception, belong to the Invertebrata. The geological formations show the probability that, at one time, the Caspian and Aral, with the Black Sea, formed a vast inland sea, now separated by the gradual filling up of the communication between them. The existence of coal deposits had been rumoured, but these proved to be lignite of ordinary quality.—(*American Annual of Scientific Discovery*, 1857.)

On the Existence of Forces capable of Changing the Sea-Level during different Geological Epochs.—If, in assuming its present state from an anterior condition of entire fluidity, the matter composing the crust of the earth underwent no change of volume, the direction of gravity at the earth's surface would remain unchanged, and consequently the general figure of the liquid coating of our planet. If, on the contrary, as we have reason to believe, a change of volume should accompany the change of state of the materials of the earth from fluidity to solidity, the mean depth of the ocean would undergo gradual though small changes over its entire extent at successive geological epochs. This result is easily deduced from the general views contained in other writings of the author, whence it appears, that if the surface stratum of the internal fluid nucleus of the earth should contract when passing to the solid state, a tendency would exist to increase the ellipticity of the liquid covering of the outer surface of the crust. A very small change of ellipticity would suffice to lay bare or submerge extensive tracts of the globe. If, for example, the mean ellipticity of the ocean increased from one three-hundredth to one two hundred and ninety-ninth, the level of the sea would be raised at the equator by about 228 feet, while, under the parallel of fifty-two degrees, it would be depressed by 196 feet. Shallow seas and banks in the latitudes of the British Isles, and between them and the pole, would thus be converted into dry land, while low-lying plains and islands near the equator would be submerged. If similar phenomena occurred during early periods of geological history, they would manifestly influence the distribution of land and water during these periods, and with such a direction of the forces as that referred to, they would tend to increase the proportion of land in the polar and temperate regions of the earth, as compared with the equatorial regions during successive geological epochs. Such maps as those published by Sir Charles Lyell, on the distribution of land and water in Europe during the Tertiary period, and those of M. Elie de Beaumont, contained in Beudant's "Geology," would, if sufficiently extended, assist in verifying or disproving these views.—*Professor Hennessy*, "Proc. British Association," Dublin.

On the so-called Triassic Rocks of Kansas and Nebraska, by F. B. Meek and F. V. Hayden.—In several of our publications on the geology of Nebraska, we have mentioned a formation (No. 1 of the Nebraska section) consisting of reddish and yellow sandstones, and various coloured clays, with seams aud beds of impure lignite, holding a position at the base of the Cretaceous series of the north-west. Although entertaining some doubts respecting the exact age of this formation, we have always placed it provisionally in the Cretaceous system, in our published sections.

Having learned through Mr Hawn that a precisely similar group of strata, holding apparently the same position, occurs in North-eastern Kansas, we placed these latter beds on a parallel with No. 1 of the Nebraska section, in a paper read before the Philad. Acad. Nat. Sci., May 1857. Soon after the publication of this paper, however, a few fossils Mr Hawn had shipped to us some time before, from a bed near the base of a section of the Kansas rocks he had furnished us for publication, came to hand. On examining these fossils, we at once discovered they were not, as had been supposed, Cretaceous forms, but similar to those of the Permian of the Old World. From this it became manifest, that in drawing a parallel between the Kansas and Nebraska formations we had carried No. 1 too low in Kansas, by bringing it down so as to include the bed from which these fossils had been obtained.

This misunderstanding in regard to the lower limits of No. 1, in Kansas, also led us to place on a parallel with that formation all the lower two hundred feet of Mr Marcou's Pyramid Mountain section (New Mexico), referred by him to the Trias. Suspecting, however, that No. 1, as thus defined, might possibly include beds not properly belonging to it, we distinctly stated in the closing remarks of the same paper, that we yet wanted positive evidence we might not be making it include beds older than any part of the Cretaceous system.

Although we are now aware that in drawing this parallel between the Nebraska rocks and those of Kansas and New Mexico, we carried No. 1. too low, we yet regard all, or nearly all, of Mr Marcou's Pyramid Mountain section, referred by him to the Jurassic system, as equivalent to the Cretaceous formations Nos. 1, 2, and 3, of Nebraska; while the lower two hundred feet of the Pyramid Mountain, referred by Mr Marcou to the Trias, we think equivalent to the Kansas deposits between the base of No. 1, as we now understand it, and the beds containing the Permian fossils.

In our paper on the collections brought in by Lieut. Warren's expedition to the Black Hill, read before the Acad. Nat. Sci., Philad., March, 1858, we remarked that in consequence of the occurrence in No. 1 of the genus *Baculites*, and numerous leaves closely resembling those of some of the higher types amongst our existing dicotyledonous forest trees, we thought we were hazarding little in referring it to the Cretaceous epoch.

More recently Mr Hawn has published a paper in the Transactions of the St Louis Acad. Sci., in which he places this formation in Kansas and New Mexico (as we had done) on a parallel with No. 1 of the Nebraska section, but refers the whole to the Trias.*

This difference of opinion caused us to examine, with no little interest, during our recent expedition to Kansas, some of the localities mentioned by Mr Hawn, near the junction of the Grand Saline and Smoky Hill branches of Kansas River, with the view of determining definitely whether or not the formation regarded by him as Triassic could really be the same as No. 1 of the Nebraska section. In this we were particularly successful; for we not only found these Kansas formations agreeing exactly in all the details of their lithological characters with No. 1 in Nebraska, but we also discovered in them several good specimens of the same dicotyledonous leaves so abundant in No. 1, at the mouth of Big Sioux River, and at Blackbird Hill, on the Missouri, in Nebraska. Associated with these leaves, we likewise found specimens of the same peculiar trilobate leaf (*Ettingshausinia*) mentioned by Mr Hawn as occurring in the formation referred by him to the Trias, thus establishing beyond the possibility of a reasonable doubt the identity of the supposed Triassic deposits of Kansas, and No. 1 of the Nebraska section.

In regard to the leaves here referred to, we would merely remark that they are abundant in this formation, both in Nebraska and Kansas,

* Trias of Kansas, by F. Hawn. Trans. St Louis Acad. Sci., vol. i. p. 171.

and certainly belong to higher and more modern types of dicotyledonous trees than have yet been found even in Jurassic rocks. Dr J. S. Newberry, our excellent authority in fossil botany, to whom we have submitted the whole collection, decidedly concurs with us in the opinion that the rocks in which they occur cannot be older than lower cretaceous. In a communication recently received from him respecting these remains, he says : " They include so many highly organized plants, that were there not among them several genera exclusively Cretaceous, I should be disposed to refer them to a more recent era."

" A single glance is sufficient to satisfy any one they are not Triassic. Up to the present time, no angiosperm dicotyledonous plants have been found in rocks older than the Cretaceous; while of the eighteen species which comprise your collection, sixteen are of this character." . . . .

" The species of your fossil plants are probably all new, though generally closely allied to the Cretaceous species of the Old World. From the limited study I have given them, I have referred them to the following genera :—*Sphenopteris, Abietites, Acer, Fagus, Populus, Cornus, Liriodendron, Pyrus ? Alnus, Salix, Magnolia, Credneria, Ettingshausinia.*"

" Of these the last two are exclusively Cretaceous, and highly characteristic of that formation in Europe. . . . . . .

" I may say, in confirmation of the assertion that your fossil plants are Cretaceous, that I found near the base of the yellow sandstone series in New Mexico, considered Jurassic by Mr Marcou, a very similar flora to that represented by your specimens, one species at least being identical with yours, associated with *Gryphæa, Inoceramus,* and *Ammonites* of Lower Cretaceous species."

We have only to add, in regard to the formation under consideration, that we think it will no longer be doubted that it really belongs where we have always placed it, in the Cretaceous system.*

Between the base of No. 1 and the beds from which the Permian

* After the reception of a brief preliminary report by us, published last winter in the " National Intelligencer," on the collections brought in from the Black Hills by Lieut. Warren, Mr Marcou published a paper in the " *Archives des Sciences de la Bibliothèque Universelle*" of Geneva (a translation of which has recently appeared in the " New York Mining Journal"), in which, after speaking of some points of difference in our opinions respecting the geology of the " far west," he says, " In other respects, the series of Messrs Meek and Hayden agrees perfectly with mine, and it is with great pleasure I see that these learned geologists admit not only the existence of the New Red Sandstone (Permian and Trias) and Jurassic, but that they are led to regard, as Jurassic, formation No. 1 of their Nebraska Cretaceous series, a formation which, from their description, I have no hesitation in regarding as Jurassic."

It was perhaps owing to the necessary brevity of our preliminary statement of the Jurassic and other discoveries in the Black Hills, seen by Mr Marcou in the " Intelligencer," that he misunderstood us. We have nowhere said we had recognised the Trias in the north-west; nor have we admitted in any of our publications that No. 1 of the Nebraska section is Jurassic. We stated that in consequence of the similarity between the lithological characters of No. 1, and the Jurassic deposits in the Black Hills, and the absence of organic remains near the junction, we were in doubt respecting the particular horizon at which the line should be drawn between them. At the same time, we stated that the beds from which the Jurassic fossils described by us were obtained, hold a position *below* No. 1 of the Nebraska section.

fossils are obtained in Kansas, there is a considerable thickness of red, blue, green, and whitish clays, with a few beds of sandstone, and near the base gypsum deposits. This series may—at least in part—be Jurassic or Triassic, or both (much more probably the former); but until we have some reliable palæontological evidence, it would only be groping in the dark to attempt to define its age; knowing as we do that lithological characters are of no value whatever, as a guide in drawing a parallel between these formations and those of the Old World.

As we expect soon to publish a paper giving in more detail the results of our examinations amongst the rocks in which so many Permian fossils have been found in Kansas, we would merely remark here, that the coal measures of that region pass upwards by imperceptible gradations into an extensive series of rocks, consisting usually of more or less impure magnesian limestones, alternating with generally much thicker beds of blue, green, red, and ash coloured laminated clays, or very soft shales, with occasional beds of sandstone. Into this series nearly all the species of fossils found in the middle and intermediate coal measures pass in great numbers.* Associated with these, however, we occasionally meet with fossils belonging to types regarded in the Old World as characteristic of the Permian epoch. As we ascend in this group of strata, which comprises, nearly, or quite all the Lower Permian, and much of the upper coal measures of Professor Swallow's and Mr Hawn's section† we find the Carboniferous forms very gradually diminishing in numbers, to be replaced by Permian types, or others rather intermediate in their affinities, between those of the Permian and Carboniferous epochs.

Still higher in the series, without passing any horizon of unconformability, or meeting with any *abrupt* change, either in the fossils, or the lithological characters of the rocks, we find, when fairly up into the Upper Permian of Professor Swallow's and Mr Hawn's section, that we have lost sight nearly, or entirely, of all the coal measure types, and meet only with Permian forms.

From these facts, we are inclined to the opinion that the entire series, from near the top of the Lower Permian of Professor Swallow's and Mr Hawn's section, down even lower than the horizon where they draw the line between the coal measures and the Lower Permian,‡ should be regarded as intermediate in age, and as filling the hiatus between the Permian and upper coal measures of the Old World; while we think only the Upper Permian of their section really represents the Permian rocks, as developed on the other side of the Atlantic.

This intermediate series might be very appropriately termed the Permo-Carboniferous group, to indicate its relations both to the Permian and Carboniferous rocks. In case however, it may be thought best, in order to avoid the inconvenience of introducing a new name into our nomenclature, to class it along with either the Permian or Carboniferous,

* Amongst these we recognise nearly all the Carboniferous fossils figured by Mr Marcou in his "Geology of North America."

† Transactions St Louis Academy of Science, vol. i., p. 171.

‡ We found the genus *Monotis* ranging down several hundred feet below the base of what we understand to be the Lower Permian in Professor Swallow's and Mr Hawn's section.

we would certainly place it in the latter, since Carboniferous types greatly predominate in its fauna.

In conclusion, we would state, that there is no unconformability, so far as our knowledge extends, amongst all the rocks of Nebraska and north-eastern Kansas, from the coal measures to the top of the most recent Cretaceous. The whole series in N.E. Kansas, and along the Missouri, as far up as Heart River in Nebraska, where the latest Cretaceous deposits pass beneath the water-level, dip to the north-west. Consequently, the elevating forces that produced this inclination of these various formations must have been called into play—as in the region of the Black Hills—after the close of the Cretaceous epoch, and previous to the deposition of the Miocene Tertiary formations of the north-west.

New Ornithological Periodical.—"The Ibis," a Magazine of General Ornithology, edited by Philip Lutley Sclater, M.A., F.L.S., F.Z.S., &c., has been established by a society of gentlemen interested in the progress of the science of ornithology, with a view of supplying what seems to them to be a desideratum—a method of communication for the many naturalists who are now turning their attention to this interesting study, and an organ through which they may more readily bring their labours and discoveries in different parts of the world before the public. Germany has for several years produced two journals exclusively devoted to this branch of zoology; and it is hoped, therefore, that there will be no difficulty in obtaining sufficient support in this country to carry on the present undertaking, which at present stands alone in its particular field. "The Ibis" will be issued in parts, on the first day of each quarter, forming a yearly octavo volume of about 400 pages, illustrated by eight coloured plates of birds and eggs. For the execution of these, the services of the best zoological artists will be called into requisition.

MISCELLANEOUS.

On the Density and Mass of Comets. By M. Babinet.—All astronomers are agreed that the mass and density of comets are very small, and that their attraction cannot produce any sensible effect upon the movements of the planetary bodies. We shall see that, from the effects observed, combined with the law of optics, we may deduce the conclusion, that the direct shock of one of these bodies could not cause the penetration of the infinitely rarefied matter of which they are composed, even into our atmosphere.

It is a well-ascertained fact, that stars of the tenth and eleventh magnitudes, and even lower ones, have been seen through the central part of comets, without any sensible loss of brilliancy. Amongst the observers who have frequently proved this optical fact, we find the names of Herschel, Piazzi, Bessel, and Struvé. In most instances, says Mr Hind, there is not the least perceptible diminution in the brilliancy of the star.

I shall take as an example the well-known comet of Encke, which is sometimes visible to the naked eye, and generally presents a rounded mass. In 1828 it formed a regular globe of about 500,000 kilometres in diameter, with no distinct nucleus; and Struvé saw a star of the eleventh magnitude through its central part, without noticing a diminution of brilliancy. In an observation of M. Valz, on the other hand, a star of the seventh magnitude almost entirely effaced the brightness of a brilliant comet. Let us start from these observed facts.

Since the interposition of a comet, illuminated by the sun, does not sensibly weaken the light of a star in front of which it forms a luminous current, it follows that the brilliancy of the comet is not a sixtieth part of that of the star, for otherwise the interposition of a light equal to a sixtieth part of that of the star, would have been sensible. We may, therefore, assume, that at the utmost the brilliancy of the comet equalled a sixtieth part of the light of the star. Thus, by this hypothesis, if the comet were rendered sixty times more luminous, it would have a lustre equal to that of the star; and if it had been rendered sixty times sixty times, that is to say, 3600 times more luminous than it was, it would then have been sixty times more luminous than the star, and in its turn would have made the latter disappear by the superiority of its lustre.

The conclusion from this is, that it would have been necessary to illumine the cometary substance more than 3600 times more than it was illumined by the sun, to enable it to cause the disappearance of a star of the eleventh magnitude.

We may assume that the light of the moon causes the disappearance of all the stars below the fourth magnitude; thus the atmosphere illumined by the full moon acquires sufficient luminosity to render stars of the fifth and all lower magnitudes invisible. Between the fifth and the eleventh magnitudes there are six orders of magnitude, and according to the fractional relations of these different orders, we may admit that a star which is a single degree of magnitude above another, is two and a-half times more luminous than the latter. A star of the fifth magnitude is 250 times more brilliant than a star of the eleventh magnitude. Thus the illumination of the atmosphere by the moon is much more intense than the illumination of the cometary substance by the sun itself, since it would be necessary to render the comet 3600 times more luminous to enable it to extinguish a star of the eleventh magnitude, whilst the luminosity of the atmosphere illuminated only by the moon is sufficient to render invisible stars which are 250 times more brilliant.

The disproportion becomes still more striking when we consider, that according to the measurements of Wollaston, to which Sir John Herschel says he sees no objections to be made, the illumination of the full moon is a little less than the eight hundred thousandth part of the full illumination of the sun.

To complete the data of our definite calculation, we shall call to mind that, according to the density of the air in the lower strata of the atmosphere, and its total weight, as indicated by the barometric column, the whole stratum of air which constitutes the atmosphere is equivalent to a stratum of about eight kilometres in thickness, and possessing the density of the air at the surface of the earth.

We have already found that it would be necessary to render the comet 3600 times more luminous for it to extinguish the lustre of a star of the eleventh magnitude. To render a star of the fifth magnitude invisible, it would require to be made 3600 + 250 times more brilliant than it is. In other words, if the atmosphere were 3600 + 250 times less compact than it is, it would be equivalent to the comet. As 3600 + 250 make 900,000, the nine hundred thousandth part of the atmosphere would suffice to produce the same effect of illumination as the comet; but as the latter is in the full light of the sun, while the atmosphere is only illuminated by the moon, when it extinguishes stars of the fifth magnitude, this circumstance gives the atmosphere a further advantage in the proportion of 800,000 to 1, which, under ordinary circumstances, gives the atmosphere a superiority equal to 900,000 + 800,000, or 720 billions. But this is not all; the thickness of the cometary substance being 500,000 kilometres, whilst that of the atmosphere is only eight kilometres, we must increase the above relation in the proportion of 500,000 to 8, which brings it to forty-five millions of billions; thus—45,000,000,000,000,000.

Thus, according to these data, the density of the substance of a comet could not be calculated at so high a quantity as that of the atmosphere, diminished by the enormous divisor, forty-five millions of billions. The shock of a substance so rarefied would be nothing at all, and not the least particle of it could penetrate even into the most rarefied parts of our atmosphere.

According to experiments of my own, gases lose their property of elasticity long before they are reduced to such low density. I do not think that at the ordinary pressure a gas could completely fill a vessel with 20,000 times the original volume of the gas. The substance of comets is therefore a kind of very divided matter, with its molecules isolated and destitute of mutual elastic reaction.

It follows from the preceding, that both the mass and the density of a comet are infinitely small, and without any hypothesis, we may say that a sheet of common air of one millimetre in thickness, if transported into the region of a comet, and illuminated by the sun, would be far more brilliant than the comet.

The mass of the earth, according to the calculation of Baily, may be reckoned at 6,000,000,000,000,000,000,000 kilogrammes.

The matter of comets being assimilated above the air, of which the density would be 45,000,000,000,000,000 times less than that of the ordinary air, this would lead us to assimilate it to the substance of the earth, diminished to about 194,000,000,000,000,000,000 times less than its ordinary density. By this estimate, a comet as large as the earth would only weigh 30,000 kilogrammes; this makes thirty tons of 1000 kilogrammes, or the weight of thirty cubic metres of water. ("Comptes Rendus," 1857, Feb.)

In a subsequent paper presented to the Academie in May 1857, M. Babinet enters into a calculation to ascertain the mass and density of the great comet of 1825, which did not diminish the light of a star of the fifth magnitude seen through the centre of the comet, to the amount of one-fifth. His conclusion, founded on the diminution which light undergoes in passing through air of known rarity, is that the substance of the comet of 1825 possessed a density, which, compared with atmospheric air at the surface of the earth, must be indicated by a fraction having unity of its numerator, and for its denominator a number superior to unity, followed by one hundred and twenty-five ciphers.

When Herschel, in his last work on astronomy, spoke of a few ounces as the mass of the tail of a comet, he found nearly as many disbelievers as readers. Nevertheless, says M. Babinet, his calculation is exaggerated in comparison with the preceding determination. M. Babinet promises, in a future paper to take up the very suggestive question, "How are comets visible?"

The Discovery of America by the Northmen.—The following short sketch has been written at the request of several persons abroad. It may be of use for insertion in, or in preparing articles for, educational works, encyclopedias, the journals of historical societies, and other similar works, through which it may be wished to give still further publicity to historical facts so important. They have indeed already been referred to in some books of this kind, but often with considerable errors. The present paper is communicated by Charles C. Rafn, and is founded on his work "Antiquitates Americanæ sive Scriptores Septentrionales rerum Ante-Columbianarum in America," published by him in 1837, through the Royal Society of Northern Antiquaries of Copenhagen.

The Dane Gardar, of Swedish origin, was the first Northman who discovered Iceland in 863. Only a few out-places of this country had been visited previously, about 70 years before, by Irish hermits. Eleven years subsequently, or in 874, the Norwegian Ingolf began the colonization of the country, which was completed during a space of 60 years. The colonists, many of whom belonged to the most illustrious and most civilized families in the north, established in Iceland a flourishing republic. Here, on this distant isle-rock, the Old Danish or Old Northern language was preserved unchanged for centuries, and here in the *Eddas* were treasured those folk-stones and folk-myths, and in the *Sagas* those historical tales and legends which the first settlers had brought with them from their Scandinavian mother-lands. Iceland was therefore the cradle of an historical literature of immense value.

The situation of the island, and the relationship of the colony to foreign countries in its earlier period, compelled its inhabitants to exercise and develope their hereditary maritime skill and thirst for new discoveries across the great ocean. As early as the year 877, Gunnbiorn saw for the first time the mountainous coast of Greenland. But this land was first visited by Erik the Red in 983, who, three years afterwards, in 986, by means of Icelandic emigrants, established the first colony on its south-western shore, where afterwards, in 1124, the bishop's see of Gardar was founded, which subsisted for upwards of 300 years. The head firths or bays were named after the chiefs of the expedition. Erik the Red settled in Erik's Firth; Einar, Rafn, and Ketil, in the firths called after them; and Heriulf on Heriulfsnes. On a voyage from Iceland to Greenland this same year (986), Biarne, the son of the latter, was driven far out to sea towards the south-west, and for the first time beheld the coasts of the American lands, after visited and named by his countrymen. In order to examine these countries more narrowly, Leif the Fortunate, son of Erik the Red, undertook a voyage of discovery thither in the year 1000. He landed on the shores described by Biarne, detailed the character of these lands more exactly, and gave them names according to their appearance. Helluland (Newfoundland) was so called from its flat stones, Markland (Nova Scotia) from its woods, and Vineland (New England) from its vines. Here he remained for some time, and constructed large houses called after him Leifsbúdir (Leif's Booths.) A German named Tyrker, who accompanied Leif on this voyage, was the man who found the wild vines, which he recognised from having seen them in his own land, and Leif gave the country its name from this circumstance. Two years afterwards, Leif's brother, Thorwald, repaired thither, and in 1003 caused an expedition to be undertaken to the south along the shore, but he was killed in the summer of 1004 on a voyage northwards, in a skirmish with the natives.

The most distinguished, however, of all the first American discoverers is Thorfinn Karlsefne, an Icelander, whose genealogy is carried back in the old northern annals to Danish, Swedish, Norwegian, Scottish, and Irish ancestors, some of them of royal blood. In 1006, this chief, on a merchant voyage, visited Greenland, and there married Gudrid, the widow of Thorstein (son of Erik the Red), who had died the year before in an unsuccessful expedition to Vineland. Accompanied by his wife, who encouraged him to this voyage, and by a crew of 160 men on board three vessels, he repaired in the spring of 1007 to Vineland, where he remained for three years, and had many communications with the aborigines. Here his wife Gudrid bore him a son, Snorre, who became the founder of an illustrious family in Iceland, which gave that island several of its first bishops. His daughter's son was the celebrated Bishop Thorlak Runolfson, who published the first Christian Code of Iceland. In 1121 Bishop Erik sailed to Vineland from Greenland, doubtless for the purpose of strengthening his countrymen in their Christian faith.

The notices given by the old Icelandic voyage chroniclers respecting the climate, the soil, and the productions of this new country, are very characteristic. Nay, we have even a statement of this kind as old as the eleventh century, from a writer not a Northman, Adam of Bremen; he states, on the authority of Svein Estridson, the King of Denmark, a nephew of Canute the Great, that the country got its name from the vine growing wild there. It is a remarkable coincidence in this respect that its English re-discoverers, for the same reason, name the large island which is close off the coast "Martha's Vineyard." Spontaneously-growing wheat (maize or Indian corn) was also found in this country.

In the meantime, it is the total result of the nautical, geographical, and astronomical evidences in the original documents which places the situation of the countries discovered beyond all doubt. The number of days' sail between the several newly-found lands, the striking description of the coasts, especially the white sand-banks of Nova Scotia, and the long beaches and downs of a peculiar appearance on Cape Cod (the Kialarnes and Furdustrandir of the Northmen) are not to be mistaken. In addition hereto, we have the astronomical remark that the shortest day in Vineland was 9 hours long, which fixes the latitude of 41° 24′ 10″, or just that of the promontories which limit the entrances to Mount Hope Bay, where Leif's Booths were built, and in the district around which the old Northmen had their head establishment, which was named by them Hóp.

The Northmen were also acquainted with American land still farther to the south, called by them Hvítramannaland (the land of the White Men), or Irland it Mikla (Great Ireland). The exact situation of this country is not stated; it was probably North and South Carolina, Georgia, and Florida. In 1266, some priests at Gardar, in Greenland, set on foot a voyage of discovery to the arctic regions of America. An astronomical observation proves that this took place through Lancaster Sound and Barrow's Strait to the latitude of Wellington's Channel. The last memorandum supplied by the old Icelandic records, is a voyage from Greenland to Markland in 1347.

Connection of the Northmen with the East.—The following remarks are communicated by Charles C. Rafn, and intended to draw attention to the "Antiquités Russes et Orientales d'après les monuments historiques des Islandis et des anciens Scandinaves," a work edited by him, and published by the Royal Society of Northern Antiquaries (tom. i., ii., with 23 plates, Copenhagen, 1850–52, imp. in 4to.):—

The period when the Northmen wandered from their home in the East to Northern Europe is removed far back, and presents itself in darkness and myths. Future inquiries will perhaps explain how long their forefathers retained their speech and manners in their eastern abode. In this place we would only point out the remarkable fact, that the same age which saw the Northmen discovering and colonizing Iceland in the far West, beheld them also reappearing in the East, and with extraordinary energy. Summoned thither from the Scandinavian North, Nestor assures us that, under the name of Variago-Russians, they established the Russian empire in 862, and for more than a century exercised great influence over its affairs, both internal and external. The correctness of this statement by the Slavonic chronicler, and the important part played by the Scandinavian Russians in the first period of that power, becomes evident at once from the names borne by the historical actors themselves, almost all of which belong to the Old Danish or Old Northern language, and are recognised in the Northern Sagas and Runographic monuments. They are easily known, in spite of their being corrupted by the spelling of the Slavonic writer:—Rurik, Sineus and Truvor (Rœrik, Sune, Thurvard); Oskold, Dir (Hoskuld, Dyri); Igor, Oleg, Olga (Ingvar, Hœlge, Hœlga). The men "of the Russian nation," sent by Oleg in 907 and 911 as ambassadors to Constantinople, all were Northmen:—Karl, Frialaf, Vermund, Rolf, Steinmod, Ingiald, Gauti, Roald, Kar, Freyleif, Roar, Eythiof, Thrain, Leidolf, Vestar. In Igor's great embassy of more than fifty persons, who in 944 concluded the important treaty with the Greek emperors, Karamsin has only found three Slavic names. The rest are Northern, such as—Ivar, Vigfast, Eylif, Leifr, Grim, Kár, Kolskegg, Kol, Hallvard, Frode, Audun, Adolf, Ulf, Gamle, Bursteinn, Asbrand.

The names given by Byzantine authors to the vessels of the Russians, *σκεδἰα, καράβιον, ἀσκος,* will be found among the Skaldic names of ships in the Snorra-Edda: *skeid, karfi, askr.* In his book on the government of the empire, composed in 949, the Emperor Constantine Porphyrogenneta mentions the principal waterfalls or fosses in the Dnieper passed by the Russians in their expeditions to Constantinople. He names them both in Russian (*ῥωσιστὶ*) and in Slavic (*σκλαβινιστὶ*), and adds their signification in Greek. The Russian names, as has already been shown by preceding authors, are pure Old Northern: Ἐσσουπῆ (*ei sofa*), *i.e.*, not to sleep; Οὐλβορσὶ (*holmfors*), the holmfoss; Γελανδρί (*giallandi*), the yelling; Αειφὰρ (*æfr*, vehement), the wasting; ΒαρουΦόρο (*barufors*, Slav. *vulniprag*), the billowfoss; Λεάντι (*hlæandi*, the laughing, or *lóandi*, the soil washing); Στρούβουν (*strengbuna* or *strandbuna*), the little foss.

Liutprand, Bishop of Cremona, who visited Constantinople in 946 and 968, expressly asserts that the people whom the Greeks called Russians (Ῥῶς) were the same nation as those named Northmen by the Frankish authors. These Northmen (Danes, Swedes, Norwegians, and some English) flocked, usually by land, through the Russian territory, and took service under the name of Verings (Βάραγγοι) in the Imperial Guard.

A remarkable confirmation of the statement made by Nestor would be afforded if we could, as is probable, venture to assume that the Igvar occurring on several Swedish Runic stones is the Russian Grand Prince Igor. Sixty Runic monuments have been carefully examined and copied for this work, many of them by persons specially employed by the Society for this purpose; twelve of these inscriptions speak of an Igvar, and are carved in memory of men who had taken part in his expedition (*i faru med Igvari*), some of them as ship-commanders.

The work to which Icelandic, Norwegian, Swedish and Danish scholars have contributed valuable papers, commences with extracts from the Eddas, and the mythic-historical Sagas, among which is the whole of the remarkable *Sogubrot* or Saga-fragment on the old kings of Denmark and Sweden, and the whole of the charming and important Hervarar Saga. Next follow numerous extracts from the Old Northern historical Sagas. The Northmen made frequent voyages to Gandvik (the White Sea) and Biarmaland, and over the Baltic to Austrveg. The history of the kings of Norway in the tenth and eleventh centuries touches that of Gardarike or Russia in numberless instances. Olaf Tryggvason passed his youth there. The Norwegian prince Eymund repaired thither in 1015, and took part in the feuds between Iaroslav, Burislav, and Vartislav; the whole of one Saga is devoted to this Eymund. Saint Olaf was intimately connected with the Russian court, and his son Magnus the Good, afterwards King of Norway and Denmark, spent there a good part of his youth. Together with Rognvald Brusason, at a later period Earl of the Orkneys, Harald Hardrade was long the lord of the marches to the Grand Prince, and Harald himself was afterwards chieftain of the Vering Guard in Miklagard (Constantinople). The Færeyinga Saga speaks of Rafn, called Holmgardsfare on account of his voyages to Novgorod, and mentions the Færingman Sigmund's expedition to Gardarike, The lives of native Icelanders contain numerous similar accounts; thus Egil's Saga tells us of Egil's and Thorolf's exploits in Courland, and Nial's Saga has preserved the details of Gunnar's and Kolskegg's attack on Reval and Eysysla. In 1009 Biorn Arngeirson heroically distinguished himself in the service of Vladimir the Great. Another still more famous Icelandic bard and hero, Thormod Kolbrunarskald, after living several years in Greenland, betook himself to Norway, in company with another native American, Skuf, owner of Stokkanes at Eriksfiord, and probably kin with the celebrated Gudrid, wife of Thorfinn Karlsefne; in 1029 both followed Saint Olaf to Gardarike.

The attention of English readers is directed to an Old-English or Anglo-Saxon document, the voyages of the Northmen Ohthere and Wulfstan in the north of Europe, as related by King Alfred. This paper, with its numerous illustrative notes, is communicated by P. A. Munch. An accompanying *fac-simile* of the MS. in the British Museum has been kindly forwarded to Sir Henry Ellis.

As an illustration to the ancient Icelandic geographical monuments, a mappemonde from the twelfth century, and three planispheres from the thirteenth and fourteenth, have been appended. These are remarkable for having the same orientation as those of the Arabian cartographers in the middle ages; they have the south at the top. Among the geographical annotations, for which we are indebted to the Abbot Nicolas of Thingeyrar, in the north of Iceland, is a journey to the Holy Land in 1151–1153, containing interesting notices for comparison with other voyages to the East at the same period; among them is an Arabic appellation not found in other European voyagers of the same date. To this division also belongs a plan or ichnography of Jerusalem.

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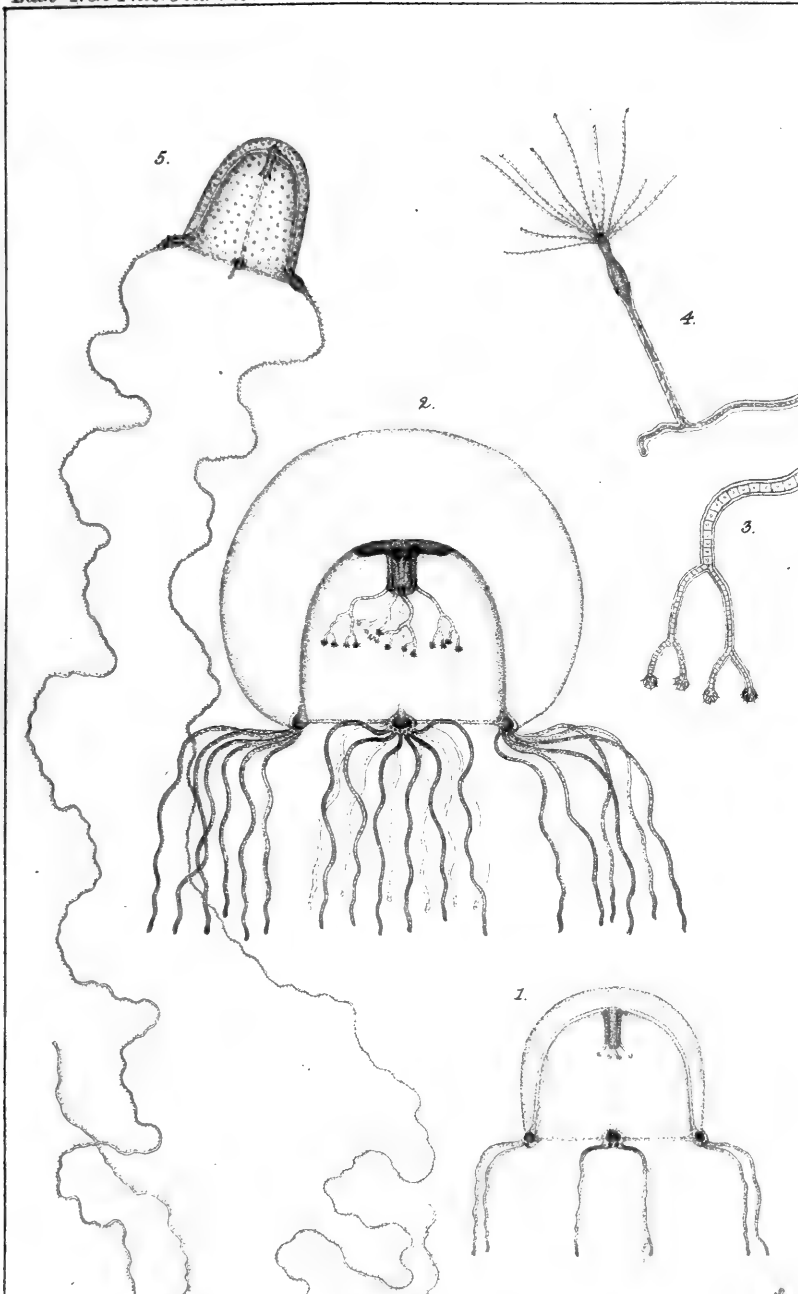

T. Strethill Wright etched on stone. W. H. Mc Farlane Lith^r Edin^r

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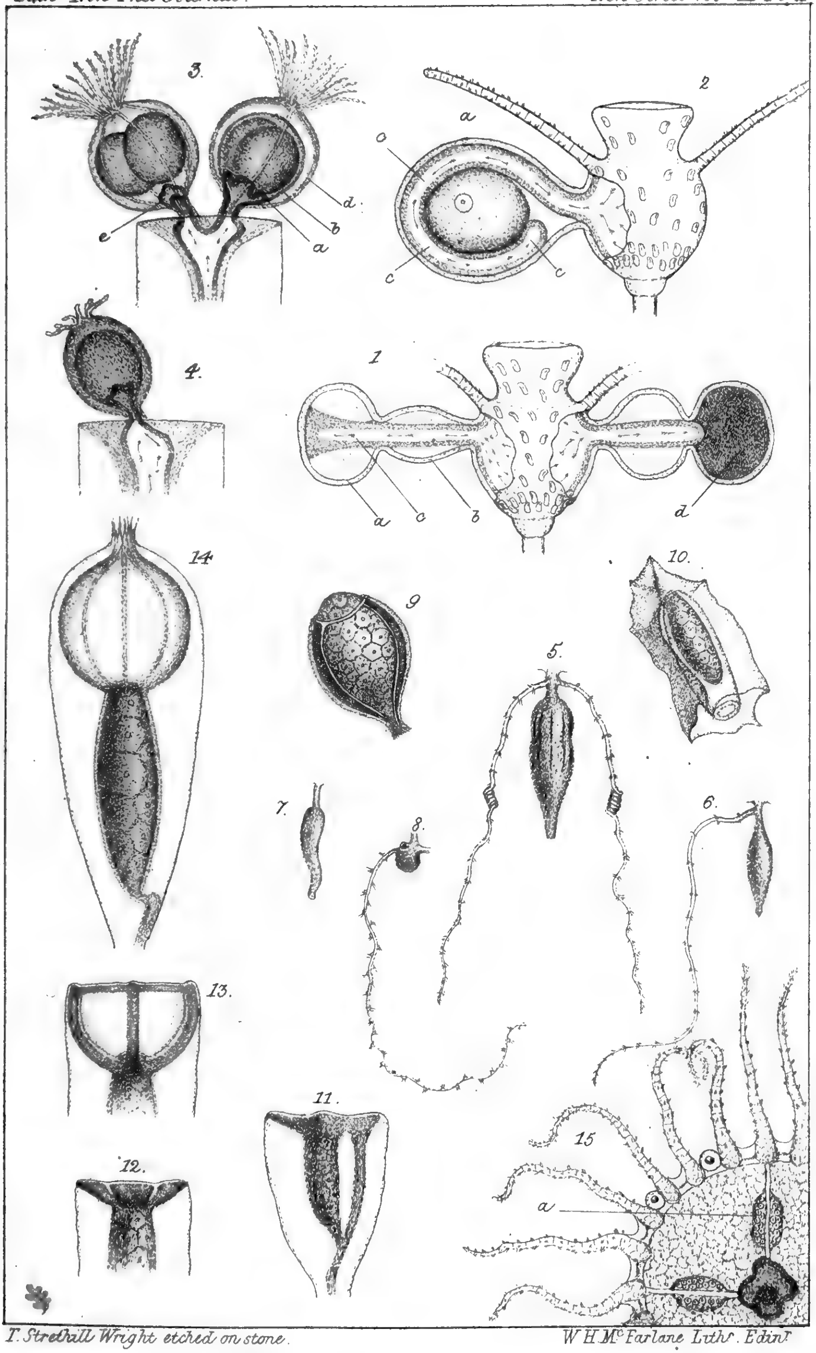

T. Strethill Wright etched on stone. W H McFarlane Lithʳ. Edinʳ

Eudendrium rameum. Laomedea dichotoma.
Laomedea geniculata.

T. Strethill Wright etched on stone.

W. H. M^c Farlane Lith^r Edin^r

Laomedea lacerata.

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THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

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*Observations on the Lake District.** By JOHN DAVY, M.D., F.R.S. Lond. & Edin.

IN this paper I propose to submit some observations on the Lake District, restricting myself chiefly to that which is peculiar in its surface, the climate, and its inhabitants. What I shall offer will be merely a sketch; and it will be given chiefly with the intent of calling the attention of those interested in the subject, with the hope that, after having slaked their thirst for knowledge here, they may be induced to refresh themselves by breathing the air of our mountain fells, and gratifying their senses by the enjoyment of the beauties of landscape,—the very staple, as they have been called, of the district;—beauties depending on a rare union of the wild and cultivated, of lake and meadow, of stream and grove, and these, it is remarkable, so wonderfully varied within a very limited space.

I do not consider it necessary to enter into minute details respecting the geology of the district,—a subject on which the amplest information can be obtained from the writings of one of the most distinguished geologists of the present day. It may suffice to remark, that the rocky structure of the district is chiefly composed of metamorphic slate, occasionally associated with granite, and here and there intersected and disturbed by veins or dykes of trap. All the bolder features of the country are formed of these materials,—such as the higher hills and

* Read at the last meeting of the British Association.

mountain ranges,—the latter, where of greatest elevation, reaching a height of from 2000 to 3000 feet perpendicular above the level of the sea. I need not particularize the several mountains and their heights; mention of them may be found in most of the guide-books, and with much exactness in the earliest of its class, and one of the most useful—Otley's. The composition of the lower hills, the declivities of the higher, and the majority of the knolls, is of a different material—chiefly, to use the provincial term, of "Samel," which consists of water-worn gravel and water-worn stones, so compacted together as to form a mass almost of the firmness of rock, and little more pervious to water. This "samel" is chiefly remarkable for two circumstances,—one, the absence of all organic remains; the other, its ingredients being a mixture of fragments, all bearing the marks of friction, confusedly mixed together, large and small, irrespective of gravity.

Besides rock, and its coarser detritus the "samel," there is another element in the physical geography of the district which must not be overlooked,—the soil,—and which may be considered as a finer detritus, less compacted, more mellow, and in its very compound nature not entirely destitute of organized matter. It is chiefly remarkable for the absence of clay; and it is also remarkable for the manner in which it is distributed, that is, so unequally, varying in depth within a very limited space, and that greatly—a variation probably regulated by the inequalities in the subjacent surface of rock. Commonly it is found of best quality on the sides of the hills. In the bottoms of the valleys it is mostly of an inferior kind,—a soil with excess of sand and gravel,—these brought down by the streams. Even on the hill-sides it varies in composition as well as in depth, as is indicated by marked differences in the kinds and vigour of vegetation, where the growth is spontaneous.

As the hills and valleys may be considered co-ordinate, the latter originating from the uprising of the former, but not volcanic or by eruption, so, too, must be viewed the receptacles of water constituting the lakes; these receptacles differing mainly from the valleys in which they occur in being of greater depth, and commonly having corresponding to them hills of greater elevation. In their formation, they remind me —to compare great things with small, the works of man with the works of nature—of a practice in Malta, where a tank and a house, the one so necessary to the other in that arid island, are made at the same time,—the tank formed of the quarry from which the stone has been hewed of which the house is constructed. I have remarked that the hills of simultaneous formation with the valleys are not of volcanic origin. Some of the smaller pieces of water, those designated tarns, from their form and general appearance might suggest the idea of their being craters of volcanic eruption; but as there are none of the usual accompaniments, such as beds of ashes and scoriæ, or lava streams, in connection with them, that I am aware of, the notion is not supported by fact. As I have referred to guide-books for the heights of the mountains, so I may also for the depths and dimensions of the lakes, merely remarking, that some of the largest are so deep that they never freeze except in winters of unusual severity, and that the extent of surface of the whole of them is so large as to have a material influence on the climate of the district.

Taking a general view of the surface, the following are some of its most remarkable features, and those perhaps most concerned in giving character to its scenery:—Mountain peaks and ridges in bold forms, in their boldest and wildest consisting of naked weather-worn rock; mountain declivities, the lower hills and hillocks presenting undulating lines or dome-like forms,—these lines and forms of beauty, as much as those which tower above them are of grandeur, and equally so, whether formed of naked projecting rock, or covered with pastoral turf, or with forest trees or coppice-wood.

These latter graceful forms convey the idea that they have been produced by attrition, such as that which might be effected by glacial action; and that an action such as this has been exerted at a distant period many circumstances tend to prove. The most striking are the scratches and grooves on the surface of the rocks—*i. e.*, of such rocks as have been recently laid bare—rocks that had previously been protected from the action of the weather by a layer of "samel," or by a growth of turf, and the occurrence of similar markings in the

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larger stones embedded in the "samel." The cause of the attrition, so strongly manifested in these engraved marks, is probably glacier action; and judging from their parallelism, it seems likely that each valley had once its own glacier, the scratches and grooves according with the line of descent; and in support of this notion, it may be mentioned that collections of water-worn stones are of no uncommon occurrence in situations where moraines on the glacier theory were likely to be formed.

It may require some exercise of the imagination to conceive these dales, now so charming in their manifold beauty, once regions of everlasting winter—the seat, not of the lake, the stream, the meadow, but of accumulated ice, such as that of the glacier, in constant and destructive motion. But a not less exercise of the imaginative faculty, I may remark, is needed to conceive a former state, and one perhaps of greater horror, which must have existed at a still earlier period, when, after the elevation of the mountains and formation of the valleys by their uplifting, the whole surface was naked, arid, and barren, totally destitute of vegetation, and altogether unfit for animal existence, in brief, a *dead land*, as much as that melancholy lake in which the Jordan empties itself and is lost, is a *Dead Sea*. In both these aspects the conditions of the district are only examples of what is to be witnessed in other regions and on a vaster scale. And are they not fine examples of good, as it were, springing out of evil? of causes in immediate operation incompatible with vegetation and with animal life depending thereon, and yet in their effects productive of fertility, creating a land, not unlike the Promised Land, flowing in milk and honey—products these so characteristic of a pastoral well-watered country such as is the lake district?

The climate of the district to which I shall now pass has been studied more, I believe, than that of any other region of the United Kingdom, and has been specially fortunate in the men who have directed their attention to it. At the head of these may be mentioned Dalton, who started in his distinguished scientific career in this field of research. To him we are indebted for many valuable observations, and of a high character, as affecting the principles of meteorological science. To two other meteorologists we also owe much, viz.,—the late Mr Fletcher Miller of Whitehaven, and Mr Marshall of Kendal. The zeal and perseverance of these gentlemen, from year to year, in registering phenomena, employing the best instruments, are deserving of all praise. Limited as I am in regard to space and time, I can do little more than notice some of the marked peculiarities of the climate.

The most worthy of note are, the mildness of the seasons; the large amount of rain; the small amount of snow; the comparative dryness of the air; the little thunder and lightning; the prevalency of westerly and south-westerly winds, and the not infrequency of storms, almost deserving the name of hurricanes. In and towards the centre of the district these peculiarities are most distinctly marked,—the centre, where the mountains are highest, and from whence, with the lakes, which are associated with them, they diverge after the manner of the spokes of a wheel.

In no part of England, I believe, with the exception of the south-west coasts of Cornwall and Devonshire, is the winter temperature higher and the summer lower. The former is denoted by the many evergreens which flourish here unprotected in the open air; the latter by the circumstance, that a fire morning and evening is welcome, with few exceptions, throughout the summer. The season of least equability of temperature, as in Britain generally, is the spring, especially in March and April; occasionally in these months, more especially in the first, there is great severity of cold. It is mostly accompanied by a serene state of atmosphere, and a calm, after a prevalency of northerly winds, with a high state of the barometer, denoting the influx of a great aerial wave; and this, no doubt, judging from the quarter whence it comes, of a low temperature.

The amount of rain is a variable one for the district, taken as a whole. As it is probably one of the chief causes of the mildness and equability of the climate, its fall in different parts may serve as a tolerable criterion of the degree of these qualities. Speaking generally, it may be said to be greatest in the central portion of the district, amongst the higher mountains, and to diminish in quantity in all directions with the distance from that centre. I may mention a few examples in illustration; thus, in one year, that of 1846, at Kendal (omitting the decimal parts of an inch), there fell 52 inches; at Bowness, 83; Grasmere, 110; Seathwaite in Borrowdale, 143; Buttermere, 96; Keswick, 67; Cockermouth, 52; Whitehaven, 49 inches. And these amounts probably, judging from that for Kendal, are nearly the average yearly for each place. So great a fall of rain, especially amongst the higher mountains where there is so little wood,—the fells being perfectly destitute of wood,—may raise a doubt as to the correctness of the hypothesis that forests are promoters of rain, and that the cutting down of forests conduces to drought.

In relation to rain it is worthy of remark, that though the average quantity in the district is so great, the number of rainy days is not proportionally large; on the contrary, it is less than in many parts of Great Britain in which the amount is less; thus, in 1853, whilst at Kendale

	Days.		Amount in inches.
The number of rainy days was . .	150	...	39
At Ambleside, it was	146	...	66
,, Doncaster, ...	223	...	31
,, Falmouth, ...	203	...	30
,, York, ...	174	...	22

It is also worthy of remark, that the heavy falls of rain to which the district is subject have a purifying effect, not only washing the roads clean, but also the atmosphere; and are mostly followed by a clear sky and pleasant weather. This purifying influence of rain is sometimes strikingly denoted by a film of the nature of soot that appears on the lakes and tarns, in their calm state, and is oftenest seen after a light rain with little wind at the instant, during a period of unsettled weather. That the matter of which this film consists has been brought down from the atmosphere I have no doubt; probably it has been wafted from the manufacturing districts not very distant—a transfer, which, whilst beneficial to them, may also be of service in its fertilizing effects to the lake district, especially the upland fells, where, there is reason to believe, it is precipitated in greatest quantity, and where the discoloration of the fleeces of the sheep, pastured there during the winter and early spring, may be attributed to it. The discolouring effect is most conspicuous when the ewes have their lambs by their side,—the one so begrimmed by the mists, as the shepherds say,—the other so purely white. That the blackening matter is of the nature of soot, I infer from the examination I have made of it, both microscopically and chemically. And that it may be brought from such a distance is easily conceived, considering its lightness, and the carrying power of the wind, and remembering that matter of a heavier kind, such as volcanic dust and the sand of the desert, has often been transported to vastly greater distances.

The prevalency of westerly and southerly winds is an important element in the climate. It is these winds, chiefly, which bring rain, and with rain coolness in summer and mildness in winter. To them, too, may be owing the little snow that falls and the shortness of time it lies. Another quality of these moist winds is their containing ozone, as it would appear, in larger proportion than winds of a drier character from the opposite quarters; and judging from the properties of this substance, especially its oxidating power, its presence in such a degree cannot be without effect, and that probably beneficial.

That dryness of air should be one of the peculiarities of the lake district, or a moderate dryness, where so large a quantity of rain falls, may seem paradoxical; yet it is not difficult to account for. Several circumstances may be concerned,—such as the absence of clay,—the particles from the disintegration of rocks constituting clay being carried to lower levels, where, as a retainer of moisture, it is more wanted, —the rapid manner in which, from the nature of the ground, its drainage is effected,—and the almost constant agitation of the air by winds effecting thorough ventilation. Exceptional cases there may be; they are chiefly to be met with in situations in which, from the abruptness of the rocky heights by which they are sheltered, they are deprived of the direct rays of the sun during a good part of the year,—such as Stonewhaite in Borrowdale,—or from being unduly shaded by trees, impeding a wholesome circulation of air. Instances of the latter are of too common occurrence about the dwellings of the wealthier class, who in their partiality for ornamental planting create the evil. The longer continuance of a moist state of ground under trees, so striking on our turnpike roads, where overshadowed by foilage, shows at least that, if forests, as I am disposed to think, do not favour the production of rain, they may check dryness of the air and drought by retarding evaporation from the earth's surface.

The rare occurrence of thunder-storms, which I have mentioned in noticing the peculiarities of the district, could hardly have been anticipated in one so mountainous. That it is a fact, however, I am satisfied. In no country in which I have resided have I witnessed such an infrequency of atmospheric electrical phenomena. So far as my own knowledge extends, limited, indeed, to about fifteen years, I am not aware of any house having been struck by lightning, or any person injured. It may be conjectured, that the many mountain peaks draw off the electricity of the atmosphere and prevent its accumulation; and the more so, as their terminal points, rising into the region of low clouds, are almost constantly moist, and thereby the better fitted to act the part of conductors.

More or less connected with the foregoing are other qualities or circumstances which may be briefly adverted to,—such as the absence of malaria, the little tendency to the formation of peat, the purity of the water of the lakes and streams, and its colour, the aptitude of the soil and climate for vegetable growth, and its fitness for the abode of man.

The absence of malaria is remarkable, as denoted by freedom from ague. In the country parts I have never known of the occurrence of a single case. This happy freedom is probably owing to the comparative coolness of the climate, the purifying effects of the heavy rain, the quality of soil, and the little prevalency of marshy ground. The same perfect exemption from the disease does not, I regret to have to say, exist in the towns or larger villages; in them, in summers of unusual heat and dryness, instances of intermittent fever have been observed, and they may be attributed to imperfect drainage and a neglected state of the sewers, liable in such seasons to have collected in them animal and vegetable matters in a state of offensive decomposition.

The little tendency to the formation of peat may be owing to some of the same causes just enumerated; the reverse of which seem to be in operation in countries abounding in peat, especially in Ireland, where there is much low land and obstructed natural drainage, a greater frequency of rain, and a greater degree of humidity of air, and consequently a greater exemption from seasons of drought.

The purity of the water of the lakes and rivers is such as might be expected, considering the geology of the district. Its freedom from peat-stain is a proof that might be adduced, if needed, in connection with the statement of there being so little peat. This purity of water I cannot but think a charm in the scenery, whether seen in the white foam of the falling torrent, in the blue depths of some of the mountain streams, where pent up in deep basin hollows, formed of light-coloured rock, or in the dark surface of the tarn or lake, a surface-hue referable chiefly to the quality of the bottom, consisting of rock or gravel of the same colour, where most remarkable, derived from a stain or incrustation of black oxide of manganese.

The last and most important qualities of the district—the aptitude of its soil and climate to vegetable growth, and its fitness for the abode of man—are shown in a satisfactory manner, in the instance of the latter, in the stalwart and fine forms of its people, and their generally healthy condition; and in that of the former, in the free and rapid growth of trees and shrubs, and where agriculture is duly attended to, in the excellence of the pastures and the goodness of the crops—those which are suitable, such as green crops generally, and oats and barley. Trees, as records of average influences, afford perhaps, the best criterion of the condition of vegetable life; here the indications which they give are of the best kind—growing erect and flourishing most where well exposed to light and air. A like conclusion, as to salubrity, may be drawn from the absence of any epidemic disease amongst the people, and the high average of length of life belonging to them, with persistency of bodily and mental vigour. It is no mean praise of the climate of the district to be able to say that cholera has never yet invaded its dales.

I wish I could be as complimentary as regards the mental attributes of the population. Their country, in its picturesque character, it might be supposed, would be favourable to poetical feeling; yet in the native mind it does not seem to have exercised any influence of the kind. Those poets who have made the region classical have been sojourners rather than to the manner born,—excepting, perhaps, the most distinguished of them, Wordsworth, whose native place was on its confines, and whose school-boy days were passed nearly in the heart of the district. What is remarkable in the people generally is their solid cast of mind, their forethought, the absence of the enthusiastic and imaginative, and of the inquiring disposition; the men thrifty and calculating, moderately honest, somewhat exacting; the women industrious, somewhat dry in their manner, not licentious, and yet not remarkable for female virtue,* especially the unmarried; altogether men and women of commonplace character, nowise poetical nor fond of poetry; even ballad poetry, such as that of the borders, is scanty amongst them. Of the race of Northmen, occupied chiefly as shepherds, and small farmers cultivating their few paternal acres, they remind one of the sturdy and sedate Norwegians from whom they are supposed to have sprung.

To the stranger it may be interesting to know when the

* The Bishop of Carlisle in his visitation charge to his clergy, delivered on 19th August last, adverting to the large proportion of illegitimate births in his diocese, says "It was his painful duty to inform them, that, without any exception, in the counties of Cumberland and Westmoreland there were more illegitimate births than in any other county in England. The county of Norfolk, it was true, came within a fraction of the number. His returns only extended to the end of the year 1856, and from them he learnt that while in the years 1853–54, the proportional number of children born out of wedlock in Westmoreland was from 8 to 9 per cent.; in 1855–56 it was 10 per cent. In Cumberland, in 1854, it was 9 per cent.; and in 1855–56 it was also 10 per cent. Part of Lancaster was then within the limits of the diocese; and he had no means of separating them; but Lancaster stood out in the most favourable light, the proportion in that county being only 6 per cent."

From the Registrar General's Reports it would appear that in London the illegitimate births are 8·3 per cent.; in Derbyshire 8·3; in Yorkshire 9. In justice, these statistics should be compared with those of prostitution.

district is best worth visiting for the enjoyment of the scenery peculiar to it. There are three periods when it has great attractions; these are the depth of winter, the advanced spring, and the early autumn. In the winter season, there is beauty and grandeur often combined,—the one as charming as the other is impressive,—the snow-clad mountains in the distance, the full streams and torrents, the verdure of the mosses and other low plants clothing every wall, the numerous evergreens enlivening the copse, and the wonderful effects of light and shade, of cloud and mist, imparting, as the latter often do, a perfect alpine character to the mountains seen indistinctly through them. In the advanced spring the great charm is the charm of colouring; and the same remark applies to the early autumn. Words are inadequate to describe at either season the beauty of hues which, wherever the eye turns, meets its gaze; in the one season most marked by delicacy and freshness; in the other season by intensity and richness of colour. A peculiarity of the district is the amplitude of its coppice wood, well taken care of. In the scenery it is an important feature at either of the seasons mentioned; never being allowed to exceed the age proper for felling, that is, about fourteen years, it gives the country an aspect of perpetual youthfulness,—the opposite of that derived from old and venerable forest trees. Surprise, perhaps, may be felt that I have not mentioned summer, at its height, amongst the attractive times. Though the most resorted to by tourists, and when, indeed, very enjoyable—what country is not at that season?—yet I cannot but hold it to be in a less degree enjoyable than at the other periods,—for then there is an excess of verdure, a monotony of colouring, and in the finest weather, with a cloudless sky, and shrunken streams, and shrunken water-falls, there is a sad abstraction of the grand and impressive. One month, indeed, is often an exception,—that of July, which of all the summer months is most subject to rain and broken weather; and then when there are gleams of sunshine flashing out from amidst clouds, and lighting up the watery rocks, and emerald meads, and misty mountains, the effects are often wonderfully fine. And in the same month, that monotony of colouring alluded to, is often broken in upon by the mower, imparting, after the hay is carried,—the great crop of the country,—a lighter and brighter colouring, enhanced, perhaps, by the idea of a successful and provident industry.

It may perhaps be asked, how is the climate of the district likely to agree with the invalid requiring change of air? Such inquiry it is not easy to answer, except in the most general manner, as in every instance that change of air is advisable the nature of the ailment ought to be considered. In general terms, merely, I can have no hesitation in saying that the climate of the lake district, with its scenery, and the exercise required to enjoy it in all its varieties, is likely to be eminently beneficial to the dyspeptic and overtasked inhabitant of the city, whether suffering from excess of application to office-work, or from the dissipations of society,—late hours, crowded parties, and convivial excesses. In the instance of the asthmatic, with whom the confined and less pure air of towns does not agree, it may also prove serviceable, especially if a place of abode be selected at a considerable elevation, Indeed, to most persons, whether invalids or in good health, the mountain air proves singularly refreshing and invigorating. In breathing it a consciousness of power is experienced in exchange for that of lassitude, which in warm weather is so commonly felt in the dales. The difference may partly be owing to a greater degree of coolness of air in ascending; but I think only in part, and that something is due to the quality of the air itself. Hitherto, in England, but little attention has been given to atmospheric influences on health, at different elevations,—these probably not being great, and the effects, whatever they are, not striking like those which are witnessed in alpine regions. The lake district is well adapted for observations of the kind; and such as have been made, limited though they are in number, tend to prove that a certain degree of restoring and health-preserving power is exercised by our mountain air,—if that term be applicable to heights ranging from six or seven hundred to one thousand feet above the sea-level.

Some Ethnographic Phases of Conchology—(*concluded*). By DANIEL WILSON, LL.D., Professor of History and English Literature, University College, Toronto.

Did the object of this paper require a minute consideration of the modern economic applications of shells and other marine products, it might be greatly extended by reference to the varied applications of mother-of-pearl shells to all the purposes of inlaying, carving, and decorating. The value of the shells imported in recent years into Britain for this class of manufactures alone, has fallen little short, annually, of L.40,000 sterling. The uncut cameo shells of various kinds, including the products of widely distant seas,—*e.g.*, the *Cassis rufa*, or bull's mouth; the *Cassis Madagascariensis*, the black helmet, or queen conch; the *Cassis cornuta*, or horned helmet; the *Strombus gigas*, or fountain shell; the *Strombus pugilis*, and the *Pyrula carnaria*, are annually imported to the value of upwards of L.3000 sterling, and in the hands of the cameo engraver are speedily converted into valuable works of art. But the modern application of marine shells for the purposes of ornament and utility bring them within the range of most modern trades. Buttons, studs, knife-handles, paper-cutters, penholders, card-cases, parasol-handles, card-counters, jewel and needle-cases, snuff-boxes, thimbles, richly carved and jewelled brooches, beads, necklaces, and artificial flowers, are all made from these varied spoils of the sea. The ingenious Chinese turn them to numerous uses, one of the most noticeable of which is to supply a substitute for glass. Various species of the *Placuna*, as the *P. sella*, and *P. placenta*, being thin and translucent, are used in China for glazing windows and for lanthorns; while the powdered dust of the same shells furnish the silver pigment for their water-colour drawings.

While thus noticing with interest the development of novel and varied modern arts which turn the spoils of the ocean to such diverse uses, and lead to the transport of the gigantic marine shells alike of the Indian Ocean and Antilles, to the marts of the old world, to contribute to European luxury and refinement: a greater interest attaches to the evidences, still traceable, of an ancient trade in the same products of the Florida Gulf, carried on among the widely scattered tribes and nations of the New World, before its discovery by Columbus. Reference has already been made to the varied uses to which these tropical shells were applied by the insular Indians of America, when first discovered by the Spaniards, but their economic employment was not limited to the inhabitants of the islands. Abundant evidence exists to prove that they were greatly valued, and even regarded with superstitious reverence, both by the more civilized nations of the neighbouring mainland around the Gulf of Florida, and also by the rude Indian tribes even so far north as beyond the shores of the Canadian Lakes. In one of the singular migratory scenes of the ancient Mexican paintings, copied in Lord Kingsborough's "Mexican Antiquities,"* from the Mendoza Collection, preserved among the Selden MSS. in the Bodleian Library, at Oxford, a native figure is represented carrying a large univalve shell in his hand. He is barefooted, and dressed only in a short spotted tunic, reaching to his loins. In his right hand he bears a spear, toothed round the blade,—it may be with inserted flints or points of obsidian,—while he holds the large shell in his left hand. A river which he is passing is represented by a greenish stripe winding obliquely across the drawing, and his track, as indicated by alternate footprints, has previously crossed the same stream. On his trail he is followed by other figures nearly similarly dressed, but sandalled, and bearing spears and large fans; while a second group approaches the river by a different trail, and in an opposite direction to the shell-bearer. Other details of this curious fragment of pictorial history are less easily interpreted. An altar, or a temple, appears to be represented on one side of the stream; and a highly-coloured circular figure, like a shield, on the other, may be the epitomized symbol of some Achæan land or Sacred Elis of the New World. But whatever be adopted as the most trustworthy interpretation of the ancient hieroglyphic painting, its general correspondence with other migratory depictions is undoubted; and it is worthy of note, that, in some respects, the most prominent of all the figures is he who is represented

"Mexican Antiquities," vol. i., plate 68, as fording the stream, bearing one of the large tropical univalves in his hand.

The evidence which such a remarkable native record affords of an importance attached to the large sea-shells of the Gulf of Mexico, among the most civilized of the American nations settled on its shores, is well deserving of notice ; but the same class of tropical marine products acquires a new and still more important significance when they are met with among the relics pertaining to Indian tribes settled in the northern regions of the continent, some of them two to three thousand miles distant from the native habitat of the mollusca by which these coveted treasures of the ocean are produced, and separated by hundreds of miles from the nearest sea-coast.

Tracing them along the northern route through the Mississippi and Ohio valleys, these shells have been found in the ancient graves of Tennessee, Kentucky, and Indiana, and northward to the regions of the Great Lakes. Dr Gerard Troost, in a communication to the American Ethnological Society,* has described a singularly interesting series of disclosures of ancient relics and sepulchral remains in Tennessee. The crania of the graves were characterized by remarkable artificial compression, as in the example figured by Dr Morton, Plate LV., *Crania Americana.* These ancient graves abounded with relics—"Cases, trinkets, and utensils, all of a very rude construction, and all formed of some natural product, none of metal." From an examination of these, Dr Troost was led to the conclusion that the race to whom they pertained came from some tropical country. Numerous beads were formed of tropical marine shells of the genus *marginella,* ground so as to make a perforation on the back, by means of which they could be strung together for purposes of personal ornament. Plain beads were made from the columellæ of the *Strombus gigas ;* and such columellæ were found worn to a uniform thickness, perforated through the centre, and in all stages of manufacture, from the rude state in which such are found on the island shores of the West Indies, to their condition as perfected beads and links of the much prized *Wampum.* But another conchological relic of the same locality possesses a much

* Transactions Amer. Ethnol. Soc., vol. i. pp. 355–365.

greater interest. Dr Troost describes and figures various rudely modelled and sculptured idols found in the same locality; from some of which he was led to assume the existence of Phallic rites among the ancient idolators of the Ohio valley. One of these specimens of aboriginal sacred sculpture was accidentally discovered in ploughing a piece of land newly reclaimed from the forest. The utensils found in the Tennessee graves have all been made of stone or obsidian; and the greater number of the idols are in like manner sculptured in stone of various kinds and degrees of hardness. But the figure now referred to is made of clay and pounded shells, and, like other examples which have been met with, has been hardened in the fire. It represents a naked human figure, kneeling, with the hands clasped in front; and when found it still occupied as its primitive niche or sanctuary a large tropical shell (*Cassis flammea*), from which the interior whorls and columellæ had been removed, with the exception of a small portion at the base, cut off flat, so as to form a pedestal for the kneeling figure. The special application of this example of the tropical cassides, thus found so remote from its native habitat, adds a peculiar interest to it, as manifestly associated with the religious rites of the ancient race by whom the spoils of southern seas were transported inland, and converted to purposes of ornament and use.

The discovery of examples of similar tropical relics, or of articles of personal ornament fashioned from them, when found to the north of the Great American Lakes, is still more calculated to excite surprise, though the chief interest they possess is from the light they are calculated to throw on the traces of ancient migration, or of traffic between the north and south in ages prior to the displacement of the red man by the European. Two of such large tropical shells, both of them specimens of the *Pyrula perversa*, the native habitats of which are the Antilles, and the Bay of Campeachy on the mainland, have been presented to the Canadian Institute; not as additions to its specimens of native conchology of the tropics, but as Indian relics pertaining to the great northern chain of freshwater lakes. The first of these was discovered on opening an Indian grave-mound, at Nottawasaga, on the Georgian Bay, along with a gorget made from the same kind of shell. The second example was brought from the Fishing Islands, near Cape Hurd, on Lake Huron, and a third specimen, now the property of James Beaty, Esq., Toronto, partially honeycombed by age and decomposition, constituted one of the contents of a large sepulchral depository in the same Northern Lake district. It was found lying at the head of one of a group of Indian graves, along with a copper kettle, and other relics, and belongs, I believe, to an interesting series of Indian relics, discovered, along with sepulchral remains, in 1846 and 1847, in different parts of the district lying between Georgian Bay and Lake Simcoe, and described by Dr E. W. Bawtree, in the Edinburgh Philosophical Journal for July 1848. In one pit, about seven miles from Penetanguishene, three large conch shells were found, along with twenty-six copper kettles, a pipe, a copper bracelet, a quantity of shell beads, and numerous other relics. The largest of the shells—a specimen of the *Pyrula spirata*—weighed three pounds and a quarter, and measured fourteen inches in greatest length. But a piece had been cut off this and another of the large shells, probably for the manufacture of beads. It exhibited abundant marks of age and frequent handling, its outer surface being quite honeycombed, while the inside retained its smooth lamellated surface. Another sepulchral depository, about two miles from the former, yielded a large number of shell-beads of various sizes, along with other relics; a third, discovered on elevated ground in the neighbouring township of Oro, contained twenty-six copper kettles, underneath one of which lay another of the large tropical shells, seemingly carefully packed in beaver skins and bark; while in a fourth cemetery in the same district, among copper arrow-heads, bracelets, and ear-ornaments, pipes of stone and clay, beads of porcelain, red pipe-stone, &c., sixteen of the same prized tropical univalves lay round the bottom of the pit arranged in groups of three or four together. Numerous skeletons, or detached skulls and bones promiscuously heaped together along with these relics, attested the sepulchral character of the depository. The kettles also had been rendered useless by the blows of a tomahawk, according to the invariable practice of the Indians with the offerings deposited alongside of their dead. In more than one of these cemeteries there were also found iron axes and other relics, which sufficed to fix the date of some, at least, of the interments subsequent to intercourse having been established between the Indians of this district and Europeans. More recently, in 1856, an extensive Indian cemetery was disturbed in the same locality, and found to correspond very closely to those already described. About six miles from Orillia, where the North River crosses the Coldwater road, which is on the line of the old portage between Lake Couchiching and the Georgian Bay, it runs through a valley with low heights rising on either side. On the northern height, about a quarter of a mile from the road, the Indian relics now referred to were found. Many skeletons were disturbed, and along with these were numerous specimens of native art, beads and other ornaments of bone, some curious rings made from the vertebræ of the sturgeon; and also glass beads and copper kettles, some of the latter with handles and rims of iron. Besides these miscellaneous relics lay two of the large univalve shells of the tropics. In this, as in the former cases, the traces of European art fix the date of the deposit at a period subsequent to the discovery of America by the Spaniards, and in all probability to the explorations of the French among the Hurons of this district in the early part of the seventeenth century. It is not improbable, however, that some, at least, of the shells, may have been preserved and handed down from one generation to another as *great medicines*. One example which I have examined, found lying at the head of a skeleton in an Indian grave on Georgian Bay, has the upper whorls removed, so as to expose the internal canal. Five lines, or notches, are cut on the inner face of the canal, and it is perforated on the opposite edge, showing in all probability where the wampum, scalp-lock, or other special decoration of its owner was attached. It also exhibits abundant traces of its long and frequent use. The surface is smooth and polished, as if by constant handling, except where it is worn off, or decayed, so as to expose the rough inner laminæ of the shell: and all the natural prominences are worn nearly flat by frequent attrition. The specimen in the collection of the Canadian Institute, brought from the fishing islands on

Lake Huron, is also cut and greatly worn, and exhibits abundant traces of long exposure.

Other examples of these large tropical shells which have been found in Canada, and also in the State of New York were probably deposited at an earlier date: but all, or nearly all, appear to have been offered as tributes in honour of the dead. The modes of sepulture of the different tribes greatly vary, and some of their rites are peculiarly characteristic, but all of them included the deposition of valued gifts, or the favourite weapons and implements of the deceased, alongside the corpse. One manner of disposing of the dead consists in placing the body on a scaffold, or raised platform, around which the last gifts and offerings are suspended, after they have been rendered unserviceable to the living by some process of injury. This constitutes the final sepulchral rite of the Chinooks, Kliketats, Coulitz, and all the Indians of the Columbia River. The most common and characteristic elevated bier of these western tribes is the canoe, raised on poles, and decorated with relics pertaining to the deceased; and with the offerings of his friends. These Indian biers are invariably erected on an isolated rock or island, or some equally inaccessible spot, so as to be beyond the reach of beasts of prey, and are the final resting-places of the dead. Mr Paul Kane has a highly characteristic oil painting of the Cemetery of the Coulitz Indians, executed by him from sketches taken at the spot, on the Coulitz River, where these singular canoe-biers are erected on a small island. Among the Babeens this mode of scaffolding the dead is confined to females, while the males are invariably burned. But different ideas regulated the final honours paid to the dead among the eastern tribes settled around the great lakes. Among the Pottowatamays, the Menamonies, the Ottawas, the Indians of the Six Nations, and other tribes, the practice prevailed of interring their dead in large sepulchral depositories, into which the bones were promiscuously gathered, after the final honours and sacrifices had been offered to the deceased. This custom fully accounts for the large ossuaries brought to light within the original localities of these tribes; and as the custom of depositing the favourite weapons and implements of the deceased alongside of him, is common to nearly all savage people, and appears to have been universal among the Indians of the New World, this shows the origin of the interesting objects of native art which many of these cemeteries have disclosed.

About the year 1837, one of a class of extensive ossuaries, which have furnished many relics pertaining to the period of ancient Indian occupation of the Canadian clearings, was accidentally discovered in the township of Beverly. An elevated ridge, running from north to south, is covered by an old growth of full-grown beech trees, standing somewhat widely apart; and across this, and consequently running from east to west, a series of deposits of human bones were exposed, ten or eleven of which were opened, They contained an immense number of bones, of both sexes and of all ages, promiscuously heaped together, and interspersed with many Indian relics, which furnished the chief temptation to their exploration; and from their extent and the evidence they disclosed of repeated interments, they undoubtedly indicated a permanent location of the tribe, of which so many members had there found their last resting place. One of these remarkable sepulchral depositories which was carefully explored, was found to measure forty feet in length, with a breadth of eight feet; and throughout this entire area it consisted, to a depth of six feet, of a solid mass of human crania and bones. Along with numerous specimens of clay-pipes, beads, amulets of red pipe stone, copper bracelets, and personal ornaments of different kinds, obtained from those Beverly ossuaries, there were found various shell-beads, a worked gorget made from a large sea-shell, with the original nacre of red not entirely gone, and two entire specimens of the large tropical sea-shells already referred to. One of these furnishes another specimen of the *Pyrula perversa*, and the other is described by Mr Schoolcraft, as the *Pyrula spirata*, a shell said to be peculiar to the western coasts of Central and South America. The beads found along with these tropical univalves, and made apparently from others of the like kind, appear to have corresponded to those of a remarkable southern discovery in the Grave Creek mound, Virginia, described in the Transactions of the American Ethnological Society.

The interest which pertains to such Indian relics, manifestly depends on the fact of thus discovering along the shores of the great inland chain of fresh-water lakes, specimens of the large sea-shells of the Atlantic and Pacific Coasts of Central America, and of the West Indian Isles. The attractions offered by this and other allied species of the large and beautiful tropical shells are sufficiently apparent, and, as we have seen, are by no means limited to the untutored tastes of the American Indian, nor to the products of the Mexican coasts. Their employment in the construction of vessels for ordinary use has already been referred to; but other and more important applications of some of them to special and sacred uses among the inhabitants of the Old World, seem to offer illustrations more in accordance with the discoveries here referred to. In India, China, and Siam, this is especially the case. There the *Pyrum*, and others of the large and beautiful shells of the Indian Ocean, of the species *Turbinella*, are highly prized by the natives of the neighbouring districts; and this is especially the case with a sinistrorsal variety found on the coasts of Tranquebar and Ceylon, and made use of by the Cingalese in some of their most sacred rites.

The greater number of the genus *Pyrula*, are dextrorsal, or rise in a spiral line from right to left, so as to present the mouth on the right side when held with the elongated canal or tube downward. Such is not the case, however, with the two species referred to as belonging to the American continent, and hence apparently the origin of the name given to the more abundant of these, the *Pyrula perversa*. But in the East Indian Seas, examples of sinistrorsal monstrosities of the native species are occasionally met with, and are highly prized. Such reversed shells of the species *Turbinella*, are held in special veneration in China, where great prices are given for them. They are kept in the pagodas by the priests, and are not only employed by them on certain special occasions as the sacred vessels from which they administer medicine to the sick; but it is in one of those sinistrorsal *Turbinellæ* that the consecrated oil is kept, with which the Emperor is anointed at his coronation. It is probably in reference to this custom that Meuschen, who considered what is now recognized as the full grown shell a different variety from the smaller one,—called by him the *Murex pyrum*,—gave to it the name of *Murex sacrificator*.

These shells are often curiously ornamented with elaborate carvings, fine specimens of which are preserved in the British Museum. In the Synopsis of the Zoological Galleries in that Museum, it is remarked, "The *Turbinellæ*, from their form, have been called turnip shells, or rape shells. These are often used as oil vessels in the Indian temples, and for this purpose are carved and otherwise ornamented, as may be seen by some in the collection. When reversed, they are much sought for by the Ceylonese, and highly valued; one of these reversed clamp shells is in this collection. They are said to sell for a very large price in Ceylon and China."

The *Turbinellæ pyrum*, which is one of the most prized of these Ceylonese *Turbinellæ*, is also an article of great importance in the ornamental manufactures of the East Indies, and is so extensively employed, that upwards of 4,300,000 shells have been exported in a single year, from Ceylon to the ports of Calcutta and Madras. These are chiefly employed in the manufacture of armlets, and anklets, often highly ornamented, and generally known by the name of *bangles*. The process at the apex of each shell is also made into a button or bead. These are the *Kranthas*, necklaces of which have been so commonly worn by the Sepoys in the East India Company's service, as almost to be deemed a regular part of their uniform.

Some of these personal ornaments of the modern Hindoo, manufactured from the solid porcellaneous *Pyrum*, closely correspond to the relics of similar construction found in ancient American grave mounds, and supposed by their first discoverers to be wrought in ivory. The chief value of the latter, however, arises from their discovery in latitudes altogether remote from the native habitat of the living mollusk, and the consequent traces which they disclose of ancient migration, or of trade and traffic between widely severed tribes of the American continent. While the tropical shells thus met with in the regions of the Great Lakes may be assumed to represent one among the prized treasures of southern latitudes, the north had its coveted mineral wealth, of the diffusion of which throughout the whole tribes of the northern continent we have abundant evidence from various sources, and referring to very different periods. Among the relics entombed in the sacrificial mounds of the Mississippi valley have been found objects formed from the mica of the Alleghanies, and the native copper of Lake Superior, mingling with others modelled from the tropical fauna of the southern continent.

It is in the western region of the great lakes that the mineral treasure is found which attracted the attention of the Indians long before the discovery of the continent by Columbus or Cabot, and, in that prehistoric period of America, furnished the chief element of traffic, and the source of intercourse between the north and south. The traces of mining operations afford abundant proof of the working of the copper by the Indians of Lake Superior, without any skill in the metallurgic arts, and indeed without any precise distinction between the copper which they mechanically separated from its native matrix, and the unmalleable stone or flint out of which they were ordinarily accustomed to fashion their spear and arrow heads. This metal, Mr Schoolcraft remarks, in his "History of the Indian Tribes," "was employed by the Indians in making various ornaments, implements, and instruments. It was used by them for arm and wrist bands, pyramidal tubes, or dress ornaments, chisels and axes ; in all cases, however, having been wrought out exclusively by mere hammering, and brought to its required shape without the use of the crucible or the art of soldering. Such is the state of the manufactured article, as found in the gigantic Grave Creek mound, and in the smaller mounds of the Scioto Valley, and wherever it has been scattered, in early days, through the medium of the ancient Indian exchanges. In every view which has been taken of the subject, the area of the basin of Lake Superior must be regarded as the chief point of this intermediate traffic in native copper. In exchange for it, and for the brown pipe-stone of the Chippewa River of the upper Mississippi, and the blood-red pipe-stone of the Coteau des Prairies, west of the St Peters, they received certain admired species of sea-shells of the Floridian coasts and West Indies, as well as some of the more elaborately and well-sculptured pipes of compact carbonate of lime, grauwacke, clay-slate, and serpentines, of which admirable specimens, in large quantities, have been found by researches made in the sacrificial mounds of the Ohio Valley, and in the ossuaries of the Lakes. The makers of these may also be supposed to have spread more northwardly the various ornamented and artistic burnt-clay pipes of ancient forms and ornaments, and the ovate and circular beads, heart-shaped pendants and ornamented gorgets, made from the conch, which have received the false name of ivory, or fine bone and horn. The direction of this native exchange of articles appears to have taken a strong current down the line of the great lakes, through Lakes Erie and Ontario, along the shores of the States of the Ohio and New York, and into the Canadas. Specimens of the blood-red pipe-stone, wrought as a neck ornament, and of the conch-bead pendants and gorgets, &c., occur in the ancient Indian burial grounds, as far east as Onondaga and Oswego, in New York, and in the high country about Beverly, and the sources of the several small streams which pour their waters into Burlington Bay, on the north shores of Lake Ontario."

The conchological relics now referred to are of peculiar value, from the illustration they afford of the area embraced by this ancient traffic between the north and south. Whatever doubt may be thrown on the derivation of the specimens of ancient native manufacture, or of the copper found in sepulchral and other deposits in the Southern States, and in Central America, no question can exist as to the tropical and marine origin of the large shells exhumed not only in the inland regions of Kentucky and Tenessee, but in the northern peninsula lying between the Ontario and Huron Lakes, or on the still remoter shores and islands of Georgian Bay, at a distance of upwards of 2000 miles from the coast of Yucatan, on the mainland: the nearest point where the *Pyrula perversa* is found in its native locality.

It is obvious from the large and cumbrous size of the American *Strombi* and *Pyrulæ*, that they must have possessed some peculiar value or sacredness in the estimation of the Indian of the northern regions, to encourage their transport from so great a distance, through regions beset by so many impediments to direct traffic. Their transport to Canadian Lake districts appears to have been practised from a very remote period. Mr Schoolcraft describes specimens of the *Pyrula perversa* obtained by him in these regions, in an entire state, among traces of Indian arts and customs "deemed to be relics of the anti-Cabotian period;" and from the circumstance of their discovery in sepulchral mounds, and laid at the head of the buried chief, with his copper kettle and other peculiarly prized relics, the *Pyrula* of this continent would appear to have been held in no less veneration by the natives of America, than the Asiatic species now are by the Cingalese, or the more civilized and cultivated priests of China. Their appearance when found among sepulchral deposits, as already described, exhibits abundant traces of constant handling in the uses to which they were applied. But whatever these were, we can scarcely doubt that they were connected with Indian superstitions, and not with any purposes of mere practical utility, such as they sufficed for with the ancient inhabitants of the Antilles, and as are provided for in like manner, by means of other species of similar large shells of the Southern Ocean, among the Australian Islanders. It seems not improbable that the gigantic univalves thus brought from the Gulf of Mexico, and introduced among a people familiar only with the miniature shells of the fresh-water mollusks, owed not a little of the veneration in which they appear to have been held, to the natural wonder with which the untutored mind is apt to regard whatever greatly exceeds the scale of its ordinary knowledge. Magnitude, rarity, and difficulty of acquisition, give their chief value to many of the treasures of civilized, as well as of savage life. In all probability the *Pyrulæ* thus venerated by the ancient Indians of Canada West, closely corresponded to the *Conopas*, or rude Penates of the Peruvians, as described by Rivero and Von Tschudi. Any singular or rare object in nature or art seems to have sufficed for one of these Peruvian minor deities, amulets, or charms. "Every small stone or piece of wood of singular form was worshipped as a Conopa. These private deities were buried with their owners, and generally hung to the neck of the dead."

Trifling as such relics of Indian superstition, or of the rude traffic of barbarous tribes, may appear, they are not without some value to us, both in regard to the light they throw on the ancient history of the American Continent, and also perhaps in respect to some of the forms in which the progressive civilization of its new occupants may be modified by the same physical causes which largely controlled the ancient intercourse between north and south, and between west and east.

In no respect is the continent, to which these relics pertain, more strikingly diverse from that of Europe, than in its broadly-marked physical characteristics. The greatest diameter of Europe is from east to west, so that its chief area of occupation is embraced within a nearly similar range of temperature. Yet along with this great uniformity of climate, its surface is broken up by mountain ranges, its coasts are indented by bays, estuaries, and land-locked seas, and its border tribes and nations are isolated by means of peninsulas and islands, so that amid all the resources of modern civilization, the individuality of nations has been preserved to a remarkable degree, and we still study among its diversified populations the relics of people and languages pertaining to ante-Christian centuries. Altogether different is it with the American continent, where the great levels are so little broken, that not only the boundaries of properties and townships, but even of states, provinces, and dominions, are drawn without reference to any natural features of the country, except in such cases as the great lakes, the St Lawrence, the Rio Grande, and very partially in that of the Mississippi. The most important navigable river of Europe, moreover, flows from east to west, in one parallel of latitude, and through a population in all ages rendered somewhat homogeneous by influences of climate and all external circumstances; but the Mississippi and the Missouri together flow through 20° of latitude, with all the varieties of climate still further increased on a continent which extends its widest area within the Arctic circle, and where consequently the curves of equal temperature, in the isothermal lines drawn across the two continents, approach as much towards the equator in the meridian of Canada as they recede from it in that of the west of Europe.

Looking back into the most ancient history of Europe, we find that that continent also had its northern mineral treasures: its tin, pertaining to the Kassiterides, or British Islands, and its amber, found then, as now, in most abundance on the shores of the Baltic. But it was by maritime intercourse, through the agency of the Phœnician merchantmen of Asia, that the north of Europe exchanged its mineral treasures for the coveted possessions of regions lying towards the tropics. Herodotus, in the earliest known reference to the British Isles as the source of tin, refers to them only to declare his total ignorance of them; and in noticing the rumour that amber is brought from the northern sea in which they lie, he says:—"I am not able, though paying much attention to the subject, to hear of any one that has been an eye-witness that a sea exists on that side of Europe." Nor did this singular isolation, so peculiarly characteristic of Europe, disappear even in the later ages of Roman rule. Dr Arnold, in contrasting our knowledge of the globe with the ignorance of earlier ages, remarks:—"The Roman colonies along the Rhine and the Danube looked out on the country beyond those rivers as we look up at the stars, and actually see with our eyes worlds of which we know nothing."

The Indian relics now specially referred to, when considered in connection with the copper weapons, implements, and ornaments of southern grave-mounds, appear to throw a light on the past history of the American continent in its ante-historic ages, and to show it then as now, as clearly distinct in political as in physical characteristics from ancient or modern Europe. Europe never could be for any length of time the area for a nomadic population. In America, with its great unbroken levels, even the home-loving Anglo-Saxon becomes migratory, and seems to lose in a degree his old characteristic of local attachment. In Europe the diverse ethnological elements are still kept apart by its physical features. The Iberian of Ante-Christian centuries survives in the Pyrenees, and the Gaul and Briton of the first century find still their representatives on the coasts of Brittany, and in the mountains of Wales. But an aboriginal population, marked by many nearly homogeneous characteristics, appears to have occupied the entire area of the American continent; and now when its ancient tribes are being displaced by the colonists that Spain, England and Ireland, France, Italy and

Germany, Poland and Hungary, pour unceasingly on its shores: the distinctions of Iberian, German, Celt, and Saxon, which have survived there for well-nigh two thousand years, appear to vanish almost with the generation that sets foot on the shores of the New World. When we consider how largely all European history has been affected by the peninsular character of Greece and Italy, and by the insular character of Britain, as well as in its modern centuries by the isolation of Spain, France, Denmark, and the Scandinavian Peninsula, we cannot fail to perceive in this a key to some of the contrasting elements of fusion already noticeable among the people of European descent throughout the American continent. May we not further draw from this, important inferences as to the causes of those homogeneous characteristics noticeable among the whole aboriginal tribes of the new world, to which an undue importance has been attached by American ethnologists, from their supposed bearing on the great question of human origin and descent from one or more centres of creation.

On the Temporo-Maxillary Articulation. By J. Smith, M.D., Edinburgh.

The following notes on certain points of interest connected with the Temporo-Maxillary Articulation, must be regarded as the result of a few observations and inquiries made in a subject as yet by no means fully wrought out. The characters of the temporo-maxillary articulation present many anomalies and complications, rendering its investigation one of much difficulty, and any theories in reference to it, subject to great latitude of opinion. The remarks advanced in the present paper are therefore to be considered as suggestive, rather than conclusive in their nature, and as admitting and probably requiring, much further research and many modifications.

Considerable difficulties present themselves in attempting to demonstrate the peculiarities of external character in the condyles of the lower jaw, especially in the human subject. Because the multiplicity of movements performed by, although perhaps not strictly essential to the joint,—and the numerous different accidental and other conditions of relative parts, such as the teeth, &c., from infancy to old age,—lead to many modifications in the mode of using the jaw, and, consequently, to great dissimilarity of form in the condyles, not only of different individuals, but of the same individual at different times. Through all these varieties, however, there will, upon careful examination, be found to be certain general principles distinctly traceable.

Before proceeding further it may be as well to premise that the description necessary here to be given may appear too artificial; but to be intelligible this is required. Allowance must accordingly be made for using terms, the intention of which is rather to *illustrate* than *describe* the structures under notice.

On looking at the condyles of the lower jaw, we find them set with their long or transverse axes, *not at right angles* to the plane of motion as an ordinary hinge would be, but set *obliquely* to it. That is to say, instead of being both at right angles to a line drawn from the centre of the chin, directly backwards to a point midway between the articulations, each condyle is rather placed at right angles to a line drawn in the horizontal direction of that ramus to which it respectively belongs. Owing to this construction, then, the condyles cannot, in the movement of merely opening and shutting the mouth, act as a simple hinge; as such a hinge would, correctly, be at right angles to the plane of motion.

Instead, therefore, of each condyle constituting a part of the common axis upon which this motion of the jaw is made, each appears rather to constitute an articular surface winding spirally round that axis. Here the error of confounding the *whole condyle* with that limited portion of it forming its *true articular surface* must be guarded against. This *articular surface* passes over the condyle, from its *anterior* aspect at the external end, to its *posterior* aspect at the internal end.

This proposition may, perhaps, be best and most easily illustrated by the analogy afforded by some of the lower animals. In the Carnaria—such as the lion, tiger, leopard—a construction of this kind is very evident; but in man also, the same character prevails, and in a well-developed condyle is distinctly marked.

The articulating surface of the condyle thus acquires some of the properties of a screw: that screw being a conical screw, or helix, and having its axis lying at right angles to the plane of vertical motion in the jaw, or some way nearly so; and being from the direction of the thread (that is the articular surface), a right-hand screw on the left side, and a left-hand screw on the right side; the base of the cone being placed externally.

In using the word screw here, it is not of course meant that either a perfect screw, as defined in mechanics, exists, or that the power of one is imparted to the joint. In fact, only a limited portion of such a conical screw is presented in the condyle,—half, or a third of a turn of the thread being all that is necessary for the purposes of the joint, the remaining portion being unnecessary, and consequently absent. This absence of that complementary portion indeed, leading to some difficulty in recognising that which is present.

The *Glenoid cavity* will, in all such examples, be found to correspond to the characters of the condyle, constituting as it were a longitudinal section of a spiral chamber: the condyle and glenoid cavity together thus constituting a certain portion of a *conical tap*, moving in a corresponding portion of a *conical die.*

Regarding the *action* of the joint, viewed as thus constructed, it will be seen that as the respective surfaces of a *conical tap* and *die* are never wholly in contact unless the screw is completely home, so in many stages of motion in this joint, the condyloid and glenoid surfaces must be to some extent separate from each other. And on attentively observing the action of the condyle within the glenoid cavity, this will be found to be the case; as in opening the jaws the point of contact between the surface of the condyle and glenoid cavity recedes, inwards and backwards, describing a spiral track over the condyle, corresponding to the articular surface, and passing from the *anterior* external until it only exists at the *posterior* internal aspect of the articulation; and returning again until the whole is in contact, as the mouth is closed. By this means a great amount of friction is avoided; what would otherwise be a *rubbing*, being thus converted into a *rolling* motion, between the condyloid and glenoid surfaces; while greater steadiness and security is afforded to the jaw during these movements, by one or other condyle being always within the glenoid cavity.

So far this spiral character modifies the action of the joint during this simultaneous motion of both articulations, both acting alike. But it will be seen that the action of two *reverse* screws, as these are—thus taking place *at once*, would, under the circumstances in which they are placed, prevent the *complete* or *perfect* action of either; and it seems that this peculiar construction is therefore most perfectly exercised only during what may be considered as the essential action of the jaw—namely, that of *mastication*.

During mastication in man, the condyle of one side remains within the glenoid cavity; the jaw is projected towards this side—while the condyle on the other side emerges from the glenoid cavity, and glides forward upon the zygoma. The substances to be masticated are crushed between the teeth of *that side on which the condyle remains in situ;* and this condyle, during the closure of the teeth, by the construction of joint which has been indicated, screws, if we may so speak, home in its spiral chamber, and so brings back the jaw to its natural position.

It only remains to say a word regarding the interarticular cartilage found in this joint. The condyle, *while covered by this structure*, fits accurately the hollow of the glenoid cavity. In the dry condition of the bones this adaptation is not so complete, being barely sufficient in some instances for illustrating the subject of the present remarks. But along with thus filling up spaces, which would otherwise be left vacant, between the articulating surfaces—another, and perhaps the chief purpose fulfilled by the interarticular cartilage, is that of affording a means of greater security for that condyle which during mastication leaves the glenoid cavity—the double concave cartilage following its movement, and thus serving as a sort of portable socket for the condyle when acting, as it were, beyond the articulation—a movement which, by its anomalous character, may account for some modifications found in this when compared with other joints.

Contributions to the Natural History of the Hudson's Bay Company's Territories. Part II.—*Mammalia* (continued.) By ANDREW MURRAY, F.R.S.E., President of the Botanical Society of Edinburgh.

REIN-DEER (*Rangifer Caribou*).—In my last communication on this subject, I drew attention to the antlers of the American rein-deer,—their peculiar form, their mode of growth, and the habits of the animal,—as bearing on the question of its identity with the Lapland rein-deer, and made some suggestions and speculations, with the hope that they might lead some of my correspondents to inquire more particularly into these points, and give us reliable information upon them, which might enable us to come to a correct conclusion on the subject. I am happy to say, that these observations have had the desired effect, and that, with an additional supply of horns and heads, I have this year received divers remarks on the points I indicated for inquiry. One intelligent correspondent, Mr J. Mackenzie of Moose Factory (from whose communications I have received much satisfaction), goes at some length into the subject, and his information, as to the time of the year when the horns are cast at the different periods of the animal's life, clears up the discrepancies which have been noticed in the statements of different authors on this subject. It will be seen that the casting takes place at different times in the young and older animals. I cannot do better than bring his views before the reader in his own words, particularly as he comes to a different opinion from that which I felt disposed to adopt on one or two of the points which I speculated upon. Mr Mackenzie says—"I have consulted one of our most intelligent natives, a man of about sixty years of age, who has been a deer hunter from his youth, and the result of our "conference" I will presently give you. I send by the ship a deer's head and antlers, which were received about last Christmas, and said to have been killed early in December; it bears some resemblance to the North American species, a representation of which is given in your pamphlet, although the brow antler, however, forms a small angle with the head, and does not come down parallel with it, as in the heads sent you by Mr Hargrave; it has also a second projecting prong, bent near the head, without any terminal points or fingers, but these it would have had, had the animal lived a year or two more; indeed the horns do not cease growing till the seventh year. I do not believe that the brow antler is intended for the purpose of clearing away the snow, but is intended rather as a means of defence against the animal's numerous enemies. The wolf, wolverine, and lynx, destroy them, I am informed, in great numbers; but the animal, on its guard, appears to me to have a good means of defence in his brow antler. Generally, however, he is taken at a disadvantage; when lying down, and off his guard, the lynx (of the cat tribe) moves stealthily along, and with a bound springs upon his back, and fastening his claws in his neck and throat, worries him to death. The wolf and wolverine are not numerous (the latter, indeed, is rarely found) in this part of the country, but of the three the latter is the most savage, and with him the deer has little chance of escape when attacked. Indian opinion here is, that for clearing away the snow, the animal uses his fore-legs alone; and whether it is hard or soft, they are well adapted for the purpose. My own opinion is, that our rein-deer is the same as the Lapland rein-deer. The following information, collected, as I have already mentioned, may tend to throw some light on the subject. The rutting season is in September; the females carry their young till the latter end of May or beginning of June, or till the *last snow* is disappearing. The horns begin to grow in about a month; at the end of the year they fall off, being about 8 inches long, and not branched; at the end of the second year they are about 1½ feet long, curved, and with terminal points, and are cast off in spring; the third year the front and brow antlers commence to grow, but are not large at the end of the year, and are cast off again in spring; the 4th year they are larger, but not full-grown, and are cast off in spring; the fifth year they are still growing, and are cast off in *March;* after the fifth year they are cast off in November. The Indian also states, that the antlers have a variety of shapes, and that it is rare to find two exactly alike. With regard to the training or domestication of the rein-deer I can say nothing from my own experience, nor from that of any Indian at this place; but I may mention, that I have recently seen a gentleman who passed many years near the head waters of the River Synauria (a river which falls into the St Lawrence, near the Town of Three Rivers, in Lower Canada), and that he had seen a young rein-deer among the Indians as tame as a lamb; it entered the lodge, and followed its master like a dog; but it was at last killed by the dogs."

Mr Mackenzie's observations will be of use in correcting misconceptions on one or two of the points alluded to by me. It would appear that the American species uses its feet in clearing away the snow from its food, as much as the Lapland species does; and the cup-shaped structure of its feet, as shown in the specimens now sent home, is admirably adapted for this. That it does not use the projecting shovel-like brow antlers for the same purpose I am less willing to admit; the apparent adaptation of their form to this purpose induces me to defer forming a definite opinion upon it until further information be obtained; the rather that, however intelligent and truthful the Indian referred to by Mr Mackenzie may be, his statement is merely negative, and is inconsistent with the observations of such authors (few in number though they be) as notice the point.

As to the identity of the Lapland species with the North American, we cannot expect to arrive at any correct result, until we have the means of making a more complete comparative examination than has yet been done of the two species alongside of each other. Notwithstanding the greater distance of its locality, we possess both better materials and more accurate information on scientific points regarding the species from North America than that from Lapland. It is to the latter that our inquiries should now be directed, and more accurate information sought for on such points as the periods of growth and shedding of the horns, referred to in my previous communication, and in Mr Mackenzie's letter. His statements on this point have been confirmed to me by Mr Hargrave, who also informs me, that the head with distorted horns, sent last year, which was figured in the first part of this paper, was a young animal, not more than two years old. He mentions, that a slight bend is common in the first year; that this becomes of the distorted form above referred to in the second year, but afterwards disappears. I was misled, by the teeth being much worn, into the supposition that it was an old animal. These worn teeth must be the milk teeth; and we thus have incidental information as to the period the animal carries them.

Information on such points becomes of importance, because the North American and Lapland species are so closely allied to each other, that we cannot expect to find distinctions of a prominent nature, and must be content with the accumulation of those of a more subordinate character. I may notice, that I find the view which I adopted—viz., that the species are distinct—has also been entertained by Professor Spencer Baird of America, who, in his recent "General Report upon the Zoology of the several Pacific Railroad Routes, Part I.—Mammal," includes two species of rein-deer as inhabiting the northern shores of North America, and both distinct from the Lapland deer (the *Rangifer caribou* and *R. Grœnlandicus*); at the same time admitting that their distinctness is questionable.

MOOSE DEER (*Cervus Alces*, Lin.).—Mr Hargrave has had the kindness to send me a magnificent head and horns of this fine elk, which is another animal as to whose identity with its European representative we are still in doubt. The Scandinavian elk is undoubtedly very near it, if not the same.

The enormous palmation and weight of the horns in this species is very striking. Colonel Smith says that the horns sometimes weigh fifty pounds. The present specimen weighs 32 lb., but that is inclusive of the head. Sir John Richardson, in his account of the animal, records a statement relating to the horns of deer which I think must have originated in some curious mistake. Speaking of the moose deer, he says,—"It is probable, however, that La Hontan in this passage confounds the Canada stag and moose deer together. He mentions the animal being able to run in the summer season for three days and nights in succession, and the excellent flavour of its flesh—facts which apply to the moose deer, but not to the Canada stag; on the other hand, the weight of the horns, which he says sometimes amounts to *four hundred weight*, is true only of the stag." Now, the Canada stag, or *wapiti*, is the representative of the red deer in America, and was indeed long thought to be identical: it is a larger animal than our stag, but smaller than the moose, which is as high as a horse. Large specimens of the male moose are mentioned, which have attained a weight of eleven or twelve hundred pounds; and is it possible that a smaller animal should have horns weighing four hundred weight? I suspect a cypher has been added, and that we should read 40 lb. instead of 400, which would then make it clear that the animal referred to by La Hontan was the moose. With regard to the moose being able to run for three days and nights in succession, an instance of its doing so is recorded in the narrative of Captain Franklin's second journey, where three hunters pursued a moose deer for four successive days, until the footsteps of the deer were marked with blood, although they had not yet got a view of it. At this period of the pursuit, the principal hunter had the misfortune to sprain his ankle, and the two others were tired out; but one of them having rested for twelve hours, set out again, and succeeded in killing the animal, after a further pursuit of two days' continuance. The cause of the footsteps being marked with blood might be from the phalanges of the hoof splitting, or possibly from the hoof becoming worn down by incessant and long-continued action on the icy crust of the snow. We are accustomed to hear of the cattle in long journeys in the Cape of Good Hope and Australia becoming knocked up, and the traveller being arrested in his journey by the failure of his beasts of burden. I daresay many people entertain the idea (as I did myself) that this knocking up was the consequence of physical exhaustion on the part of the cattle. Mr Ford, one of the best zoological draftsmen in Britain, first enlightened me on this point. He had accompanied Dr, now, deservedly, Sir Andrew Smith in one or more of his exploratory expeditions to the interior of the Cape; and he told me that this failure of the cattle was occasioned, not by exhaustion, but by the actual wearing away of the hoof, till blood oozed from it at every pore. The Calahari desert was particularly obnoxious, as it is composed of a slaty formation, highly inclined, which shivered easily off into sharp fragments. It was like walking on bundles of pen-knives, with their edges placed upwards. The cattle gave in sooner in this desert than in any other district, in consequence of the greater abrasion of the hoofs upon this slaty formation; and, till they grew again, the animal was useless, and scarcely, even to crop its food, would it stir from the spot where it was unyoked. I do not know what length of time would be necessary to incapacitate an ox,—of course, it must be various, according to the extent and nature of the ground travelled over; but although soft snow might protect it longest, I imagine the brittle fragments of a hard frozen crust of snow might be not much less destructive than the slaty splinters of Calahari.

I have examined the hair of the moose deer, and find that its structure is the same as that of the rein-deer, which I have already described in my paper last year.

ALPINE HARE (*Lepus glacialis*, Leach).—This beautiful hare furnishes an admirable example of the adaptation of structure to habit. For heat and comfort nothing can surpass the thick, delicate, white fur, which, on the under side of the paws, assumes such a compact, double-plied, felt-like character, that one would think no degree of cold could penetrate it. The whiteness of its colour also is so pure that it is most difficult to discern it on the snow. Sir John Richardson notices that in one of the boat voyages in which he took part along with Franklin, they landed on a rocky islet off Cape Parry, which, although not above 300 yards in diameter, was tenanted by a solitary Alpine hare. The whole party went in pursuit of this poor animal; but it availed itself so skilfully of the shelter of the rocks, and retreated with so much cunning and activity from stone to stone, that none of them could obtain a shot at it, although it never was able to conceal itself from their search for more than a minute or two at a time.

Its flesh is said to be better eating than either the American or European hare.

QUEBEC MARMOT (*Arctomys empetra*, Schreb.)—This animal, although recorded as being found in the Hudson Bay Company's territories, would appear to be confined to their southern parts. I have received none from my northern correspondents, but only from Canada, where it would appear not to be rare.

Musk Rat (*Fiber zibethicus*, Cuv.)—This is a very common species in the Hudson Bay Company's territories, and supplies a large portion of the furs sent to this country. Its skin is used as medicine or medicine-bags by the natives, in which state the specimens sent to me have arrived.

Beaver (*Castor Americanus*, Brandt).—Considering the immense number of animals both of this, and more especially of the preceding species, which have been for a long series of years taken for the purpose of supplying the wants of civilized Europe, we might have expected that specimens would be by no means rare in our museums. The contrary is the case however, so much so that when my friend Dr J. A. Smith a year or two ago wished to compare the semi-fossil bones of a beaver found in the boulder clay of Scotland with the recent skeleton of a beaver, the comparison could not be made in Scotland from want of a specimen of the recent animal in any of the museums in that country. I applied to Mr Mackenzie to assist us in remedying this deficiency, and he has very kindly done so by sending both a full-grown living beaver, and a fœtus taken from the mother before birth. In sending a living specimen Mr Mackenzie remarked that it would probably ultimately answer the purpose of a skeleton, should the climate of Edinburgh not agree with the animal's constitution. I had destined it for the pond in the Edinburgh Royal Botanic Gardens, where Professor Balfour could have given those interested in natural history an opportunity of studying its habits at their leisure. It might easily have been kept alive if it once had reached the gardens. There would have been no difficulty in supplying it with birch twigs and branches, its native and proper food; and Mr Mackenzie informs me that it is by no means particular in its food, and that if it had the run of the kitchen (that is, I presume, the opportunity of selecting what it chose from the debris of an ordinary family's table) it would do very well. Unfortunately, it never got the chance of trying the climate of Edinburgh, nor we the chance of trying experiments upon it or its food. It reached London alive, but that was all. It died next morning. It was, however, carefully transmitted to me, and along with the fœtus received last year was presented by me to Professor Goodsir, who has undertaken to make a careful dissection of it, and to communicate anything he might think of interest. There are a number of points in the internal anatomy on which information is wanted, such as the castor, and the glands which produce it, and others which might throw light on some disputed (I cannot call them doubtful) points in its economy and habits. For instance, Hearne states, that the usually received notion that the animal uses its tail as a trowel to plaster its work, is merely a vulgar prejudice, arising from its flapping it on the ground occasionally, and more particularly when about to plunge into the water. Now an examination of the muscles of the tail might, were it necessary, throw light upon this point. But I imagine that the whole structure and habits of the animal explain the use of the tail sufficiently even without anatomical assistance. On examining its external peculiarities we find that its fore paws and feet are short and comparatively small and weak, and not provided with a web; the claws are strong, and well adapted for digging, but not equal to those of the hind feet. The hind feet and legs are enormously strong, the fingers united by a strong broad web, the claws excessively developed, and each in the form of a strong gouge. The combination of machinery in the fore and hind legs and feet thus corresponds with what we know of the habits of the animal so far as that can be observed; and the structure of that portion whose working is difficult to be observed in action, or has not been noticed sufficiently, shows what its real working is. Those who have observed the animal in its native haunts, tell us that it uses the fore paws for carrying the mud and stones used in its constructions, and that it carries this stuff between them and its breast, which quite corresponds with their attitude in my dead specimen. It no doubt uses the fore paws for other purposes, as digging, swimming, and walking (for nature seldom or never creates an organ merely to fulfil one purpose). As clearly, the hind paws are much used in digging, but most in swimming;—the powerful hind leg, enormous web foot, and strong claws, would prove this although no one had ever seen the animal using them. Combine these different actions of the fore and hind feet together and see what would be the result. Suppose the animal swimming across its pond or river with a burden of heavy materials clasped to its breast by its fore paws, and powerfully propelled by its hind legs, and that it had no tail or only a common tail—what must inevitably be the consequence? The hind feet would propel the animal rapidly enough—no doubt about that—but where to?—why, to the bottom, for, being overloaded in front, it would be top heavy, and its head falling down and the more violent the exertions of the hind feet, the sooner it would reach the bottom, and the deeper its head would be buried in the mud. That this is the necessary and inevitable consequence of the want of the action of the fore paws, will be evident to every one if they will merely fancy what would be the result of their trying to swim with their arms folded; of course, if there is not only the inaction or abeyance of the fore arms to be conquered, but also the weight of a load of mud or stones to be counteracted, a counterpoising lever of more than ordinary power will be necessary, and this is supplied by the broad flat horizontal tail, which is constructed on the best principles for attaining such an object. Were it different or differently placed, the end would not be answered; suppose it vertical like a fish's tail, it would answer equally well as a swimming organ, but not as a counterpoise. It must be powerful, and it must be horizontal, and as the resistance has to be exercised directly and in a short space, it is denuded of hair, or nearly so, and covered with polygonal scales. A few scattered hairs occur, interspersed between them, but these are not abraded as they would have been had the tail been used as a trowel. That this is the interpretation of the structure and purpose of the tail is I think self-evident from its fitness. The habit of flapping the tail on the ground before plunging into the water is probably only the mechanical repetition of the action with which it habitually starts into motion, and which in the water is essential to its progress.

The teeth of the beaver are often quoted as good examples of the mode in which rodent teeth grow from the pulp at their base, with a hard enamel-like steel on the outer edge, and softer material on the inner side, and thus have their sharpness and chisel-like form always kept up by the very thing which at first sight would seem to be likely to make them blunt—viz., their constant use. The incisor teeth in the fœtus are conical, thus showing that the chisel form in the adult is the result of abrasion. The specimens sent me are from the neighbourhood of Moose Factory.

I have adopted the specific name *Americanus* given to this species by the Russian naturalist Brandt, who has separated the American animal from the European and Asiatic (the true Castor fiber) on osteological grounds, chiefly drawn from the skull. For the reason alluded to above (want of specimens for comparison), I can give no opinion as to the propriety of this separation.

Mus leucopus, Rafin.—In his description of this species, Sir John Richardson says,—" The tail is thickly clothed with short hairs, lying pretty smoothly, no scales whatever being visible." In my specimen it is not *thickly* clothed with hairs; it is rather sparingly clothed with hairs, and the scales are very apparent under them. He also says that " its " (the tail's) " upper surface is of a hair-brown colour, considerably darker than any other part of the animal, and contrasts strongly with the inferior surface, which is white." The upper surface of the tail in my individual is not nearly so dark as the back of the body; still, however, as it agrees in all other respects with *Mus leucopus*, I have no doubt that it is that species, and that these differences are only accidental variations in my specimen.

SHREW-MOLE (*Scalops Canadensis,* Cuv. ?)—I have had no opportunity of comparing this animal with any named specimens, and my determination is made entirely from the description in Sir J. Richardson's " Fauna Bor. Amer." My specimen agrees, for the most part, with the description in that work; but there are one or two points on which I am not quite satisfied. In particular, the whole of the fore foot is said to have a close resemblance to that of the common mole. Now, although this has a general resemblance, it cannot be said to bear a close resemblance. It wants the sabre-shaped bone of the mole, and the nails are greatly smaller. The description of the nails of the shrew-mole is, that they are large, white, and have a semi-lanceolate form, with narrow, but rather obtuse points. These in my specimen can scarcely (according to my ideas) be said to be large; but large is a word of very doubtful interpretation; what is large to one person may be very small to another; so that, on this item, I must mark my species with a query.

There is one point in the history of the shrew-mole which I should like to see either confirmed or expunged from our books—viz., that although a burrowing animal, it has the singular habit of coming daily to the surface exactly at noon.

Sorex parvus, Say.—This shrew may be readily distinguished from other American shrews by its tail being rounded instead of being more or less angular. One might be disposed to think that this is a character of little value, depending merely on the greater or less plumpness of the individual; but it does not appear to be so, and other characters concur with this to establish the species.

This one is certainly not well named; as, though undoubtedly a small animal, it is the largest of the North American species.

Sorex Forsteri, Rich.—The tail in this species is quadrangular. It is the smallest quadruped known to the Indians; and I cannot call to mind any quadruped with which I am acquainted, from any quarter of the world, which is smaller.

Among the specimens which have been sent me is one which differs slightly from the description of *S. Forsteri*. Its colour is wholly mouse-dun, whereas that of Forsteri is wholly clove-brown on the back. The specimen is in spirits, however; and the clove-brown being, from what we see in other specimens, a tinge of that colour in certain lights, it is probable that the darker colour is merely owing to the medium in which it has been sent; at all events, that the specimen is at most only a variety.

AMERICAN OTTER (*Lutra Canadensis*).—I have received a specimen from the York Factory district, in the shape of a medicine-bag, which is a favourite use of it with the natives.

PART III.—*Aves.*

Before commencing the enumeration of the birds, I should wish to make an ample preliminary acknowledgment of the assistance I have received in determining them, from our celebrated ornithologist Sir Wm. Jardine, Bart., and also from Dr J. A. Smith of Edinburgh. Their extensive knowledge and familiarity with the subject have saved me much labour; and wherever the species were difficult of determination, the reader has the satisfaction of knowing that it is introduced in accordance with the careful examination and deliberation of these gentlemen as well as myself.

Archibuteo Sancti Johannis, (Gmel.)

Received both from Severn House and Trout Lake Station.

Very near our own *Archibuteo lagopus*, or rough-footed falcon; indeed, the pale-coloured specimen scarcely differs from some European specimens of that bird.

Falco peregrinus (Gmel.), (Peregrine Falcon).

Trout Lake Station and Severn House, Hudson's Bay.

Sir J. Richardson says this bird is frequent in the barren grounds. Sir W. Jardine tells me it is the *Falco anatum*, Bonap., of the American ornithologists. Well known at New Jersey from the havoc it makes among the water-fowl in winter. Mr Ord says, that the ducks when struck by it are lacerated from the neck to the rump.

Falco candicans (Gmel.), (American Gyr Falcon).

York Factory.

A constant resident in Hudson's Bay territories, known as the "speckled partridge hawk," and the "winterer."

Circus cyaneus (Linn.), (var. *Hudsonicus*); or it may stand *C. Hudsonicus*, (Linn.)

From Moose Factory and Severn House.

The male varies from the European specimens in the upper parts being darker, and in the lower breast and the belly being barred at wide intervals with pale sienna,—agreeing in this respect with the figure given by Bonaparte in his continuation of "Wilson's North American Ornithology." The young male differs in the darker general plumage and the deeper tint of the sienna on the under parts.

Nyctea nivea (Daud.), (Snowy Owl).

York Factory.

Two beautiful specimens received; one wholly white without a single dark spot.

Surnia funerea (Gmel.), (Hawk-Owl).

Trout Lake Station, Severn House.

Asio brachyotus, (Short-Eared Owl).
Trout Lake Station.
Slightly varies in shade of colour from some British specimens.

Chordeiles Virginiana, (Briss.)
Trout Lake Station.

Ceryle alcyon (Linn.), (Belted King-fisher).
York Factory.
The only king-fisher that inhabits the Fur countries in Hudson's Bay territory.

Perisoreus Canadensis (Linn.), (Canada Jay, or Whiskey Jack).
Severn House.
Very forward, and intrudes himself upon man, but pines away in confinement.

Corvus Americanus, (Audub.)
Trout Lake Station. Hudson's Bay.
The American representative of our *Corvus corone* or carrion crow.

Agelaius phœniceus, (Vieillot.)
Hudson's Bay.
This showy bird winters in vast numbers in the southern parts of the United States and Mexico. Its range to the north does not pass the 57th parallel.

Agelaius xanthocephalus, (Bonap.)
From Hudson's Bay.

Turdus migratorius, (Linn.) (American Robin).
Severn House, Trout Lake Station.
The colour is unusually bright in the specimens received.

Seiurus Noveboracensis (Bonap.), (*aquaticus*, Sw.)
Severn House.

Anthus Ludovicianus, (Gmel.)
Hudson's Bay.

Sylvicola æstiva, (Gmel.)
Hudson's Bay, Trout Lake Station, Severn House.
Known throughout the whole of the fur countries.

Sylvicola striata (Gmel.), (Blackpoll warbler).
Hudson's Bay Trout Lake.

Sylvicola parus.
Severn House, Trout Lake.

Otocorys cornutus (Sw.), (Shore Lark).
York Factory, Severn House, &c.
Appears common.

Plectrophanes nivalis (Linn.), (Snow-Bunting).
Severn House, Trout Lake Station, Hudson's Bay.
Only goes to the south when the snow becomes deep.

Plectrophanes Lapponica, (Linn.)
Trout Lake Station and Severn House.
Like the last, is common to the northern regions of both Europe and America.

Plectrophanes pictus, (Sw.)

Severn House.

Seems scarcer than the others. Richardson mentions that he had only obtained one specimen. Three have been sent to me.

Zonotrichia leucophrys, (Gmel.)

Severn House, Hudson's Bay.

Zonotrichia albicollis, (Gmel.)

Hudson's Bay.

This species winters in the southern parts of the United States. Among the Cree Indians it bears the euphonius name of Oochaechimmenaw-kaw-mawkaw-seesh.

Spizella monticola (Gmel.), (*Emberiza canadensis*, Faun. B. Am.)

Severn House.

This bird winters in the United States.

Linota borealis=*canescens* (Gould).

Severn House.

The same bird known in this country as the Mealy Redpoll.

Loxia leucoptera, (Gmel.)

Hudson's Bay, Severn House, and Trout Lake Station.

Corythus enucleator (Linn.), (Pine Grosbeak).

Severn House.

Scolecophagus ferrugineus, (Gmel.)

Severn House, Trout Lake.

The most northern species,—called Rusty Grakle by Americans. The male is not rusty, but the female has a ferruginous tinge. Feeds on maggots and insects.

Lanius septentrionalis, Gmel.=*borealis* of Vieillot "Orn. Amer. Sept.;" but he unfortunately gave the same name to a bird in his "Faun. Franc.;" Gmelin's name, therefore, should stand. It is very difficult to make out the birds of this genus; and there almost seems reason to look upon the American species as varieties of the European, but ornithologists have accepted them as different.

Trout Lake Station and Severn House.

Tyrannus borealis (Sw.), (*T. Cooperi*, Bonap.)

Hudson's Bay.

A rare bird, and to be seen in very few collections.

Colaptes auratus, (Linn.)

Trout Lake and Hudson's Bay.

One of the woodpeckers; but as it feeds on ants, and therefore does not require so much labour to get its food as the other woodpeckers, its bill is less suited for such work. It is only a summer visitant to the fur countries.

Apternus tridactylus, (Sw.)

Severn House.

One specimen.

The common three-toed woodpecker.

Lagopus albus (Gmel.) = *L. subalpinus*, (Nils.), and *L. saliceti*, (Less.), of Europe; and also = *L. Scoticus* of Britain. (*Vide* Jardine.)

In consequence of Sir William Jardine's desire to procure specimens of this species in the various states of plumage, to assist in elucidating the question which he has started, whether it is not the same as the common grouse of this country, I begged my correspondents to furnish me with a good series of specimens in their plumage at different seasons of the year, and a fine series of lovely skins, beautifully preserved, has accordingly been sent, which have proved of much use to Sir William in his inquiry. The above synonymy shows the result to which he has come.

I also particularly drew the attention of my friends to the white-tailed grouse in relation to its affinity to this species, but no specimens of it have as yet been received. Mr A. M'Donald, stationed at Little Whale River, however, writes me as follows on the subject:—"I am not aware that the white-tailed grouse is to be found in this locality. We have two sorts of the ptarmigan—the large one, which is generally found among the willows, is, I believe, the willow grouse. The other is much smaller, and confines itself almost entirely to the rocks.* This latter may be the white-tailed grouse to which you refer. I have never seen it in summer, and indeed they do not, I believe, make their appearance till after a considerable quantity of snow has fallen. They are of about the size of the common pigeon." He adds, "I will be able to procure good specimens of both these, and, if possible, in the various stages." As specimens of this white-tailed grouse are exceedingly scarce in museums in Britain, such a supply will be acceptable.

Tetrao Canadensis, (Linn.)
Trout Lake and Hudson's Bay.

Tetrao phasianellus, (Linn.)
Trout Lake Station.

The *Tetrao obscurus* (Rich. and Sw.), or Dusky Grouse of the Northern Zoology, has not yet been received.†

* This smaller bird, if not the white-tailed species, will be *L. mutus* (Leach), or common ptarmigan of Great Britain. The white-tailed bird cannot be mistaken, none of the tail feathers being *black*, as in the other two species.

† *Tetrao obscurus* (Say), and the *Tetrao obscurus* (Richard and Swain), Faun.

Porzana Carolina (Linn.), (Carolina Rail).
Severn House.

Pluvialis Virginiacus, (Borkh.)
Trout Lake Station and Severn House.
The American representative of our golden plover, specifically distinguished from it by its lesser size, and the axillary feathers being dusky, instead of white. Like our own golden plover, this bird is highly prized as food.

Charadrius semipalmata, (Kaup.)
Trout Lake Station and Severn House.
Plentiful in Arctic America.

Squatarola helvetica, (Linn.)
Severn House.
This may be looked upon as only a northern state of our grey plover. It is in full *breeding plumage*, and the ground colour of all the upper parts nearly white; certainly appears to be influenced by climate.

Strepsilas interpres, (Linn.)
Hudson's Bay and Severn House.
A citizen of the world.

Grus Canadensis, (Temm.)
Trout Lake Station.

Botaurus lentiginosa (Montag.), (American Bittern).
Severn House.

Numenius Hudsonicus, (Lath.)
Severn House.

Tringa alpina, (Linn.)
Severn House.

Totanus melanoleucus (Gmel.), (*vociferus*, Sab.)
Severn House.
The specimens received agree with Gmelin's description of the breeding plumage, but differ somewhat from those usually seen, which generally come farther from the south.

Totanus flavipes, (Vieill.)
Severn House.

Limosa fedoa, (Linn.)
Hudson's Bay.

Limosa Hudsonica, (Lath.)
Severn House.

Phalaropus lobatus, (Ord.)
Severn House.

Anser hyperboreus (Gmel.), (Wavey; Snowy Goose).
Moose Factory and Severn House.

Bernicla Canadensis (Linn.), (Cravat Goose; Canada Goose)

B. Am., are quite distinct, and specimens of the latter from northern latitudes are much wanted.

There are most probably more than one species confounded under the old name of *Anas Canadensis* of Linnæus, founded on the figures of Brisson, Catesby and Edwards, which all evidently refer to one species. Sir John Richardson mentions two Indian synonymes for it—viz., *Neescah* and *Mistehay-neescah*, besides that of *Apisteeskeesh* for Hutchin's goose, from whence we may, I think, legitimately infer that the Indians recognise two species at least, this being peculiarly a case where dependence may be placed on the observations of natives, the animals being one of the objects of their chase, and a knowledge of the habits and distinctions of different species being essential to their success in hunting them. Three skins have been received, which appear to belong to three different species; the one of middle size being without doubt the true Canada goose. The smallest one differs in the form of the bill, which is more Bernicle-like, it resembles *B. Hutchinsii;* and Sir William Jardine informs me it agrees very exactly in size, &c., with a bird from Mexico, described by Cassin, from the Philadelphia Museum, under the name of *parvipes.* And he adds,—"Its being from Mexico is no drawback, the Philadelphia Museum possesses only one specimen, and that would be migratory." The largest specimen seems also distinct, and does not appear to have been described; and as it is obvious that, whether it be really a new species or merely in a different state of plumage, it must, when it becomes known, be sooner or later described and made identifiable as a variety, if not as a species, I think I can do no harm in describing it, and giving it a provisional cognomen.

Bernicla leucolæma (Murray). (Plate IV., fig. 1.)

Beak black; head and greatest part of the neck black; chin and throat white, the white extending upwards and backwards beyond the ear coverts, and also extending downwards along the under side of the neck almost to the end of the black portion, but tapering away and becoming narrower and somewhat interspersed with black feathers as it extends downwards; the under eyelid broadly white; the white on the cheeks, &c., without black flecks; the black on the fore part of the head and behind the white space flecked with white; the back and the wing coverts, the secondaries and tertials light brown, with lighter coloured edges to the feathers; primaries dark brown; tail feathers black; the rump black; upper tail coverts white; lower part of the neck pale dirty lavender; upper part of breast still paler; lower part and belly almost white, except a broad pale lavender-coloured band across the middle, just before the tops of the thighs, or, perhaps, I should rather express it as breast and belly pale lavender-coloured, with a broad white band across the breast; vent and under tail coverts white; legs and first phalanges pale brown, probably paler when in life; remainder of the phalanges and interdigital membranes bright yellow, sparingly spotted here and there with black or brown. Length, 40 inches.

Its general appearance is very much the same as that of the Canada goose. The following are the particulars in which it differs:—

In colour.—In the Canada goose the white cravat does not extend downwards along the under side of the neck, but is quite abruptly defined, and cut off; in *B. leucolæma* it does, so as to give the appearance not only of a white cravat under its chin, but also a white frill or shirt appearing in front down its black waistcoat. In the Canada goose the white cravat is flecked more or less with blackish specks; in *leucolæma* it is wholly white. In the Canada goose, the black head in front of, and above the white cravat, is wholly black; in *leucolæma* it is flecked with an occasional white speck, and most so where it joins the upper mandible both in front and on each side. In the Canada goose the space between the *rami* of the lower mandible is black or blackish; in *leucolæma* it is pure white. The white on the lower eyelid is comparatively broad and distinct in *leucolæma;* in the Canada goose it is a mere line like a thread.

The general tone of the plumage of the body, both above and below, is considerably paler in *leucolæma* than in the Canada goose—the black primaries having become brown, the brown back having become somewhat fawn-coloured, and the fawn-coloured under side having become dirty white, with a pale bluish or lavender-coloured broad band stretching across the belly between the two thighs.

The black on the neck extends rather a shorter distance down in *leucolæma* than in the Canada goose.

The legs are yellowish-brown, and the interdigital spaces bright yellow in *leucolæma*, instead of being black as in the

Canada goose. I believe that in some species of geese the colour of the leg changes according to the age ; but this would not appear to be the case in the Canada goose, because Captain Ord informs me that the colour is constantly black, both in old birds and young broods, which he has reared since 1852.

There are also some differences in the relative proportions, which I shall tabulate for the sake of brevity and easier reference, and shall include in the comparison the proportions of the following species supposed to be *B. Hutchinsii*. The measurements are taken from the specimens which I have received from Hudson's Bay, one of each bird, and all these apparently full grown :—

	B. Canadensis.	*B. leucolæma.*	*B. Hutchinsii?*
	Inches.	Inches.	Inches.
Length of bird, from tip of bill to end of tail feathers, measured along the back,	39½	40	32
Length of upper mandible, from tip to where the downy plumage begins, measured along the middle, . .	2	2½	1¾
Breadth of upper mandible across the nostrils, ...	1¼	1½	1¼
Height of upper mandible at the nostrils, ...	½	½	½
Length of head, from base of the middle of the mandibles to the occiput, .	3¼	3⅛	2½
Length of wing, from carpal joint to end of longest wing feathers, . .	19¾	19¼	15½
Length of tarsus, . . .	3½	3	3
Length of first phalanx of middle toe, .	1¼	1½	1¼

There is also a slight difference in the arrangement of the scuta on the phalanges of the Canada goose and *leucolæma*, though not very decided. In the next species this is much more marked.

B. Hutchinsii, Richard and Swain. (Plate IV., fig. 1).—The preceding measurements show that this is a much smaller bird, and it will be observed that the proportions are different. The bill is proportionally much smaller, narrower, and deeper, than in the other two. The colour is much the same as in the Canada goose, but darker and richer on the back, and with a greater shade of fawn on the belly, instead of the lavender colour in the Canada goose, owing to the colour of the terminations of the abdominal feathers. The cravat-patch wants the black flecking which Captain Ord informs me he has found a constant character in his specimens of the Canada goose.

There is a marked difference in the mode of arrangement of the scuta on the first phalanx of the middle toe. In the two preceding species there are three oblique transverse scuta at the distal extremity, those further back being broken up into polygonal plates; while in this species there are seven broad transverse plates so placed instead of three; the remainder are also transverse, though narrower. The difference in the arrangement in the different species is shown in the plates.

I may add, that before coming to the conclusion that these two species were distinct from the Canada goose, care has been taken to consult every accessible authority. The specimens have been shown to Sir John Richardson, who concurs in the opinion that they are distinct, and states that they are different from anything he noticed in his Arctic expedition.

The want of some information as to the habits of the birds sent by my correspondents, deprives us of one important aid in determining the species. For instance, Hutchin's goose, to which this comes nearest, differs from the true Canada goose in frequenting the sea-coast, feeding on mollusca, and having a fishy taste, instead of feeding on herbage in the fresh-water lakes, which is the habit of the Canada goose proper. This specimen was taken at Severn House.

Anas boschas (Linn.), (Common Mallard).
Trout Lake Station and Severn House.

Dafila acuta (Linn.), (Pintail).
Trout Lake Station and Severn House.

Rhynchaspis clypeata (Linn.), (The Shoveller).
Moose Factory and Trout Lake.

Mareca Americana, (Steph.)
Hudson's Bay.

Somateria V. nigrum, (Gray).—Proc. Zool. Soc. 1858.
Severn House.

This specimen was sent to me by Mr Bernard R. Ross, as the common Eider Duck of the Mackenzie River district, which he thought might be of interest from having been shot on Great Slave Lake,—the Eider being supposed exclusively a sea duck,—but its occurrence in this fresh-water lake may have been accidental, or it may have been there for breeding purposes, many sea ducks having recourse to fresh-water lakes for this purpose. A circumstance of greater interest, however, is, that it is not the common eider, but the Kamskatchan species *Somateria V. nigrum*, distinguished by a black mark in the shape of the letter V under the chin, and it is the first time that this species has been recorded as being taken east of the Rocky Mountains. Its occurrence in Great Slave Lake certainly does not necessarily imply that it is to be found in Hudson's Bay and the east coast, but it may be so, and I would direct the attention of my friends there to it. It is so easily identified by the black V under the chin that if it occurs there I think we may now be certain of ascertaining the fact.

Harelda glacialis, (Linn.)
Severn House.

Fuligula affinis (Eyt., Yarr.), (Amer. Scaup Duck).
Severn House.

Clangula albeola (Linn.), (Buffel-headed Garrot).
Severn House, Moose Factory, Trout Lake Station.

Querquedula Americana, (Linn.)
Hudson's Bay.

This is the American representative of our common Teal. Sir J. Richardson remarks that the only difference he could find between the common teal and its American representative was, that the English bird has a white longitudinal band on the scapulars which the other wants. The American bird has usually a transverse broad white bar not possessed by the English. He makes the two species only varieties, but other authors have followed Pennant, and rightly (as it appears to me) kept them distinct. The female specimen sent me, howver, wants the transverse white bar, and Sir John refers to a specimen (he does not say whether male or female) in the Hudson's Bay Company's Museum which wants it.

Dendronessa sponsa (Linn.), (Summer Duck).
Hudson's Bay, Moose Factory, Trout Lake Station.

Oidemia perspicillata (Flem.), (Surf Scoter).
Hudson's Bay.

Oidemia velvetina (Cassin), (*Deglandii*, Bonap.).
Trout Lake Station, Moose Factory, Severn House.

Until put right by Sir Wm. Jardine, I confounded the single specimen received of this species with the *Oidemia fusca*, or velvet scoter of Britain and Europe, to which it is very closely allied—the specific differences consisting in the proportions of the bill, the form of the tuberosity on it, and in the white spot under the eye being larger, and extending in a narrow circle partially round the eyelids. Sir Wm. suggests that both the American and European bird may range in each continent, and that we may find the American form here, or if not, that it is just one of those very close forms which requires farther examination to enable us to say whether it is an extent of variation only, or really a distinct species.

Oidemia Americana (Linn.), Trout Lake.
Mergus serrator (Linn.); Trout Lake, Severn House.
Mergus cucullatus (Linn.); Hudson's Bay, Trout Lake.
Pelecanus erythrorhynchus (Gmel.); Hudson's Bay.
Larus zonorhynchus (Rich. and Sw.) (?); Hudson's Bay.

Sir Wm. Jardine remarks that in any specimens or figures of the *L. zonorhynchus* which he has seen, the black mark on the bill is at some distance from the tip, which is not the case in this specimen. It does not agree with any other, therefore, most probably, is a variety of this species.

Larus argentatus (Gmel.); Severn House.
Lestris cephus, Brunnich 1764 (*Buffonii* Yarr.); Moose Factory.
Xema Bonapartii (Rich. and Sw.); Severn House.

Fortunately several specimens of this gull have been received. It is rare in collections, but would appear not to be so in Hudson's Bay.

Sterna Hirundo (Linn.), (Common Tern.); Hudson's Bay.
Sterna arctica (Temm.); Moose Factory and Trout Lake.
Sterna nigra (Linn.); Moose Factory, and Severn House.
Uria grylle (Lath.), (Black Guillemot.); Severn House.
Podiceps cornutus (Linn.); Trout Lake.

The band on the head and cheeks is much paler in the specimen received than in European specimens.

Colymbus arcticus (Linn.), (Black-throated Diver); Severn House.
Colymbus glacialis (Linn.), (Great Northern Diver); Severn House.

The Old Red Sandstone of Herefordshire. By the Rev. W. S. SYMONDS, F.G.S., Rector of Pendock, Worcestershire.

The Fluviatile Drift.

The city of Hereford stands partly on the lower beds of the Old Red Sandstone, partly upon an alluvial gravel of the ancient Wye,* ranges of hills, composed of Upper Silurian rocks, or the Cornstone series of the Old Red Sandstone, rising on every side. The soil around is of uncommon fertility, being mostly a subsoil of Old Red clay which nourishes some of the most luxuriant plantations, orchards, and meadows in the world.

Herefordshire abounds with the "fossils of the antiquary." Cromlechs and cinerary urns, old skulls, ancient coins, and weapons of war, have been collected from sepulchral mounds, where our forefathers buried their dead, the relics of an ancient people, of whose ways and doings we know little more than we know of the Pteraspis or Cephalaspis of far more ancient date.

The remains of man are found at Hereford lower than the usual depth of a grave, for I have seen portions of the human skeleton dug up from below fifteen feet of superficial covering in the middle of the streets, and with these were associated immense numbers of the bones of the domestic animals, such as sheep, oxen, goats, deer, dogs, and foxes; they may have been buried during a siege. Below all these are the bones of deer, goats, and oxen, in old fluviatile drift, and Mr Curley informs me that they have been disinterred at the depth of thirty feet; while Mr Suter, the Honorary Secretary of the Woolhope Field Club, possesses many bones still more ancient from a black lacustrine silt *below* that river shingle. Thus, first a lake, and afterwards a river, once flowed over the site of this ancient city.

It has been well remarked, that "some of the more recent of geological events are probably in reality of as great antiquity as we have been accustomed to assign in our imaginations to the most remote," and no geologist can study the

* See Mr Curley's admirable map of Hereford.

changes that have taken place in the valleys of the Wye, Lugg, and Frome, without being persuaded that many thousands of years must have elapsed since the Wye deposited its shingle below the site now covered by the streets of the city, or that still more distant period when Athelstane Hill bounded the waters of a lake.

There is certain evidence that all the alluvial flats and low lands around Hereford have been lakes since the present configuration of the surrounding land, and even since the creation of our domestic animals. The Lugg Meadows, two and a-half miles from Hereford, are a good example of this silting up of lakes; also the Frome Meadows, from Weston Beggard to Hampton Bishop, and the great bend of the Wye between Rotherwas and the confluence of the Lugg. The study of the great river and lake history of the Hereford district is a subject of immense interest, but too long to dwell on here; suffice it to mention, that there is no doubt that in a recent *geological* epoch, a chain of lakes, connected by broader rivers than at present, occupied the river vales of this county, and that these lakes washed the shores of a land which possessed much the same configuration as at present. During the earlier lacustrine conditions, the mammoth, rhinoceros, and hyena were inhabitants of the land, but the lake epoch continued until the days of the goat, the sheep, and the ox. The land has risen gradually through unnumbered ages; while subaerial denudation, disintegration, and erosion, scooped-out ravines and wore away barrier rocks, as at Whitchurch beyond Ross, and Sugwas above Hereford, till the lakes were drained, the valleys filled, and the river beds deepened.

Since that epoch the rivers have again and again shifted their beds, and deposited their shingle over the lacustrine silts of the lakes, and when there was no man to record the changes as they occurred.

The uppermost Silurians and the lower rocks of the Old Red Sandstone.—The transition from the Upper Ludlow rocks of the Upper Silurians into the lowest Old Red is so gradual, that it is difficult, as regards either mineral composition or fossils, to draw any arbitrary line, or to mark the horizon where the one formation ends and the other begins. The Upper Ludlow bone-bed was always believed to furnish a certain horizon as regards the appearance of fish, but Pteraspis has since been detected *below* that Ludlow bone-bed, while certain Silurian genera of shells range into the Tilestones, which also contain true Silurian fish, as *Onchus Murchisoni.*

Downton Beds and Tilestones.—I look upon the Downton sandstones as the uppermost Silurians, and the Tilestones as intermediate beds, distinct and separate, yet true passage beds between the great epochs of the Silurian and Old Red.

Let no geologist leave Hereford for the examination of the Old Red rocks, without having first thoroughly worked out those sections in the neighbourhood which furnish information respecting the transition or passage beds; and thanks to transit by rail, many of these may be reached in an hour. Let Kington *via* Leominster, be the first point. Kington, with its lovely scenery and old plutonic rocks of Stanner, stands preeminent in the land of the Silures as a glorious locale for the geologist, whether he would disinter the skeleton head of *Pteraspis Banksii*, one of the most ancient of fishes, and that venerable lobster the *Pterygotus Banksii*, or wander past the old church to the once molten hypersthene rock of Stanner, and note how it alters the Woolhope limestone at the deserted quarries of Burlingjob, and Llandovery conglomerate a little farther west.

The Downton sandstone quarries of Bradnor Hill are within a short walk of the town, and display the Upper Ludlow shales with numerous fossils, which pass into the Downton sandstones, or uppermost Silurians, containing abundant relics of Pteraspis, Pterygotus, and Eurypterus, with *Lingula cornea,* and *Trochus helicites,* both characteristic Upper Silurian shells. Besides *Pterygotus Banksii,* my friend, Mr R. Banks, has also discovered here the remains of a crustacean so gigantic that the name "*Pterygotus gigas*" has been proposed.* Descending the hill to the south, Kingswood and the south-eastern flank of Hergest may be examined, and a fair correlation thus seen of the Ludlow rocks, the Downton beds, and Tilestones, but not so perfectly as near Ludlow, which we will now describe, with a hint to the traveller not to partake too freely of Here-

* Siluria. New edition, 1858.

ford cider at Kington, as some philosophers assert that it is apt to give a hazy character to the physical geology of Kingswood.

Ludlow Tilestones.—The uppermost Silurians (Downton beds) overlie the Ludlow bone-bed, and furnish a section at Ludford, close to the town of Ludlow, again to the north of Whitcliffe coppice, and at Norton, on the road to Onibury. I lately examined these rocks carefully, under the guidance of Mr Lightbody, who has done such good work among this region of faults, and in company with Dr Melville, and Mr H. Salwey. I differ, I believe, in my correlation of the beds, from the opinion expressed by the geological Surveyors, and this opinion I record, though it may seem presumptuous, because I would gladly stand corrected if the river and railroad sections could be described more satisfactorily. In Ludford Lane there can be no mistake, the strata being Upper Ludlow rock, surmounted by the "original" old bone-bed, and this again overlaid by Downton sandstone. These rocks dip south-east and pass into red marls, and brown and greenish micaceous sandstones, as they do at all junction beds; for example, Brockhill near Malvern, Hales End, Malvern, and Hagley near Hereford. Over these red beds, on *the right bank* of the Teme, are some marly Cornstones, very difficult to observe, succeeded by grey grits with fossil fish, plants, and *Pterygotus*. Still pursuing the *right bank* of the river we find marls and micaceous sandstones in regular succession. Crossing the river to the *left bank* we find, in my opinion, the *identical* beds seen on the right bank, but upraised by a fault, taking the direction of the river course. Working out the beds on the left bank, in descending order, towards the town of Ludlow, we come upon a splendid section of the grey shales and grits from which Mr Lightbody has obtained so many fossils.* At the first railway bridge is a cross fault which throws down the Cornstone marls across the grey *Pterygotus* shales, and I imagine that this fault ranges across the river, the red cornstone marls in the river bed being identical with those near the bridge. If such be the case, there is a break on the horizon of the Downton beds and no true succession at Ludlow on the left bank of the Teme. The geologist should carefully study this section, and, if possible, obtain a sight of Mr

* Siluria, p. 154.

Lightbody's most interesting collection. Mr Salwey possesses also some valuable Old Red fossils, and among them is the new *Cephalaspis Salweyi.* The museum contains a fine collection of Upper Silurian and Llandovery fossils, and the inhabitants of Ludlow are much indebted to the care bestowed by Mr Lightbody and Mr Cocking. Long may the geologists of Ludlow flourish!

Hagley Park, on the Ledbury high road, four miles south of Hereford, and the section at Flaxley, near May Hill, on the Ross and Gloucester railroad, are interesting localities for those who would study the Tilestones.

The following are the most characteristic fossils of the Tilestones in this part of England:—Brachipoda; *Lingula cornea* (a different species, probably, to the Lingula of the *Downton* beds), Crustacea; Eurypterus, Pterygotus, and a minute bivalved crustacea called Beyrichia; Auchenaspis, Cephalapsis, Onchus, Plectrodus, and Pteraspis are known among the fishes, some of which range into higher beds, while Pteraspis has been detected *below* the Ludlow bone-bed.*

The strata succeeding the Downton beds are, when I have seen them, most difficult to interpret, as the red marls, flagstones, and micaceous sandstones (Tilestones), that intervene between the Downton sandstones and the Cornstones, are denuded, leaving valleys and gentle slopes. I have never seen so clear a section as on the railroad between the first railroad bridge at Ludlow and Tinker's Hill. A fault, however, occurs near the latter place, and interferes with the continuity of the strata. In Kingswood, south of Kington, there are reddish micaceous flagstones (Tilestones) with the same Lingula as those contained in the red flagstones on the right bank of the River Teme below the paper-mill at Ludlow; and over these lie a mass of red marls and whitish sandstones which, at Penros, near Kington, form a useful building-stone; as again in the old quarries on the eastern flank of Wall Hills, near Ledbury.†

Old Red Cornstones, Marls, and Sandstones.—The Cornstone beds of the Old Red Sandstone commence very low in the series as thin Cornstones, interstratified with red and whitish

* Siluria, page 269.

† The grey grits, with Pterygotus, described in the preceding page, are now exposed in the railway tunnel at Ledbury.

sandstone, often at the base of the Old Red beds, and not far above the Tilestones, as may be seen near Ledbury, and at Trimpley, near Kidderminster. Ascending the series of lower Old Red rocks in Herefordshire, we find the "Cornstones" expanding into large sub-crystalline masses, as on the western side of the Brown Clee Hills, Shropshire; Foxley, Orcop; Monmouth Cap, Ewyas Harold, and Whitfield; at the latter place it is still burned for lime.

True Cornstones occur high in the Old Red rocks of this part of England as well as in the lower rocks, so that they do not surely indicate the position of strata.* I have seen some grey Cornstones from the ridges of Foxley and Ladylift, near Weobly, that I could not distinguish from those near Kidderminster, which I believe to be but little above the Tilestones. Examples of sandstone and Cornstone hills are numerous around Hereford; the railroad at Dinmore cuts through a series of sandstones and Cornstones, and Robin Hood's Butts, Foxley, Moccas, Dinedor, are all within reach, and furnish fossils sufficient to keep up the interest of investigation. *Cephs. Lyellii* and *C. Lloydii* being among the most common; *C. Crouchii* is rare.

The route from Hereford to Abergavenny passes through a fine district for the examination of these rocks and the overlying Brownstones, and a good section is exhibited close to the station at Pontrilas, of some thick-bedded sandstones of this formation. When on a visit to that neighbourhood with the Woolhope Club, I detected a portion either of Cephalaspis or Pteraspis in one of the massive blocks of stone built into the arch of the railway-bridge at Pontrilas station, where the electric telegraph, streaming with human thoughts and words and actions, traverses to and fro over the dead relics of the Old Red Sandstone fish, reading a lesson to the geologist of the *progress* of the planet's history and the pre-eminence of the spiritual and reasoning creature *Man* above all the myriads of strange and pre-existing organisms that were destined to precede him.

* Bands of Cornstoneare interstratified with the grey Tilestones of Trimpley, near Kidderminster, and contain *Cephs. Lyellii; Pters. Lloydii, P. Banksii*, and *P. rostratus*.

Professor Huxley has lately published a lucid exposition of the difference of structure in the Cephalaspis and Pteraspis,* those strange fishes of the Old Red epoch, which, with "broad, arrow-like heads, and slender, angular bodies, feathered with fins, swept past like crowds of cross-bow bolts in an ancient battle." The difference consists, *first*, in the absence of osseous lacunæ in Pteraspis, and their presence in Cephalaspis; *secondly*, in the different arrangement of the vascular sinuses; *thirdly*, in the different arrangement of external surface. When treating of the zoological position of these oldest known fishes, Professor Huxley rather doubts whether they should not be classed with the Teleosteans rather than the Ganoids, of which all the existing genera are essentially fresh-water fishes.

A short walk from the station by Eyas Harold will lead the geologist to a large common a little west of the vicarage, on the east side of which is a Cornstone quarry containing relics of the *C. Lyellii* and *P. Lloydii*, but not in the same abundance as the lower beds of Leyster's Pole near Leominster, or Mathon near Malvern. The summit of Rowlestone Hill, south of Eyas Harold, also exhibits a good quarry section of grey building-stone overlying the Cornstones, in which the parish-clerk discovered an unique specimen of Eurypterus† (*Eurypterus Symondsii*, Salter), the only fossil yet discovered in these beds. The Rev. W. Wenman conducted me to the quarry a little south of the church, where I observed many ripple-marked slabs, and abundant remains of fucoids with crustacean footsteps. The church at Rowlestone possesses a curious chancel arch, and is built of the sandstone which was accumulating in the seas inhabited by the Cephalaspis and Pteraspis.

At Eyas Harold is a comfortable village inn, where the traveller may sojourn after a ramble over the Kentchurch, Orcop, and Grosmont district.

Within a walk of Eyas Harold is the old church of Abbey Dore, where a couple of hours will hardly suffice, so much interest does it possess to the lover of ancient architecture and

* "Journal of the Geological Society," August 1858, p. 267.

† "Edinburgh New Philosophical Journal," Oct. 1857, and "Siluria," new edition, p. 274.

archæological lore; while many a wild flower which the botanist loves to gather, grows in the green lanes and woods of the Cornstone marls.

The Rowlestone grey beds may be seen by ascending Kentchurch Park, where they are quarried on the east flank of the hill, and again on the south side of Orcop. These are the equivalent sandstones of those two miles south of the town of Hay, where they are so charged with vegetable remains as to have induced some persons to search for coal. These beds dip under the upper beds of the Sugar-loaf and Scyrrid, and separate the true Cornstone group of deposits from the Brownstones and Old Red conglomerate above.

The quarries around Monmouth Cap and Grosmont should be visited, for the Old Red fish are here tolerably abundant. At Grosmont are some fine old ruins of a once important fortress, which gave birth to one monarch and sheltered another.

At Kilpeck is a most interesting church of Anglo-Norman date, with the semicircular apse at the east end. The Cornstones are quarried at Kilpeck, where, in company with my friend Mr Lingwood of Lyston, I saw portions of Old Red fishes, and we obtained a very good plate of *P. Lloydii* from sandstone, interstratified with cornstone, which came from a quarry at the base of the hill between Orcop and Saddlebow.

Cornstones are cut into by the railroad between Pontrilas and Abergavenny, and are quarried for roadstone on the eminences north of that town. The Cornstones, it should be remembered, are mere calcareous bands in red and grey sandstones and marls, and appertain to the *lower* limits of the Old Red series; for I know no true Cornstones in the great overlying mass of Grey and Brownstones or Upper Old Red Sandstone.

Brownstones.—"The rocks known to English geologists under the name of the Old Red Sandstone consist of various strata of conglomerate, sandstone, marl, limestone, and tilestone, the youngest beds of which dip conformably beneath the carboniferous deposits, whilst the oldest repose upon and pass into certain grey coloured rocks. These grey coloured rocks form the upper part of the Silurian system."

These are the words with which Sir Roderick Murchison opens his chapter on the "Old Red System," in his well-known work;* and years of study among those Old Red strata tend to convince me that this original correlation of Sir R. Murchison is correct; notwithstanding the intrusion upwards and downwards of a few impertinent fossils into Old Red Sandstone strata both from the Silurian at their base and the Carboniferous rocks above. The Downton sandstones are included with the Upper Silurians, but from these beds to the limestone shale, it is my opinion that, in this district, the original correlation is the right reading; although at one time, from the phenomena displayed by these rocks in Ireland, I was inclined to agree with the Irish geologists, and rank the yellow and grey sandstones between the Carboniferous limestone and the Old Red conglomerate, as Carboniferous deposits rather than as Old Red.

The Brownstones, marls, and chocolate-coloured sandstones that overlie the true Cornstones and Eurypterus sandstones of Rowlestone and Cusop, near Hay, may be studied at the Scyrrid, near Abergavenny, with great advantage, as this hill is an excellent type of those beds that form the mountain ranges of the Brecon and Carmarthen Vans; while in the Abergavenny district, on the Blorenge, Sugar-loaf, Daren, and Pen-Cerrig-Calch, the Brownstones are much obscured. Not so in the Scyrrid-vawr, for a land-slip has bared a noble section for the geologist, and the summit of the hill opens upon as fine a view as any in this part of the kingdom. The Scyrrid may be ascended with ease from Abergavenny, but the station at Llangvihangel is the best point to start for the section on the north.

When the geologist, whose heart is in his work, stands upon the brow of this bold escarpment, he will comprehend the necessity of visiting many distant hills and rolling vales before he can hope to grasp the wondrous revelation of the physical geology around. It may, therefore, be of service to point out the especial localities to be visited. After the Scyrrid, let the Blorenge, and Sugar-loaf near Abergavenny, the Daren and Pen-Cerrig-Calch near Crickowell, be studied in succession; these hills are the best keys I know of wherewith to open the somewhat intricate locks of the upper Old Red.

The Brownstones, capped by a bastard marly conglomerate,

* Silurian System, p. 169.

are seen on the Scyrrid to dip away *from* the Sugar-loaf and Black Mountains at a low angle towards Dean Forest; while the same beds in the Blorenge mountain dip under the coal-fields of the South Wales district and at Pen-Cerrig-Calch, quite in an opposite direction, and under that isolated outline of mountain limestone and millstone grit. Dr Melville and myself, therefore, in our late visit, conceived that a vast anticlinal must have extended from the Scyrrid towards the west, and in the direction of the Sugar-loaf, forming again a synclinal in the direction of Pen-Cerrig-Calch. This anticlinal has long since been broken down and denuded, leaving the mere edges of the once continuous masses to tell the tale. Be this as it may, there can be no doubt that the deep-sea beds of the Brownstones swept over a much vaster extent of surface than is now marked in the maps as the Old Red of this part of England; and that over every portion of Herefordshire and Monmouthshire was once piled, not only the Brownstones of the Scyrrid and Pen-Cerrig-Calch, but the mountain limestone and the millstone grit, with the coal measures above them; while the great Welsh coal-field, the Forest of Dean basin, and the Clee Hill district, are mere fragments and outliers of the vast accumulations of mineral and vegetable masses which once covered up the summits of the Brecon and Carmarthen Vans, and the luxuriant hills and valleys of Herefordshire, Monmouthshire, and Shropshire. It is an astounding history! yet when we roam on the mountain tops, study the mineral masses, and compare the dip and angle of strata to strata, that which might be deemed mere theory by the uninitiated, stands out a bold and unquestionable truth. How shall we sum up that history in few words, or tell a tale on the brow of the Scyrrid that might fill a volume!

We conjecture that the Upper Ludlow deposits were by no means deep-sea deposits. The Silurian sea of this part of England appears to have been gradually shallowing and filling up with clay and sand swept in by the streams that watered the ancient Silurian lands bearing down with them the tiny seed-vessels of the *Lycopodiaceæ*, and I think we have evidence of the sinking and submergement of that sea-bed after the period of the deposition of the Downton sandstone. In

Scotland the contiguous lands of the period of the upper Old Red Sandstone furnish proof of the existence of an exuberant vegetation including coniferous trees, and highly developed vegetable structures.

The Cornstone epoch, with its numerous fishes, must have been a deeper sea than that of the Upper Silurians, or why the rapid disappearance of our familiar friends the Silurian shells and crustaceans, when we search the quarries of the Tilestones and Cornstones, and find the relics of ancient fish, but so few shells ?* The presence of peroxide of iron will not satisfactorily account for this absence of molluscan life, as the Lingula beds of the Ludlow and Kingswood Tilestones are red with iron oxides, and micaceous too.

The Brownstones have been constantly searched, yet no fossils have been detected ; I suspect that in our west of England districts and in Ireland they were deposited in a profound sea, yet after the lapse of ages, those profound depths were again filled by the gradual and continuous accumulation of marine deposits, until we reach the epoch of the Old Red conglomerate which lies above the Brownstones, and which tells of a great change on the land, and a diversion of those innumerable forces which wear down land surfaces and mountain summits, a change no doubt produced by earthquake disturbances and oscillating movements both of the land and sea at the close of the Brownstone period.

Old Red (Quartzoze) *Conglomerate and Uppermost Sandstones.*—It is well known that in Ireland the Old Red conglomerate is unconformable to the underlying Brownstones; and at one time I was inclined to believe that a similar unconformability might be detected in the South Wales district. Having, however, during the present summer carefully examined the Forest of Dean basin and a portion of the edges of the South Wales coal field, accompanied by my friend Dr Melville, I thought the evidence in favour of a true conformability between the Old Red conglomerate, both with the overlying Carboniferous rocks and the underlying Brownstones. I do not, however, believe that the semi-conglomerate with marly fragments, on the summit of the Scyrrid, is the representative of

* Lingula, Modiolopsis, and Nicula occur in the Tilestones.

the true quartzoze conglomerate of the Blorenge and Dean Forest, it is a lower and distinct bed, and occupies the position of the Dingle beds of Ireland. I know several sections which show very distinctly the correlations of the Old Red conglomerate and overlying sandstones with the Carboniferous shales and limestones; but I have never seen a satisfactory correlation of the *Brownstones* with the *Old Red conglomerate.* In the Dean Forest district the geologist who starts from the Upper Silurians of Pyrton passage and follows the Old Red beds by Blakeney and Byrant's Green to Soudley Green, may observe a fair correlation of all the beds of the Old Red from the Tilestones to the Old Red conglomerate; but there is something unsatisfactory in the valley at Soudley Green, where the Brownstones are cut off from the *Red* sandstones which underlie the conglomerate, and which are exhibited in the railroad cutting. Again, in the Dry Brook section on the Ross and Cinderford high road, after you pass the conglomerate, with the underlying red beds, all is covered up and obscure. At Soudley, Symonds's Yat on the Wye, below the Buckstone near Monmouth, and several other places, *Red* sandstones underlie the conglomerate conformably; but this is often the case in Ireland, and I would separate these *Red* sandstones from the true *Brownstones* inasmuch as they are very persistent superior beds, and may be conformable to the brownstones or otherwise.

In the Abergavenny district the Old Red conglomerate may be seen on the flanks of the Blorenge, but so covered up, that little information can be gained as regards the underlying rocks. Again, on the Daren near Crickhowell, this conglomerate is so hidden by masses of debris of *millstone grit conglomerate,* that it was with great difficulty that Dr Melville and myself could discover the Old Red pebble beds *in situ.* This millstone grit debris along the flanks of these hills is interesting as being probably the relics of the glacial epoch. Strangers visiting the Daren and Pen Cerrig Calch, would find Thomas James of Crickhowell an intelligent guide. He may be heard of at the "Bear." We were inclined to class the grey sandstones on the escarpment of the Daren as the equivalents of the yellow and gray beds of Ireland, so famous for their *Sphenopteris Hibernica* and *Anodon Jukesii,* and which have furnished at Farlow, in Shropshire, a Pterichthys, discovered by Mr Baxter of Worcester, and the remains of Holoptychius found by Professor Melville and Mr Lightbody.

It was in these rocks of the Daren that Sir R. Murchison discovered, many years ago, a scale of the Holoptychius; and I found there, on our last expedition, the well-preserved stem of a calamite-looking plant, which measured more than a foot in length, and an inch and a half in diameter; it lay on a large block of stone, and we could only detach a small portion. It is probably in the equivalents of these beds, in Scotland, that the reptile *Stagonolepis Robertsoni* occurs; but whether the sandstones, yellow, gray, and red, that overlie the Old Red conglomerate, and underlie the limestone shale with its abundant marine fossils, will eventually be classed with the Old Red or Carboniferous rocks, it is impossible now to say. Sir R. Murchison still ranks them with the Old Red, as will be seen on reference to his new edition of "Siluria," a work which contains more information upon the Palæozoic rocks than we could have thought it possible to condense within the limits of a single volume. With respect to the Tilestones of Shropshire and Herefordshire, Sir Roderick remarks that they may be classed with the Silurians or Old Red, "according to the predominance of certain fossils," and this applies also to the transition beds between the Upper Old Red and the Carboniferous deposits.

In conclusion, let me hope that the local geologists of Abergavenny and Crickhowell, with my friend and brother geologist, Dr Beavan, at their head, will search the upper sandstones on the escarpment of the Daren; for I do not doubt they would yield many interesting fossils. Our guide informed us that the handsome residence of Sir Joseph Baily is principally built of these upper sandstones. Had Crickhowell then possessed an intelligent geologist, or a working mason who possessed a spark of Hugh Miller's intellect and observation, who can say what Holoptychii or Pterichthydes, might not have been rescued; or what specimens of Old Red plants might not now have adorned the cabinets of the worthy and respected Baronet, instead of being inclosed within his walls. I have visited the Daren twice in my life, and on both occasions have seen in these rocks remains of well-preserved plants lying on the slabs of stone. Sir R. Murchison was there probably but once, and yet he detected the scale of that very fish, the Holoptychius, which is *par excellence* the characteristic organism of these beds in Scotland. It will be strange, therefore, if the educated men and intelligent women who reside in that lovely vale of Crickhowell, do not discover in the quarries of the Daren some relics of those strange fishes and extinct plants which flourished on the shore and swam in the waters; when the heights of the Daren, Gadir Vawr, and Pen Cerrig Calch, were deep deposits of an ocean bed.

On the Action of Hard Waters upon Lead.* By W. Lauder Lindsay, M.D., F.L.S.†

It is, and has long been, currently believed—1. That where there is free access of atmospheric air, pure or soft waters—that is waters absolutely or comparatively free from saline ingredients, readily corrode lead and become impregnated—sometimes to a poisonous degree, with some of the salts thereof. 2. That the rapidity and extent of this solvent or corrosive action are pro-

* I use the term *hard waters* to indicate waters containing an easily appreciable amount of neutral salts, especially of the carbonates, sulphates, and chlorides of lime and magnesia. Under this head a large proportion of spring waters is to be classed. The term is employed in contradistinction to that of *pure* or *soft* waters, which either contain no saline ingredients, or a very small proportion: such are rain, snow, and many river waters. I think it necessary thus to define my meaning, because I have found that there is frequently great difference of opinion between professional and non-professional persons as to what is, or constitutes, *hard* or *soft* water. A water, in reference to which I will immediately have occasion to make some statements, was reported upon by the analyst, an English chemist of repute, as "*very soft*," while the user of the water, a lady of great intelligence and experience, described it to me as decidedly *hard*.

Professor Christison considers a water *soft* which contains less than $\frac{1}{5000}$ part of its weight of saline ingredients; *hard* if it contains more than $\frac{1}{4000}$; *mineral* if more than $\frac{1}{2000}$. *Soft* water has the property of forming a lather with soap, and it is suitable for washing purposes, neither of which properties does *hard* water possess.

† Read before the Chemical section of the British Association, Leeds Meeting, 24th September 1858.

portionate to the purity of the water—that is, its freedom from neutral salts. 3. That impure or hard waters, that is waters containing a considerable amount of neutral salts, do not so affect, or become impregnated with, lead. 4. That such waters are prevented from acting on lead by, or in virtue of, their saline constituents, which exert a sort of protective or preservative power in regard to the lead. 5. That, if a given water does not, within a short period, cause a white coating on freshly burnished lead plates or rods, it may be regarded as destitute of any corrosive action, and may therefore be safely allowed to be kept in leaden cisterns, and transmitted through leaden pipes.

Observation, experiment, and inquiry have led me to the following somewhat opposite conclusions:—1. That certain pure or soft waters *do not* act upon lead. 2. That certain impure or hard waters, in some cases containing abundance of the very salts, which are generally regarded as most protective or preservative, *do act* upon lead. 3. That the rationale of the action in these anomalous or exceptional cases is very imperfectly understood. 4. That experimentation on the small scale, and for short periods, is most fallacious, and frequently dangerous, in regard to the conclusions thence to be drawn. 5. That water may, under certain circumstances and to certain extents, contain lead without necessarily being possessed of appreciable poisonous action on the human system. 6. That water contaminated with lead may deleteriously affect certain members or individuals only of a community, family, or household. 7. That the use of water so contaminated is the obscure cause of many anomalous colicky and paralytic affections.

The remarks which follow are intended to be purely suggestive; they are meant chiefly to introduce to the notice of the chemical section of the British Association the fact that the rationale of the non-action of certain soft waters, and of the action of certain hard waters, on lead is very imperfectly understood. The subject of the action of waters upon lead is not at all in a satisfactory state; and, in these days of sanitary legislation, when we are boasting of our acquirements in sanitary science, this is an *opprobrium scientiæ* and an *opprobrium medicinæ* which should no longer be permitted to exist.

Chemists are totally at variance; when they agree they chiefly agree in what I believe to be error; their analyses are most contradictory, and their theories still more so. In order to place this fact prominently before the reader, I need make but a few citations.

"Numerous attempts," says Dr Medlock, "have been made by some of the most able chemists to arrive at a correct solution of this important question; but it will be admitted that all their attempts have hitherto failed, and that the conclusions arrived at are unsatisfactory in the extreme. Dr Noad examined three waters, which were known to act strongly upon lead. The first was taken from a deep well in the neighbourhood of Highgate churchyard, and was found to contain 100 grains of solid matter in a gallon, of which 57 grains consisted of the *nitrates of lime and magnesia.* The second water, from a spring at Clapham, contained 77·74 grains of solid matter in a gallon, consisting of salts of lime, magnesia, potash, and soda, with 4·10 grains of *organic matter.* The third water, which was found to act upon lead, was that from the deep wells of London. This water contains about 68 grains of solid matter in a gallon, consisting chiefly of the salts of potash and soda, with very little carbonate of lime or organic matter. These waters differ widely in their chemical composition. In the first *nitrates* prevail, in the second *organic matter*, and in the third *alkaline carbonates.* The action of the first on lead he attributes to *nitrates;* that of the second to *organic matter;* and that of the third to *free alkali!* Dr Smith, who investigated the action of the waters of the Dee and Don on lead, found that the quantity of lead dissolved increased with the time the water remained in contact with the metal. He considers the action of these waters on lead to be due to the quantity of *air* dissolved in them."*

It may admit of a doubt whether the opinion of Dr Lambe of Warwick, that *all* natural waters must be held to act upon lead,† which therefore is at all times, and in all circumstances,

* "On the Action of certain Waters upon Lead:" Record of Pharmacy and Therapeutics of General Apothecaries' Company, London. Part 2, p. 33. 1857.

† Dr Lambe of Warwick: Researches into the Properties of Spring Waters, 1803, quoted in Dr Christison's Treatise on Poisons, 1835.

a dangerous metal to have in contact with drinking water, is not safer, so far as the public health is concerned, than the more modern idea that a small quantity of certain neutral salts in water acts invariably as a preventive to its action on lead. I have no desire to create unnecessary alarm; but I have a desire that chemistry should be more creditably represented in its relation to sanitary science than it at present is in reference to the action of drinking waters on lead.

In regard to the desirableness of a thorough knowledge of the chemistry of the phenomena in question, I need here say nothing. The action of drinking and culinary waters on lead is a subject of too great moment to the national health to be lightly considered. Few of our standard writers on Chemistry, Materia Medica, or Public Hygiene, omit reference to this subject. But unfortunately many errors have crept into their works; and these errors have been the means of disseminating false views, not only among the public, but also among the medical profession. Statements of the most opposite kinds will be found in our most familiar text-books on Chemistry and Materia Medica; and this is the more curious and extraordinary, inasmuch as they all profess to borrow or quote from the admirable researches entered upon and published by Professor Christison of Edinburgh, now many years ago. It is true that this gentleman lays down, as a general rule, that pure waters corrode, and become contaminated with, lead; a certain proportion of some saline matters, however, exercising a protective influence, and preventing such contamination. But, as I read and understand the narrative of his experiments and the statements of his conclusions, he appears to me to admit fully and freely that there are exceptional cases of the nature mentioned in my propositions.* These exceptional

* I append a few quotations or statements from Professor Christison's publications on the subject:—"The action is *impeded* by the coexistence of *any* neutral salts in the water; and some salts, whose acids form very insoluble compounds with oxide of lead, *prevent the action entirely in very minute quantity*."*

Water, which contains less than about $\frac{1}{8000}$ of salts in solution, cannot be safely conducted in lead pipes without certain precautions.

Even this proportion will prove insufficient to prevent corrosion, unless a

* Dispensatory, second edition. 1848. Art. *Plumbum.*

cases are not brought so prominently under notice in his various publications on the subject as they deserve to be, nor are they in general satisfactorily explained. But I think that Professor Christison has been very unfairly quoted, nay, frequently misquoted, by compilers, who have never taken the trouble to investigate the matter for themselves. In some text-books the statements made are absolutely erroneous; in others they are too dogmatic and positive,—general rules only being laid down, and exceptions, which are of the utmost importance, being omitted. In order to illustrate the errors of omission or commission to which I have just adverted, I will cite a very few quotations from well-known works on chemistry or materia medica. Professor Graham says*—"Rain or soft water cannot be preserved with safety in lead cisterns, owing to the rapid formation of a white hydrated oxide at the line where the metal is exposed to both air

considerable part of the saline matter consist of *carbonates* and *sulphates*, especially the former.

So large a proportion as $\frac{1}{10000}$, probably even a considerably larger proportion, will be insufficient if the salts in solution be in a great measure *muriates*.

"It is, I conceive, right to add that in all cases, even though the composition of the water seems to bring it within the conditions of safety now stated, an attentive examination should be made of the water after it has been running for a few days through the pipes. *For it is not improbable that other circumstances besides those hitherto ascertained may regulate the preventive influence of the neutral salts.*"*

"When lead has been exposed for a few weeks to a solution of a protecting salt, and has acquired a thin film over its surface, it not only is not acted on by the solution, but is even also rendered incapable of being acted on by distilled water."†

"Most spring waters, unlike rain or snow water, have little or no action on lead, because they generally contain a considerable proportion of *muriates* [?] and sulphates."‡

"The general result of these experiments appears to be that neutral salts, in various, and for the most part minute, proportions, *retard or prevent* the corrosive action of water on lead, allowing the carbonate to deposit itself slowly, and to adhere with such firmness to the lead as not to be afterwards removable by moderate agitation, adding subsequently to this crust other insoluble salts of lead, the acids of which are derived from the neutral salts in solution; and thus, at length, forming a permanent and impermeable screen, through which the action of the water cannot any longer be carried on."§

* Elements of Chemistry, vol. ii., p. 111. London. 1858.

* Trans. Royal Society of Edinburgh, vol. xv., part 2. p. 271.
† Treatise on Poisons, 1835, p. 481. ‡ Ibid., p. 486. § Ibid., p. 483.

and water: the oxide formed is soluble in pure water, and highly poisonous. But a small quantity of *carbonic acid*, which spring and well water usually contain, arrests the corrosion of the lead by converting the oxide of lead into an insoluble salt, and prevents the contamination of the water." Dr Graham professes to quote from the conclusions of Professor Christison; but the above two sentences contain several statements at variance with the results arrived at by the latter gentleman, and by the majority of experimenters on this subject. The crust or film produced by the action of pure water on lead is neither a simple hydrated oxide nor a simple carbonate, but a permanent compound or mixture of both,—in the proportion, according to Professor Christison, of two equivalents of the latter to one of the former. Where the water contains saline matters, in the deposit are generally found, in addition, the sulphates and chlorides and other salts of lead. Carbonic acid in the water, so far from preventing contamination, assists it, according to Professor Daniell and others, by dissolving a portion of the precipitated carbonate of lead. The carbonic acid, which is the source of the metamorphosis of the hydrated oxide of lead into carbonate, is generally derivable from the atmosphere, not from the water, and this agent operates more powerfully in pure than in hard water. Professor Fyfe of Aberdeen, in a somewhat extraordinary paragraph,* remarks—"Water, when *pure*, has *no* action with lead; but if it be admitted, the metal is slowly oxidated and dissolved. This action goes on *more quickly* when spring water is employed, the *presence of the minute quantity of saline matter* in it *favouring* the action. *Hence* the corrosion of leaden cisterns and pipes conveying water!" It is needless here to point out how completely at variance with the truth these statements are. So entirely are matters reversed, that it would almost appear as if there were some typographical error! Again, Sir Robert Kane† says—"*No danger* is, therefore, to be apprehended from the supply of water to a city being conveyed through leaden pipes and preserved in leaden cisterns; for all water of mineral origin

* Elements of Chemistry. Second ed., p. 529. Edinburgh, 1830.

† Elements of Chemistry. Second ed., p. 558. Dublin, 1849.

dissolves, in filtering through the layers of rocks in its passage to the surface, a sufficiency of saline matter to serve for its protection." Other authors follow Professor Christison more closely and correctly, and make use of more cautious expressions. But here, again, I must prefer the complaint, that the exceptional cases, to which I have already referred, are mentioned in so subordinate a way and place that they are apt to be entirely overlooked by the casual reader. Hence the propagation of errors.

In reference to my first proposition, that certain comparatively pure, or what are usually considered soft, waters, *do not* act on lead, it may be mentioned that Professor Christison* found rain water collected on his own house in Edinburgh to be devoid of any corrosive action—a circumstance which he attributes to the presence of alkaline sulphates and chlorides. Again, Professors Graham, Hoffman, and Miller, who sometime ago conducted a Government investigation into the action of waters on lead, with a view to discover "whether any comparative inconvenience would arise from a supply of soft water to the metropolis," contrary to what might have been expected, assert that, "with one exception, neither the soft waters of the Surrey Hills, which have a hardness of only two degrees, nor spring water artificially softened to three degrees of hardness, have any perceptible action on lead. The idea that soft waters invariably act upon lead seems to have its origin in the fact that certain specimens of distilled water, placed in contact with a large surface of bright sheet lead, dissolve as much as six or eight grains of the metal to the gallon."† Dr Medlock‡ asserts that "perfectly neutral and pure" distilled water, from which nitrate of ammonia has been expelled, has no action upon lead; for, in a gallon of this water, allowed to remain in contact with 560 square inches of lead for forty-eight hours, no trace of lead could be discovered.

* Treatise on Poisons, 1835, p. 484, "On the Action of Natural Waters on Lead."

† "On the Action of certain Waters upon Lead," by Dr Medlock; Record of Pharmacy and Therapeutics, Part II., p. 34; General Apothecaries' Company. London, 1857.

‡ Ibid., p. 35.

My second proposition I can illustrate more easily and fully. The illustrations which have presented themselves to my notice have been chiefly of the two following kinds:—1. Corrosion, or erosion, to such an extent as to cause leakage, of cisterns by waters of various degrees and kinds of hardness, or containing various kinds and amounts of neutral salts. 2. The poisonous action of hard or hardish waters impregnated with lead on the human body.

It is needless to multiply instances: two or three must here suffice; but they will probably serve to recall to the memory of many of my readers parallel illustrations. My attention was specially called to the erosion of lead cisterns by spring or well waters about two years ago, by my being requested to examine some cisterns, the bottom-lining of which had been repeatedly eroded to the extent of causing leakage, and which had been as repeatedly repaired. These cisterns contained the water supply of a large public Institution of which I am the physician. The Institution is supplied with water from three different sources, viz.—1. Rain water from the roof; 2. Spring water; and 3. Surface water. With the first I have here nothing to do: it is in reference to the second especially, and also subordinately to the third, that my remarks apply. The spring water is from a deep well on the northern declivity of Kinnoull Hill, penetrating the Old Red Sandstone near where the trap protrudes through it. The water rises in the well to the height of twenty-eight feet. It is good, hard, drinking water, and is used in the Institution for drinking, as well as for culinary purposes. The surface water is chiefly rain water, which percolates through the soil, and is collected in a large tank holding 95,156 gallons. This water is used chiefly for baths, water-closets, and general cleansing processes. The cisterns have no covers; they are contained in the attics of the building, but are not exposed directly to the external air. My attention was first directed to the cistern containing the spring water. I found the leaden bottom of this cistern scooped out here and there into a series of cavities or holes, some of which were minute perforations, allowing of an escape of the water. Moreover, the bottom was covered by a pretty thick layer or coating of a heavy cream-yellow, putty-like matter, which also filled the cavities or holes above referred to. The cistern was comparatively new. I was told it had been repeatedly thus eroded, and as frequently repaired. But it would appear that the mode of repair had been mere soldering; and this, it is of great importance to bear in mind, inasmuch as I believe this mode of repair to have been the cause of the subsequent more rapid erosion. It has now been abundantly proved that galvanic action occurs in a leaden cistern holding water at the point of contact of the lead with other metals, whether these be in the form of solder or of iron bars, &c.; that this galvanic action is extremely favourable to corrosion; and that it is greatest in waters containing saline matters,—that is, precisely in circumstances in which, were there no galvanic action, the corrosive effect of the water would be least. Similar phenomena had been repeatedly observed in cisterns containing the surface water; and the leakage of these cisterns became a matter of some moment, not only from the expense of constant repairs in comparatively new cisterns, but also from the damage done to roofs and walls of apartments situated below the attics by the escaped water. Facts bear out what theory would lead us to conclude, that the newer the cistern, the more rapid and energetic is the corrosive action of the water on it.

I was naturally led to make an analysis (a rough and qualitative one only, however), with a view to discover precisely the circumstances under which this corrosive action took place. This analysis embraced,—1. The deposit on the bottom of the cistern; 2. The supernatant water in the cistern; and, 3. The spring water, as drawn from the well before it had traversed iron pipes, or been contained in leaden cisterns. The results were as follows:—The deposit contained carbonates, sulphates, and chlorides of lead, lime, and magnesia; iron in abundance; and faint traces of soda. The supernatant water contained the sulphates, carbonates, and chlorides of lime and magnesia, with traces of soda. The carbonates and chlorides were most abundant—the sulphates less so; lime was plentiful; magnesia was in small quantity. There was no lead; and this is of importance to bear in mind; for it frequently happens that, though lead is found abundantly in the deposit on the bottom of such a cistern, it cannot be detected readily, or at all, in the supernatant fluid. Nor did this water contain distinct traces of iron. The spring-water, as drawn directly from the well, contained the same salts of lime, magnesia, and soda, in similar proportion, without lead or iron. The iron found in the cistern-deposit was probably dissolved as oxide by the water as it passed through the iron pipes which convey it from the well to the Institution; but it may also partly have been derived from the soil. A more careful analysis would probably, however, have detected it in the water of the cistern, and possibly in the water drawn directly from the well, being, in the latter case, derived from the iron apparatus of the pump. Distrustful of my own analysis, I had it repeated more carefully by a friend in Edinburgh.* His results were entirely corroborative of my own more rough and hasty essays. The lead in the deposit was by him converted into sulphate, with a view to ascertain its quantity. Calculating from the weight of the sulphate thus obtained, the deposit was found to contain no less than 43·18 per cent. of lead,—a large amount, to account for which it is right to mention that, in scraping the deposit from the bottom of the cistern, minute portions of metallic lead had been probably included.

Now, the water in question curdles soap with great rapidity and ease, and is therefore decidedly *hard*. But, in considering the action of water on lead, it is important to remark the nature or kind, as well as the amount, of the neutral salts present in it. The carbonates and chlorides were much more abundant than the sulphates, while lime was plentiful, and magnesia and soda occurred only in small quantity. The water of Airthrey Well, Bridge of Allan, for instance, is said to possess no action on lead; yet it contains no less than $\frac{1}{77}$ part of its weight of salts, which are chiefly sulphates and chlorides.† The experiments of Professors Christison and Taylor, and others, have established that the sulphates and carbonates are among the most protective or preservative salts, while the chlorides are among the least so. There is a difference of opinion among observers as to whether the carbonates or sulphates of lime and magnesia are most strongly

* Made in June 1857.

† Christison on Poisons. 1835. P. 486.

protective; but there is no doubt that the sulphate of lime is a powerfully protective salt, while it is also one of the most common ingredients of hard waters. According to Professor Taylor, sulphate of lime is the salt occurring in hard waters, which chiefly prevents their corrosive action on lead; and he describes the coating deposited on the lead as consisting of the sulphate of lead. The results of Professor Christison, as well as a consideration of the chemical theory of the action, would lead to the suspicion that the latter statement is not quite accurate; for it is extremely probable, that not only sulphate, but also the carbonate and hydrated oxide of lead, will at least be found in such deposits. Professor Taylor deduces from his investigations, that a water containing sulphates and lime is not likely to corrode, or become contaminated with, lead, and may therefore be safely used for drinking and cooking.

I made a series of comparative analyses, with a view to ascertain especially the condition as to hardness, or the nature and amount of the saline constituents, as well as the action upon lead, of various waters used for drinking and culinary purposes in and around Perth. The following are briefly the results at which I arrived,—the analyses or experiments in question being only tentative or qualitative,—rough and approximative in character, and not aiming at quantitative accuracy:—

I. *Well waters; decidedly hard.*—The wells, the waters of which were examined, are apparently chiefly sunk in the Old Red Sandstone, near where it is penetrated by the trap mass of Kinnoull Hill.

1. Rosemount, Bridgend, Perth; well 16 feet deep.—*a.* Water drawn from lead pipes in the house, but before entering cisterns; carbonates, sulphates, and chlorides abundant; lime and magnesia also abundant, especially the former; sediment or solid matter, on evaporating to dryness, comparatively large; no lead nor iron.—*b.* Water drawn from cisterns lined with lead, but covered with wood, placed in garrets, and not exposed directly to external air. Had precisely the characters of that described under head *a.*

2. Murray's Royal Institution, Kinnoull Hill, Perth.—West well, at a considerably higher level than the well at Rosemount. Water, after passing through lead and iron pipes, taken from a lead cistern in the Institution, having no cover; sulphates and chlorides abundant, particularly former; lime abundant; magnesia in small quantity; neither lead nor iron; burnished lead rods immersed in the water which was exposed to the air became tarnished or streaked white with carbonate in four or five days, but the water was not rendered opalescent nor muddy till the end of one month's immersion.

3. Pitcullen House, Bridgend, Perth.—The elevation of the well is intermediate between that of the wells at Rosemount and Murray's Royal Institution; all three being situated on the slope of Kinnoull Hill. The water had precisely the characters of that of the other two wells above described. Burnished lead rods were tarnished in five days, but were not further affected at the end of one month's immersion, at which time, also, the water in which they were immersed was unaffected as to its transparency.

II. *Spring waters; mostly hard.*—The springs referred to appear to rise from the trap of Kinnoull Hill (consisting of basalts, amygdaloids, and tufas, chiefly) at or near where it bursts through the old red sandstone of lower Perthshire. Like the wells above described, these springs are all situated on the declivity of Kinnoull Hill.

1. Bowerswell, Bridgend, Perth. — Carbonates, chlorides, and sulphates abundant, particularly the two former; lime abundant; magnesia in small quantity; sediment or solid matter, on evaporating to dryness, considerable; burnished lead rods tarnished after three days' immersion; no change of transparency of water after one month's immersion.

2. Muirhall Quarry, Kinnoull Hill.—This is an old basalt quarry, at a higher elevation on Kinnoull Hill than any of the springs, wells, or other sources of water supply, which I have described, or am about to describe. There is a perennial spring at the bottom of the quarry, now covered by a mass of water, which has accumulated for years. But this mass of water consists, in great measure, of rain water and of surface

drainage water from the neighbouring fields. It is a very soft, comparatively pure water. Carbonates plentiful; chlorides and sulphates in small quantity; lime and magnesia also in small quantity; considerable sediment on evaporation; burnished lead rods tarnished by five days' immersion; but transparency of water unaffected at end of a month.

3. Bridgend Water Company's supply.—Water taken from the stream immediately before it enters the reservoir at New Scone. The stream in question flows from, and constitutes the overflow of, the water in the Quarry immediately before mentioned. The composition of the water was identical with that of the quarry water, except that there was a small sediment on evaporation. Its action on lead was also precisely similar.

III. *Surface or Drainage Water; hard.*—This is chiefly rain water, percolating through the soil; but it is also partly made up of spring water of the characters already described.

1. Murray's Royal Institution, east tank.—Carbonates, sulphates, and chlorides in considerable quantity, especially latter; lime and magnesia also in notable amount, especially former; sediment, on evaporation, considerable; lead began to be slightly tarnished after one night's immersion; but the water remained clear after one month.

IV. *River water; decidedly soft.*

1. Tay River water, taken directly from the river as it flows past Perth. This is the source of supply of the Perth Water Company. It is comparatively pure; and in this respect, resembles the water of Muirhall Quarry and the Bridgend Water Company. Carbonates, chlorides, and sulphates, in small quantity, especially latter; lime and magnesia also in small quantity, especially latter; considerable sediment, chiefly mechanical impurity, on evaporation; lead began to be tarnished after a single night's immersion; it was quite tarnished in four days, but the water was unaffected in its transparency after one month's immersion.

2. Tay River water, drawn from the cistern of the water works, South Inch, after filtration. Water had precisely the characters described under head IV., No. 1.

V. *Rain waters; very soft.*

1. Pitcullen House; rain water barrel.—No carbonates; almost no chlorides; a trace of lime and sulphates; sediment, on evaporating down, very small, and chiefly mechanical impurity; lead tarnished, and water, in which it was immersed, opalescent after one night. After three nights' immersion the water was full of white pearly crystals of carbonate, which rapidly accumulated by longer exposure.

2. Murray's Royal Institution; rain water cisterns.—No appreciable amount of chlorides, carbonates, lime, nor magnesia; faint traces of sulphates; sediment, on evaporating down, very small, and chiefly mechanical impurity; lead tarnished and water opalescent after a single night's immersion. After five days, lead rod copiously covered with flocculent masses of crystals of carbonate, which also formed a plentiful sediment; they formed more rapidly, and in greater abundance, than in the rain water from Pitcullen House.

(*To be continued.*)

On the Structure, Actions, and Morphological Relations of the Ligamentum Conjugale Costarum. By John Cleland. M.D., Demonstrator of Anatomy in the University of Edinburgh.

At the meeting of the Royal Society of Edinburgh in March 1858, Professor Goodsir kindly read for me a paper "On a peculiar ligament connecting the heads of opposite ribs in certain vertebrata." I shall now give, in a more detailed form, an account of the observations mentioned in that paper, and briefly recorded in the Society's proceedings.

The ligament alluded to is one which has not hitherto been sufficiently described, or had its importance duly appreciated. Veterinary authorities take no notice of it further than mentioning, that in the horse and the sheep fibres from the inter-articular ligament of the head of the rib on one side are continued across the middle line above the intervertebral disc to that on the other.* Professor Mayer first discovered its ex-

* See Chauveau, Traité d'Anatomie comparée des Animaux Domestiques, page 134. Also see Leiyh, Handbuch der Anatomie der Hansthiere, page 211, under name "Ligamentum teres."

istence, and (in "Müller's Archiv." 1834, p. 273–277) gave an account of its appearance in various animals, illustrated by a figure, and named it *Ligamentum Conjugale Costarum.* This paper has been too much neglected; still Professor Mayer's description is confined almost entirely to the disposition of the fibres of the ligament, and even on that head is not very explicit.

Structure.—Unaware of Professor Mayer's observations, I first met with the conjugal ligament accidentally in the seal, the animal of all others in which it seems to be most developed. By the time I noticed it, the specimen was not in a condition to admit of direct observations on its functions; and I regret that I have not had another opportunity of examining a seal; but the particulars of the structure are as follows:—None of the ribs of the seal have the articular surface of the head divided in two, but each of those which arise opposite intervertebral discs has a depression on the inferior margin of its articular surface similar to that on the head of the femur, and from this springs a strong and rather flat ligament, which, sheathed in synovial membrane, passes above the intervertebral disc, and is attached in the same way to the rib of the opposite side. It lies close upon the disc, which is grooved for it, and it is covered by the superior common ligament. As it nears its attachment at each side, it is flattened out, so as to lie like a fibro-cartilage between the rib and intervertebral articular surface; and the head of the rib rolls on this portion. The synovial investment of the ligament and upper edge of the intervertebral disc is continuous with the joint on either side, so that there is one common synovial capsule in connection with the articulation of the heads of each pair of ribs to the vertebræ. The first pair of ribs and the last four pairs (viz. twelfth, thirteenth, fourteenth and fifteenth) being articulated each with only one vertebra, have no such ligament; and in connection with the second and eleventh pairs, the ligament is smaller than in the other cases. (Fig. 1.)

Dissections of the lion, the otter, the fox, and the dog, exhibited the conjugal ligament beautifully developed, in connection with all the ribs, except the few whose heads are articulated entirely with one vertebra. The arrangement in these species differs considerably from that in the seal. One description will suffice for them all:—The ligament is much rounder throughout than in the seal, and is not flattened in contact with the rib, but gets bulkier and rounder towards its attachments, and invades the articular surface of the head of the rib from the inferior margin as far as the centre. It is not, as in the seal, completely surrounded by synovial membrane; its inferior aspect alone is invested by it, while the superior aspect is in close contact with the superior common ligament, which is very strong between each pair of vertebræ. Even at its extremities it remains attached to the superior wall of the joint by a fold of the membrane, and by scattered fibres. Thus the articular surface of the rib is divided completely into an anterior and posterior part, though both parts belong to one joint, which communicates with that of the opposite side by the prolongation of its cavity between the conjugal ligament and intervertebral disc. The first and the four last pairs of ribs in the fox and dog, the first and the two last pairs in the lion, and the first and the three last in the otter, are connected each with only one vertebra, and present no trace of communication across the middle line, but the arrangement is perfect in connection with all the other ribs, except the hindermost instance of its occurrence in the lion, in which I found no communication of the synovial cavities. (Fig. 2.)

In the weasel and squirrel the conjugal ligament is very distinctly developed; and though they are such small animals, their ribs can easily be separated in pairs from the other structures, united across the middle line.

In the rabbit a few fibres may be traced from the head of one rib to that of its companion, but they are completely incorporated with the disc.

The conjugal ligament in the calf, in the sheep, and in the horse, is modified in a peculiar manner. Only part of its fibres are continued from one side to the other; while the rest, viz., the anterior fibres, are inserted into the upper edge of the posterior margin of the vertebra in front. The anterior aspect of the vertebra behind presents a cartilaginous surface projecting above the disc, and extending from side to side, on which the free posterior margin of the ligament plays. (Fig. 3.) The position of this cartilaginous surface is not marked on the dry bone except by a rounding off of the superior margin of the anterior epiphysial plate. A greater proportion of fibres pass from side to side, and fewer to the vertebra in front, in connection with the posterior ribs, than do in connection with the anterior ribs. In the middle line the greatest breadth of the ligament is from before backwards, but at its attachments to the ribs it is from above downwards, in which direction it is inserted so as to divide the head of each rib into two facets. In the sheep and calf there is only one common synovial cavity in connection with the heads of each pair of ribs, as in the lion and the dog. In the horse there are two joints at each side, distinct from one another, as in the human subject; and the conjugal ligament is invested by a separate synovial sac, which projects into the interval between the others, unconnected with either of them. In the human subject, and also in the monkey, the kangaroo, and the pig, none of the fibres of the interarticular ligament are prolonged to the opposite side.*

Actions.—In the dog, the lion, &c., the conjugal ligament is tightened both in deep inspiration and complete expiration. In inspiration, this is caused by the costo-transverse articulations lying in so oblique a plane forwards and upwards, that, when the inspirator muscles pull the ribs forwards, the thorax is expanded upwards as well, and the heads of the ribs, being the fulcra of this movement, are pressed downwards, and pull upon the ligament in that direction. In expiration, it is caused by the retreat of the points of insertion of the ligament from the middle line, in consequence of the heads of the ribs rolling their anterior facets outwards.

In lateral flexion of the thoracic part of the column, which in those animals can be effected to a great extent, the ribs of the side to which the column is bent are moved backwards, and those of the other side forwards. The backward motion

* See Luschka, Die Halbgelenke des Menschlichen Körpers, 1858, p. 76, where fibres passing from the necks of the ribs, and sometimes uniting behind the intervertebral disc, are compared with the ligamentum conjugale of Mayer.

on the one side is caused by the vertebra in front of each rib of that side pushing upon its head; and thus traction is made on the conjugal ligament, as in expiration, by retreat of its point of attachment from the middle line. Each rib of the other side is dragged after the vertebra in front of it, and, in relation to it, is not advanced; it therefore does not expand the costal arch upwards, and exercises none of that traction on the ligament which it does in inspiration. The consequence of this is that the ligament glides to the side to which the column is bent.

The movements occasioned by rotating the column on its own axis,—a movement allowed to a considerable extent in the thorax of the dog or lion,—are peculiar. Each pair of articular processes of the vertebral column in mammalia are placed in the arc of a circle, which, in the neck and lumbar region, and in the first and some of the last dorsal vertebræ, has its centre above them, but in the majority of the dorsal vertebræ has its centre beneath,—a circumstance which is favourable to the rotatory movement in the thoracic region, as less motion of the intervertebral disc is involved in it than would be were the centre of rotation above.* In the thorax of the dog and of the lion this point, which is the axis of rotation, is situated near the inferior edge of the bodies of the vertebræ, as is experimentally shown by the superior common ligament becoming much twisted in rotation, while the inferior remains straight. In each vertebra, during this action, the posterior costal facet of the side toward which the animal's head is turned is displaced upwards, and towards the mesial line of the vertebra following. Hence the articular cavity composed of it and the anterior costal facet next it, is made to look in an oblique direction downwards and forwards; and the rib which fits into it is moved forwards and upwards. The posterior costal facet, on the other side of each vertebra, is displaced downwards and away from the mesial line of the vertebra following; and

* The peculiar form of the articular processes of the lumbar vertebræ of the ruminants is no exception to the rule that the articular processes of a vertebra lie in the arc of one circle; for it is occasioned by the addition of mere limiting pieces to the extremities of the anterior articular processes, the fundamental parts of which glide on the posterior processes of the vertebra in front, in the arc of a circle whose centre is above.

hence the ribs of that side are pushed downwards; yet at the same time they are pulled forwards as much as those of the opposite side by the anterior fibres of the stellate ligament. The advance of the ribs in rotation of the column is in harmony with the oblique position into which the sternum is thrown at the same time; for the anterior extremity of the sternum, supported by the first pair of ribs, which, being connected with only one vertebra, is unaffected, retains its position, and therefore its posterior extremity is brought into a position further forward than it occupies when the body is at rest and it is pointing directly backwards. The conjugal ligament glides towards the side which is rotated downwards, that is, in the same direction as the vertebra in front of it.

All the motions, however, of the ribs which we have considered are accomplished even when the ligament is cut across; and the severed halves of the ligament glide as they would have done had they been left undivided. Thus in lateral flexion the cut ends of the ligament glide to the same side as the column is bent to. It appears, therefore, that its function is not so much to effect a harmony in the motions of the ribs as to limit their action without disturbing their harmony.

In the calf, the sheep, and the horse, the motions of the ribs are of a similar nature to those described above, but are more limited. In them the most evident movement of the conjugal ligament is its gliding backwards and forwards on the cartilaginous surface of the vertebra behind during extension and flexion. It adds greatly to the flexibility of the column that the vertebræ are not united in their whole depth by the disc, but have it partly replaced by an articular surface.

Morphological Relations.—The number of modifications which we find in the structure of the conjugal ligament in different mammalia leads us to inquire if it is merely a fusion, greater or less, of interarticular ligaments of ribs of opposite sides, or if there be not some other element in its composition. And in endeavouring to settle this point, we are led to examine the articulations of the vertebral column in other classes.

In birds, reptiles, and fishes, the ribs are connected with only one vertebra each, and do not complicate the intervertebral arrangements.

Of the articulation of the vertebral columns of birds, M. Chauveau writes (*Op. cit.*, p. 170): "In place of the mixed articulations of the mammalia column, we find true diarthroses, which may be classed with what M. Cruveilhier calls articulations of mutual jointing (*emboitement reciproque*), each vertebra articulated with adjacent vertebræ by facets convex in one direction, and concave in the direction at right angles to the first. These facets are covered by cartilage of incrustation; and it seems to us that, instead of being in direct contact with the opposing facets, which present a precisely inverse conformation, they are separated from them by an extremely thin fibro-cartilage, reminding one of the temporo-maxillary articulation of the feline carnivora. This arrangement, which, to our knowledge at least, has only been noticed in the swan,—and that only in an incomplete manner,—belongs probably to the whole class of birds; for hitherto we have found it in all the individuals submitted to our examination."

I can find no trace, however, of these interarticular fibro-cartilages in the pigeon; and have found them very imperfectly developed in the common fowl, and only between some of the vertebræ. But in the sea-gull they are very regular, and between all the separate vertebræ; and I shall use it as an illustration. Two lateral masses of fibro-cartilage invade the joint to a greater or less distance, and come together in the middle line, at the visceral edge of the bodies of the vertebræ. At the neural edge they are attached on each side at the angle where the arch springs from the body of the vertebra, and these points are united together by a straight band of a more ligamentous nature than the rest, and which appears to be the most constant part of the arrangement. (Fig. 4.)

Among reptilia the vertebræ of the crocodile are articulated by ball and socket joints provided with synovial membrane, the rounded posterior extremity of each vertebra fitting into the cup-like anterior extremity of that following. On the inferior aspect the capsule of each joint presents only decussating oblique fibres; but separating themselves from these on the lateral aspect, a bundle of fibres gather together so as to form a strong ligament, which passes round the superior border of the joint in contact with the synovial membrane, and is attached in the same way on the opposite side, by mixing with the decussating fibres on the under aspect, some passing to the vertebra in front and some to the one behind. (Fig. 5.)

This annular ligament is so strong that it can be seen very well even on a dry natural skeleton of a crocodile, without injuring the specimen. It is found between the vertebræ of all regions.

Although the vertebræ of serpents are articulated in the same way, the annular ligament is wanting in them. In the neck of the turtle the vertebræ are united on the ball and socket principle, but it is by means of intervertebral substance; still a number of transverse fibres pass from side to side in the upper margins of the articulations. In fishes the intervertebral disc is surrounded by a simple capsule of decussating fibres.

From these observations we see that the articulation of vertebræ with one another varies in every degree of completeness in different animals. We see, moreover, that transverse fibres are often developed on the neural edge of an intervertebral articulation, independently of ligaments of ribs. And when we take into consideration that the transverse ligament of the atlas is a structure of the same description,* unconnected with ribs, we cannot doubt that the *ligamentum conjugale costarum* of mammals is to be considered not merely as an extension of the interarticular costal ligament, but as containing an important vertebral element, notwithstanding its immediate disappearance in the segments where the ribs are connected with only one vertebra.

The cartilaginous surfaces on the vertebræ of the calf, sheep, and horse, are much rather to be considered as facilities for flexion and extension, analogous to the cartilaginous surfaces of the vertebræ of birds, than as having any connection with the motions of the ribs.

Explanation of Illustrations.

Fig. 1. Represents the *ligamentum conjugale costarum* in the seal, and part of one of the ribs with which it was connected; and shows the manner in which it lies in contact with the head of the rib, and is inserted

* Professor Mayer recognises the transverse ligament of the atlas as a modification of the conjugal ligament.

into its inferior margin. The other extremity of the ligament is separated from its attachment and shows the flattening.

Fig. 2. Is a view of the conjugal ligament in the lion—*a*, is a section of the intervertebral disc—*bb*, the anterior facets of the heads of the ribs—*c*, the conjugal ligament covered with synovial membrane, the torn margin of which is represented by a ragged line—*d*, the intervertebral fibres of the stellate ligament.

Fig. 3. Exhibits the disposition of the conjugal ligament in the sheep. The view is from above, and the neural canal is opened—*a, a, a,* are the continuous fibres of the superior common ligament cut across—*b*, the conjugal ligament with its anterior margin attached to the vertebra in front which is bent down to display *c*, the cartilaginous surface on the vertebra following *d*, the conjugal ligament *in situ*, kept in its place by *e, e,* strong intervertebral fibres of the superior common ligament.

Fig. 4. Represents the first and second dorsal vertebræ of a young sea-gull, in contact at their visceral margins—*a*, posterior aspect of the ring of the first dorsal vertebra—*b*, anterior aspect of the ring of the second—*c*, anterior surface of its body—*d*, interarticular cartilage adherent to the body of the vertebra above it, and consisting of two lateral masses meeting below, and joined above by a straight ligament.

Fig. 5. Shows the articulation of the bodies of two vertebræ of a crocodile. It displays the convex extremity of one vertebra fitting into a concavity of the vertebra following, and the annular ligament between them blending laterally with the decussating intervertebral fibres.

Notes on certain Vibrations produced by Electricity. By J. D. Forbes, Professor of Natural Philosophy in the University of Edinburgh.

"In the course of last summer (1858) I became acquainted with a phenomenon described by Mr Gore in the Philosophical Magazine for June (Supplement, p. 519), of the following nature:—A metal cylinder, supported on two metallic rods or rails, the latter being in connection respectively with the poles of a battery, revolves in either direction, at will, under the action of an electric current copious in quantity. Also continuous rotation of a light copper ball, supported on two circular metallic rails, takes place in either direction at pleasure, depending on the first impulse. It appeared to me very probable that this interesting fact might be applied to explain what is still obscure in the experiment on heated metals, generally known as the "Trevelyan Experiment," described by Mr Trevelyan, in the "Edinburgh Transactions," vol. xii., where there is also a paper by myself on the same subject. With a view to elucidate the experiment, I had Mr Gore's circular railway and ball constructed some months since by Mr Kemp. I had not an opportunity of seeing it tried until October 19th, when I found it to answer well, with four Bunsen's pairs connected for quantity. The same day, in Mr Kemp's laboratory, I laid a brass "Trevelyan" bar or rocker on the edge of the brass plate, forming the outer rail of Mr Gore's machine, and connecting the rail with one pole of the same battery, and the bar (by means of a globule of mercury inserted in a cavity in its upper surface) with the other, energetic vibrations commenced quite resembling those occasioned by heat in the ordinary form of the experiment on a leaden support.

"I have since found, among other results,—1. That the vibration goes on in whichever direction the electric current passes. [At first I thought that there was a superior effect when the current passed from a good to an imperfect conductor, but this has not been confirmed, as far at least as I have gone]. 2. The vibrations take place both between metals of the same kind and heterogeneous metals. 3. When heat is applied to a brass bar vibrating on cold lead, and then electricity is applied as before, the effects are superadded to one another whichever way the current passes, the vibrations becoming more energetic, and if there be a musical note it becomes graver [owing, it is assumed, to the increased arc of vibration]. 4. When a bar of brass was placed so as to vibrate on two parallel upright plates, also of brass, respectively connected with the poles of a battery, the vibrations continued, when the whole was immersed partly or wholly in water, and even when *flooded* by a powerful continued stream of cold water from a five-eighth inch pipe under considerable pressure. From this experiment I conclude that the effect of the heat developed by the electrical current in the thin upright plates may be fairly considered to be reduced so low as to be incapable of producing a sensible result (if such were ever the case). Indeed, allowing for the resistance and friction of the water tending to diminish the vibration, there is no ground for thinking that the action was less energetic in the one case than in the other. It is consequently reasonable to conclude that the effect in question is due to the repulsive action of the electricity in passing from one conducting body to another, and not to its effect in producing expansion.

"Now this is precisely the effect which I attributed to heat in the paper of 1833 already referred to. I therefore consider it a strong confirmation of the opinion I then expressed, from which I have never swerved, although it has not in general been received with much favour. The importance which I attach to this new confirmation, and the suggestiveness of Mr Gore's experiment on the rolling-ball, will be judged of from the fact, that in 1833, or earlier, I had an apparatus made, consisting of a bar resembling Mr Trevelyan's, but longitudinally divided by a non-conducting partition, while the two conducting sides were furnished with mercury cups for connecting them with the poles of a battery, the circuit being completed through the metallic base. The instrument exists, or existed a few years ago, though I am at present unable to find it. As well as I recollect, it was tried with an old-fashioned Cruickshank's battery of fifty pairs, without success. Indeed, I now find that, even with modern appliances, the experiment does not succeed when the circuit is only closed whilst *both* points of bearing of the rocker touch the mass or support."

"20th December 1858."

"Since the date of the preceding notice (which was prepared for being laid on the table of the Royal Society at their meeting on the 20th ult.), I have continued and extended these experiments. As they are still in progress, I will content myself with mentioning two results as worthy of notice. I have obtained very active vibrations of carbon (such as is used in one of the elements of Bunsen's battery) resting upon brass, and also when it rests upon two pieces of carbon connected with the terminals of a battery. For this purpose, a battery having a certain amount of intensity is requisite, in order to overcome the resistance of carbon as a conductor, but the vibrations are most energetic. The extremely small expansion which takes place in carbon by heat is another argument against that view of the Trevelyan experiment. The other experiment to which I refer is, that bismuth (and perhaps other metals) are not merely inactive as vibrators with any electric power which I have used, but the passage of electricity through them appears to have a *quelling* power which brings the rocker to instantaneous rest; yet bismuth permits a far freer passage of electricity than carbon: in one experiment I found that sixteen times as much was conducted. Something analogous was formerly observed by me in connection with heat applied to bismuth. I am now attempting to investigate the subject farther by experiment."

"3d January 1859."

REVIEWS AND NOTICES OF BOOKS.

Siluria. The History of the Oldest Fossiliferous Rocks, and their Foundations; with a brief sketch of the distribution of Gold over the Earth. By Sir RODERICK IMPEY MURCHISON. Third Edition (including "The Silurian System"), with Maps, and many additional Illustrations. Murray, London, 1859.

Our readers need not to be told the merits of this work. The former editions have made it well known and highly valued wherever the modern science of geology is cultivated. It is to this third edition, lately issued from the press, that we would direct attention. Although, as its name imports, more fully exhibiting the details of the fossiliferous rocks that lie under the Devonian or Old Red Sandstone system, "SILURIA" brings down to the present day the history of discovery in all the Palæozoic rocks; and, while to the Principality and its bordering counties, as a *vade mecum*, it is a *sine qua non*, it also throws light upon the rocks of Sutherland and Devonshire, and instructs us regarding the formations of the St Lawrence and Australia, and of many other countries remote from the British Isles.

To the observer on Scottish ground this edition opens up a new and interesting field. *Gneiss*, with its subordinate beds, so prevalent in North Britain, has hitherto been regarded as a mass of metamorphic rock lying on or pervaded by those of plutonic origin, and, in its every aspect, sternly forbidding the hope of the most sanguine to find a fossil underlying it, or imbedded in any of its associated strata. But gneiss is now no longer so barren a field, so impenetrable a covering. Of old, "conglomerate under gneiss" would have been held a solecism in geology; but Siluria proves the huge conglomerates of Wester Ross to be but the base of the quartz rocks of Ullapool and Queenaig, and of the limestones of Assynt and Durness, and shows satisfactorily that all the three are covered by the wide and wild field of gneiss that stretches across in a south-easterly direction towards the shores of the Moray Firth,—thus fixing what Hugh Miller* considered Devo-

* "In reference to the theory broached by Hugh Miller, that these quartz rocks and limestones might be the equivalents of the Old Red Sandstone series of the east coast, let me say, that if my eminent and lamented friend had lived to see the fossil evidence which prove them to be of lower Silurian age, he would, I doubt not, with his accustomed candour, have been the foremost to adopt the improved classification." Note, "Siluria," third edition, p. 196.

nian, to be of Cambrian and of lower Silurian age. There are then two gneisses, differing widely in position, and not a little in lithological character,—an older or granitoid gneiss,—a newer or stratified gneiss. Sir Roderick, as by a magician's wand, banishes the former entirely from England, Wales, and the south of Scotland; and, even north of the Caledonian Canal, where it was wont, in our estimation, to spread so far and wide, he confines it to a few spots here and there, where it peers out as if afraid to be seen. "It is indeed gratifying to me," says the learned author, p. 199, "to find, that the theoretical view I published some years ago, and have repeated in this work (see p. 179), seems now to be fully sustained—viz., that the great mountainous expanses of argillaceous, chloritic, and micaceous schists, with intercalated quartz rocks, marble, and limestones, which constitute the chief portion of the so-called primary rocks of the west of Scotland, and extend from Dumbartonshire, through Argyleshire and Inverness-shire, into Ross-shire and Sutherland, are, on the whole, the metamorphosed prolongations of the lower Silurian rocks of the south of Scotland.

"We now further know, that these crystalline masses of lower Silurian age overlap those red sandstones and conglomerates, which, much older than the Silurian red conglomerate of Ayrshire (p. 171), are doubtless the equivalents of the Longmynd or Cambrian rocks; whilst the latter repose upon ancient gneiss rocks, which are nowhere exhibited in England and Wales."

Around the Grampians, or throughout the central division of Scotland, from Aberdeen to Inverary, *gneiss*, that is, the younger of the family, should henceforth never turn aside the palæontologist, and cause him to move off to other ground; for, cropping out under it, or associated with it, he may find some calcareous bed or shaly intercalation that will reward his perseverance with a new *Maclurea*, *Orthoceras*, or even species of new genera.

Coming southward from this Llandeilo-region of Sutherland, and crossing the Moray Firth, this edition of "Siluria" lands us on another new field—the upper beds of the Devonian formation, as developed between the town of Elgin and the sea, with their unlooked-for and startling reptilian remains of *Telerpeton Elginense*, and *Stagonolepis Robertsoni*. Had the unique Telerpeton been the only reptile found there, the isolation of the rock in which it was imbedded (and in which no other fossil has been detected), would have still kept "a shade of doubt," as Hugh Miller said, "hanging on the subject." Or, had the Stagonolepis turned out, as Agassiz supposed, to be a fish, the addition to our knowledge of Old Red Sandstone fossils would not have been great. But Sir Roderick here records that this animal must have been a reptile of large dimensions and high organization, and tells us that it has been discovered in two separate localities, and that numerous footprints, probably of the same species, are to be met with in a third. So early an appearance of a crocodilian reptile affects the prevailing theory so much that some geologists, who have not yet personally examined the district, still hesitate as to the true age of its native beds. Hence, in the Appendix, p. 571, we find the following remarks :—"The affinity of the Stagonolepis to a high order of reptiles might well induce caution in referring the rock in which its remains, as well as those of the Telerpeton, occur, to so ancient a deposit as the uppermost Old Red or Devonian, the more so because, if the tract around Elgin alone be examined, the sections will seem to be obscure, owing to great denudation and thick coverings of local drift. At one time, indeed, it occurred to me, that the light-coloured sandstones of Elgin and Burghead might pertain to the liassic and oolitic series, of which there are large masses on the north or opposite side of the Moray Firth, as described by myself (*Trans. Geol. Soc.*, 2d Ser. vol. ii. p. 293). That hypothesis is, however, set aside, not only by the very different lithological characters of those rocks, but particularly by the fact that the Elgin and Burghead ridges afford no trace of any one of those fossil shells and plants which so abound in the lias and oolites of the opposite coast of Ross, Cromarty, and Sutherland, including the white silicious sandstone of which Dunrobin Castle is built. In short, after my last visit, and on reviewing my notes of 1840, when I made my second visit to the Elgin tract, and also explored the banks of the Findhorn to the south of Forres, I conclude that the yellow sandstones (in parts white) of Morayshire are as fairly linked on to the red conglomerate and sandstones containing the *Holoptychius nobilissimus*, as they are to the cornstones of the tract, the whole constituting a connected and natural series, the details of which will be explained to the Geological Society.

"In adhering to my original view respecting the age of the youngest of these Old Red deposits, I am fully aware that the question may, to a certain extent, remain open for those persons who may suggest that they pertain rather to the Lower Carboniferous, into which Devonian strata pass in many countries, than to the true Devonian group. At present, however, there is no evidence to induce me to place these sandstones in the Carboniferous system ; for, although some plants have been found in strata, which I believe to be their equivalents, in one of the northern headlands of Caithness and in the Shetland Isles, they belong to species never yet observed in the Coal strata. On the other hand, it is fair to state, that the Holoptychii, and those fishes which characterize the uppermost Old Red or yellow sandstone of the South of Scotland, have not been found in the Reptiliferous Sandstones of Elgin.—*Nov.* 27, 1858."

Its singular, varied, and oftimes beautifully delineated fishes have ever been a favourite study with geologists who, like Murchison and Miller, have been "born on the Old Red Sandstone." To them we would present a note from p. 381 :—"The last work of Pander—and other fasciculi are announced (Ueber die Placodermen der Devonischen System)—is a singularly valuable contribution to Palichthyology. The author adopts M'Coy's term of 'Placoderms' to denote a family composed of the genera Asterolepis, Eichwald, Coccosteus, Ag., Homosteus and Heterosteus of Asmus, and Chelyophorus, Ag. The Asterolepis, however, is not the Asterolepis of Hugh Miller. For the latter, Asmus's name, Homosteus, has the priority; while the Pterichthys of Agassiz is that which was first termed Asterolepis by Eichwald.

"M. Pander has evidently studied a great number of specimens of Asterolepis (Pterichthys) and Coccosteus with extreme care. He gives restorations of each, and figures of all their separate parts, which will be of very great value to the palæontologist; while his laborious attempt to unravel the complexities of the synonymy of these fishes is worthy of all praise." Perfectly unconscious of any, even the faintest, feeling that might be suggested by a patent pun on the name, we loudly demand that this work of M. Pander's be henceforth widely known to, and generally followed by, British writers on the Old Red; for in no part of our geology is there more need of such a guide. Hitherto some of its queer fish have been still more strangely treated, and their joints sometimes even generically disjointed. In our lists of Devonian fishes, teeth have been raised into a different section from that in which the scales and plates of the same animal are to be found; and, were all known that as yet lies hid in the arcana of their beds, we should not be surprised to find that incisors and grinders (if we may appropriate such terms here), that once stood and worked side by side with each other on the same jaw, figure in some treatises wide as the poles asunder. At least, as we learn from a continuation of the same note, M. Pander has condensed into one no less than eighteen of our reputed genera!

Our knowledge of the geology of Forfar and of Fife is added to by this edition of "Siluria." The southern or old "Grauwacke" region of Scotland is unravelled and satisfactorily set before us in a condensed view of what has been done in it by various hands, down to the recent discovery of Graptolites in the hard thin bedded rocks of Siccar Point, in Berwickshire. We would fain follow over the border again, and extract from this work what is new to us regarding the palæozoic rocks in other parts of England than its own Silurian domain of the west. But this may not be. We must refer to the volume itself for such, as well as for other interesting matters, drawn from British and also from foreign ground, and close with assuring our readers that this edition of "Siluria" is worthy of its eminent author, of the progress that has been made in that department of science he adorns, and of the appliances which our age affords for popularizing such publications. It contains a greater amount of illustrations, in sections and plates, than we are accustomed to meet with, and its numerous vignettes, finely illustrative of the geological structure of their subjects, afford ample proof how powerfully and pleasingly the pencil of the artist may aid the descriptive pen of the geologist.

Geological Map of England and Wales. By Professor A. C. Ramsay, F.R.S. London, Stamford.

Correct and complete geological mapping forms undoubtedly the groundwork of all true and accurate knowledge of the geological structure of a country. It is, of course, a work of years and patient labour, so that we are led to expect from time to time fresh expositions, in the form of new maps, of the advancement made towards the complete working out of British stratigraphical geology. As a summary of what has been done in this respect, and still more as an earnest of what yet remains to do, we cordially hail the present publication of the Local Director of the Geological Survey. As a mere work of art we do not remember to have seen its equal; since not only are the tints at once defined yet harmonious, but in the minute interlacing of formations, in such districts as the south-west of England, the boundary lines are kept perfectly sharp and distinct.

In the preparation of this map its author has enjoyed advantages which certainly no one else in the country possesses. His duties in the Geological Survey have led him to examine personally a very large part of England and the whole of Wales, so that he has had many long years of experience in the actual practice of map-making. In addition to the materials of his own collecting, he has, of course, availed himself of every piece of published information of reliable value; and we may hence unhesitatingly adopt his map as containing everything known, up to the date of publication, regarding the geological features of the country. At the same time, it is easy to see that the lapse of even another year will necessitate some minor alterations in the configuration of certain areas, and the practised eye may readily enough detect where such changes will probably be made. Contrasting, for instance, the south-eastern with the south-western part of the country, one cannot fail to remark the even, lumpy, unnatural boundary lines in the former district, as compared with their twisted labyrinthine character in the latter. The multiplicity of lines at the one locality points to a more minute and careful style of mapping, such as can only be done in the field on a large-scale map; and doubtless when the Geological Survey extends its labours further into the eastern counties, we shall find the old even lines become as minutely intertwisted as in the regions to the west. Not improbably, too, new subdivisions will be introduced into districts at present coloured with one uniform tint. Hence, for many a year to come we must regard each new map not as a final summary of the geological configuration of the country, but as an index pointing out what has been done since the publication of the previous one. Professor Ramsay will find time, we hope, to issue at intervals new editions of the work before us, so as to keep us up to the most recent discoveries in British stratigraphical geology.

One of the most valuable features in the present map is the introduction of explanatory sections. Hitherto it has been customary to insert along the margin of geological maps diagrams of interesting views, or sections of particular localities; but the object of Mr Ramsay's sections is to present at a glance the succession of strata in England and Wales, that the meaning of the different boundary lines may be rendered apparent to every one, even without the assistance of written descriptions. For this purpose he has inserted a diagram-section, showing the general succession of palæozoic strata in the island, and another exhibiting the sequence of the secondary rocks. Two sections, one across the Isle of Purbeck, the other across the Isle of Wight, explain the subdivisions of the Purbeck, cretaceous, and older tertiary beds. In addition to these, the design of which is to point out the order of succession, there are two sections intended to show the general geological structure of the country. The drawing of these sections is remarkably effective, all the faults, unconformities, anticlinals, synclinals, &c., being apparent at a glance.

We have but one or two suggestions to offer. In looking at the map carefully, the geologist's eye can usually detect the lines that represent faults, but it would be a considerable improvement were the more important ones, at least, marked more definitely, say with white lines, as is done on the sheets of the Geological Survey. It appears to us also that not a little information might be advantageously inserted along the coast lines, such as the nature of the rocks at any interesting locality, the names of some of their more characteristic fossils, and any other facts that might be deemed of sufficient importance. Moreover, on the geological areas in the interior, much valuable matter might be inserted without confusing the eye; as, for instance, the position of large basins, the direction of the more important anticlinal and synclinal lines, overlaps, contorted and altered strata, and even a few arrows for characteristic dips. In short, it has always seemed to us that the more information a geologist can put upon his map without confusion the better, and we are sure that on the large sheet now before us, even with all its names, and lines, and colours, a considerable body of facts, most useful both to the student and the practical geologist, might be added, and yet leave the map as clear and distinct as it is at present. Lastly, a more valuable appendix to the map could not be prepared than a succinct account of the geology of England and Wales. We believe it is Professor Ramsay's intention to write such a memoir, and we shall look forward to it with interest, not merely as a valuable guide to the student of English geology, but as perhaps the earnest of a larger work, extending and completing the plan of Conybeare and Phillips, for which we know of no one so entirely qualified.

Occasional Papers on the Theory of Glaciers, now first collected and chronologically arranged, with a Prefatory Note on the recent Progress and present Aspect of the Theory. By JAMES D. FORBES, D.C.L., F.R.S., Sec. R. Soc. Edinburgh. Pp. 278. A. & C. Black. Edinburgh, 1859.

It is with much pleasure that we remark the publication, in a collected form, of Professor Forbes's writings on glaciers. How great progress in this beautful department of natural science they express can only be understood when the previous state of knowledge and speculation on the subject is considered; and how thoroughly the author has established the foundations of his theory is best illustrated by the complete acquiescence now accorded to the essential truth of his conclusions by scientific travellers and writers who have visited the scenes of his labours. Before 1842, the "sliding" theory of De Saussure, and the "dilatation" theory of De Charpentier divided the opinions of the many eminent naturalists who studied the phenomena of glaciers; and the supposed facts on which their speculations depended afforded little ground for the analogies which some intelligent observers had pointed out between the great ice-stream and a viscous or semifluid mass such as lava.

In the year 1841 Professor Forbes first broke ground in glacial research, and at the end of a summer spent among the glaciers, he communicated the results of his observations to the Royal Society of Edinburgh in the first article of the volume before us. The chief object of this communication was to describe a remarkable structure which had scarcely been noticed at all by preceding writers, and which was thus for the first time pointed out as an organic quality of glaciers intimately connected with their origin and their motion,—the now well-known blue and white veins which no visitor to a glacier fails to examine. In the following year Professor Forbes commenced the great work of observing and measuring the motions of glaciers, which he continued to prosecute with consummate skill and with unflagging energy, until he laid a broad foundation of ascertained truth on a ground previously occupied only by vague conjecture, if not erroneous opinion. On this foundation his "Viscous Theory" of glaciers rests, than which scarcely any theory in physical science has been harder of acceptance, and none at last more surely demonstrated. Of the numerous and able objectors whom he has met on various points, from first to last, not one has ever, we believe, attempted to shake any of his facts. On the contrary, various eminent men, who could not at first accept his theory, have borne ample testimony to the correctness of his general descriptions of glacial phenomena; while the high accuracy of his minute observations and measurements is perfectly vouched by the accounts he gives of the plans which he followed, and the precautions which he took to guard against error. His surveys and maps of glaciers, his sketches, plans, and sections, showing the veined structure; his plastic models, illustrating the viscous theory; and, above all, his precise data regarding the varying motions of the different parts of the icy mass, represent an amount of persevering toil of which the casual observer can have little conception, when with their aid he sees and understands a glacier in a day.

The certain knowledge which these investigations gave regarding the origin and progress of glaciers, effectually negatived all the arguments which had been advanced in favour of the supposition that the mass of ice moves either as one rigid body, or as a finite group of rigid bodies, and gave positive proof that it is really moulded to the form of the channel through which it passes. They established the admirable truth, that the middle and the superficial parts of a glacier move faster than the sides and lower parts; and they demonstrated that the actual sliding of the ice, as it gradually melts in contact with its solid bed and walls, amounts to but a very small part of its whole motion. Reasonable opposition to the viscous theory became impossible in the presence of such facts; and if this theory has again been made a subject of controversy, no other argument is now wanted in support of it than that which, with a dignified forbearance, its founder gives in laying before the public a collection of the papers and letters in which his observations, experiments, and reasonings on the subject, were originally stated. The ingenious naturalists who visited the glaciers in 1856, and communicated their observations to the Royal Society of London, if they have not overthrown an old theory and established a new one, have done good service to glacial science by calling forth the present volume. The following remarks, taken from the Preface of the work, will explain the recent progress of the theory of glaciers :—

"In 1850, Mr Faraday delivered a lecture at the Royal Institution on certain properties of water, and more especially of water in the act of freezing. This lecture was never (I believe) published by authority. But an abstract of it appeared in the Athenæum Journal for June 15, 1850, and also in the Literary Gazette. In this brief and imperfect summary of what must evidently have been an interesting and suggestive discourse, it is stated, that if a film of water be enclosed between two plates of ice, even at a thawing temperature, the film of water is frozen, and the plates of ice cohere; and also that damp snow becomes, by the same process, compacted into a snow-ball, which will not occur if the snow is dry and hard frozen.

"These facts appear to have excited little notice, until attention was called to them by Dr Tyndall in a lecture, also delivered at the Royal Institution, on the 23d January 1857. He gave to the phenomenon the name of *regelation*. He applied it to explain the observation, that portions of ice crushed in a mould under Bramah's press may assume new and compact forms without showing any trace of flaws; this he attributed to the 'regelation' of the water in the crevices. Mr James Thomson and his brother, Professor William Thomson of Glasgow,* however, ascribed this consolidation to the effect of intense pressure, causing simultaneous liquefaction, which commences at every point of the interior of the ice to which the pressure extends (according to a previous discovery made by them to that effect), and to its subsequent solidification when the pressure is removed.

"Dr Tyndall soon applied his experiments on the consolidation or moulding of ice, and his adaptation to them of Mr Faraday's fact of 'regelation,' to the explanation of the veined structure and movement of glaciers, which certain previous speculations of Mr Sorby and himself about 'planes of cleavage' had brought under his notice.

"Thus it will be seen how the theory of glaciers became anew, in 1857, a matter of attention to men of science; and, considering the activity and ingenuity of those engaged in its study, the received doctrines were not likely to be adopted without being first thoroughly canvassed. My theory, among others, was discussed, and I congratulated myself upon the examination which it was likely to receive upon its intrinsic merits. The fact that ice can be moulded under pressure, even in hand specimens, so as completely to recover its continuity under a changed form, was an argument in favour of my interpretation of the similar fact occurring in glaciers on a great scale, which appeared to me likely to remove some natural prepossessions, as well as to throw light on the precise relations of water and ice near the freezing-point of the former or thawing-point of the latter, to which in my writings I had repeatedly referred. This practical argument was the more acceptable, because the absence of such a power of being moulded under *intense, rapid pressure* had been urged as an objection to my theory by MM. Schlagintweit, in their work on this subject.† The fact is, that the confining of the ice by lateral compression, whether in the great experiment of nature (in glaciers), or on the small scale, is, generally speaking, requisite to its success. I had, however, somewhat underrated the difficulties which my opinions had to contend with. The new generation of thinkers, whose powers of investigation

* "Proceedings of the Royal Society of London, 7th May 1857, 23d February and 22d April 1858."

† "Untersuchungen über die Physikalische Geographie der Alpen," pp. 24, 122.

were now first to be exercised on the theory of glaciers, had to review and discuss all the preliminary objections which fifteen years before had furnished the weapons of the opponents of 'plasticity' as a property of ice on the great scale. Having said all that I could urge on that subject, I had left my case with a calm and reasonable confidence that Time would be the ablest advocate of my cause. I never replied to MM. Schlagintweit's appeal to the evidence derived from the pulverization of ice under Bramah's press,* the reply being the very same as I had already made several times to the popular argument derived from the fragility of ice. It appeared to me that the difficulties felt by Dr Tyndall and Mr Huxley, in admitting my theory, even after the ingenious experiments of the former had demonstrated on the small scale the moulding power of ice, which I had long before asserted to be unquestionably true on the large scale, were also such as a longer familiarity with the subject, and perhaps a more deliberate consideration of *the whole* of my views respecting it would materially modify. I hope I may be allowed to say that the event has proved, partially at least, that I judged rightly. It was natural that the author of so interesting an experiment as the moulding of ice at a fusing temperature under Bramah's press should see in it the germ of a new theory. It is not less natural that I, who rather hoped for than expected such a palpable illustration of my opinion, should see in it, not a new explanation of the phenomena of glaciers, but a new proof that the explanation which I had advanced was correct.

"These are points which naturally fall to be decided by those of the scientific public who contemplate the question from an impartial point of view. If the aspect in which I regard it be the more correct—if the conclusions of Dr Tyndall are rather confirmatory than subversive of my own—the result of the discussion will be one more affecting personal credit than scientific truth. If it be found that the limited plasticity of ice, which, when ice is exposed in the glacier to a peculiarly violent strain, necessitates the formation of an infinity of minute rents, is really a part of my theory:—that it also embraces the substitution of the finite sliding of the internally bruised surfaces over one another under the same circumstances, still producing a quasi-fluid character in the motion of the whole:—if it be granted, moreover, that the reconsolidation of the bruised glacial substance into a coherent whole may be effected by pressure alone acting upon granular snow or upon ice softened by imminent thaw into a condition more plastic than ice of low temperature, and that the terms 'bruising and re-attachment,' 'incipient fissures reunited by time and cohesion,' were equivalent in 1846† to the phrase 'fracture

* "In this case the most extravagant distortion was sought to be produced in a few moments of time. Whilst in the glacier, an almost inappreciable distortion (for small areas or hand specimens) is produced in periods of many days or weeks. Very probably, also, MM. Schlagintweit operated at temperatures considerably below the freezing-point, otherwise they could hardly fail to have obtained the same results as Dr Tyndall."

† "The following are specimens of the phraseology used by me in that year, or previously, with reference to the pages where they will be found in the present work:—'The body of the glacier itself . . . yields, owing to its slightly ductile nature, in the direction of least resistance, retaining its continuity, or recovering it by re-attachment after its parts have suffered a bruise, according to the violence of the action to which it has been exposed' (p. 166). 'In this condition [on the 'very border of thawing'] molecular attachment amongst the granules must be comparatively easy, and the opacity disappears in proportion as optical contact is attained' (p. 201). 'Multitudinous incipient fissures occasioned by the intense strain are reunited by the simple effects of time and cohesion' (*ibid*)."

and regelation' applied in 1857:—If it shall be further found that I argued from nature's own experiment on the modelling of ice on the great scale in the irregular cavities of a mountain valley, to the same purpose as Dr Tyndall does from his beautiful laboratory experiment, whence he retraces the steps of the process to apply it to the actual glacier, and that there is no reason for accepting the experiment in the laboratory as more certain or more conclusive than the observation in the mountain valley, but that each observation confirms and illustrates the other:—Should all this be admitted on due examination, I shall, I trust, still be held to have laid just and solid foundations for a Plastic or Viscous Theory of Glaciers, without the desire or pretension to have credit for exhausting the subject in such a manner that *future* discoveries in physics can throw no more light upon it. I utterly disclaim so unworthy a pretension, and I appeal to every passage of my writings in which I have referred to the more obscure questions of physics and mechanics, as bearing on the Glacial Theory, in corroboration of this statement."

The Lithology of Edinburgh. By the late Rev. JOHN FLEMING, D.D., F.R.S.E., Professor of Natural Science in New College, Edinburgh. Edited, with a Memoir, by the Rev. JOHN DUNS, Torphichen.

In this modest volume of about 200 pages, the Rev. Mr Duns, the editor, has contributed a grateful service to the cause of geological science by introducing Dr Fleming's able "Essay on th- Lithology of Edinburgh," by a very interesting and candid memoie of the author of about equal length with the treatise. Departing from the dry path of strictly personal biography, and avoiding on the other hand a too comprehensive survey of the wide fields of natural science in which Dr Fleming roamed and wrought during the fifty years of his activity, his editor has, with admirable skill, woven in, with a very readable narrative of his friend's scientific and private life, an instructive and interesting sketch of the discussions and discoveries in natural history emanating from Edinburgh since the commencement of this century. In executing this somewhat difficult task, the biographer has very judiciously allowed Dr Fleming and his numerous distinguished correspondents to come before the reader in their own language.

Reviewing concisely the scientific life of Dr Fleming as it is here unfolded, we learn that at the age of seventeen he was an enthusiastic student of chemistry and pharmacy in the University of Edinburgh, as taught by Professor Hope in the year 1802. From early youth he studied zoology, botany, and geology, in his native district (Linlithgowshire), cataloguing its plants, constructing sections of its strata, and identifying, as far as practicable, the objects around him in the fields, &c., described its botanical riches in a paper entitled "Outlines of the Flora of Linlithgowshire," read to the Wernerian Society in 1809; and he even contemplated writing a complete natural history of the county. About the year 1808, he was made minister of Bressay in Shetland, having previously connected himself as a licensed preacher with the Church of Scotland. Through the enlightened intercession of Sir John Sinclair, he undertook a survey of the economical mineralogy of the Northern Isles, and drew up an able "Report on the Economical Mineralogy of the Orkney and Zetland Islands," while he was as yet only in his twenty-third year. At this time he communicated an intelligent "Account of the Narwal or Sea Unicorn" to the Wernerian Society, and the same year he sent to that society several papers, entitled "Contributions to the British Fauna."

In 1810, Mr Fleming was translated to the parish of Flisk in Fifeshire, where he evinced his devotion to science by his contributions to public journals and to learned societies, and by planning a course of lectures on chemistry and natural history. About this time he presented the Wernerian Society with a paper on "The Rocks in the Neighbourhood of St Andrews." In 1813, only a brief while before this, he married Miss Christie of Cupar, who, entering into his tastes, contributed at a later date many correct and tasteful drawings to his book on "The Philosophy of Zoology." About this time he received the degree of D.D. from the University of St Andrews, and in the following year, he was elected a Fellow of the Royal Society of Edinburgh. A little later (in 1815) he sent an able paper to the Wernerian Society, "On the Mineralogy of the Red Head in Angusshire," in which he discusses the mode of formation of agate balls in amygdaloid, and other difficult questions. During the next year he delivered a very successful course of lectures on botany in the Cork Institution; and, on his return to Scotland, published an interesting sketch of "Observations on the Mineralogy of the Neighbourhood of Cork;" and shortly afterwards read his first paper to the Royal Society, entitled "Observations on the Junction of the Fresh Water of Rivers with the Salt Water of the Sea." From this period of his life he devoted himself ardently to zoology, writing, in 1819, a valuable article, *Ichthyology*, for the "Edinburgh Encyclopædia," followed by a number of special papers, and by a more comprehensive work which he published in 1823, under the title of "Philosophy of Zoology." This last-named treatise was much appreciated by naturalists at the time, though the rapid progress of zoology has deprived the subjects discussed in it of the high interest they once possessed. It displays close observation and much logical and philosophical ability. Relaxing neither his zeal for original research nor his fondness for the discussion of principles, he soon afterwards published in this Journal (then known as Jameson's) several interesting memoirs, with the following titles, "The Influence of Society in the Distribution of British Animals;" "Remarks on Modern Strata;" "The Geological Deluge, as interpreted by Baron Cuvier and Professor Buckland, inconsistent with the Testimony of Moses and the Phenomena of Nature," contributing to the same and other journals a number of other shorter miscellaneous papers on special points in zoology, mineralogy, and botany. But the crowning labour of Dr Fleming's scientific life, and by far the amplest and noblest monument he reared to his fame as a naturalist, was his publication, the "British Animals," produced in the year 1828. Though now become partially obsolete as an authority, from changes which may be said to have revolutionized its science in these past thirty years, this work was a most acceptable hand-book of British Zoology at the date of its publication. It evinced not only a laudable knowledge of the literature of the subject, but a fine acquaintance with the peculiarities and habits of the animals described. It became a favourite with the general reader for its numerous curious episodal illustrations of the History of the British animals, drawn by its author from his antiquarian studies, of which he was very fond.

In the interesting geological field of the Old Red Sandstone of Scotland, Dr Fleming was an early discoverer, having been the first to call attention, in 1827, to the occurrence of "scales of vertebrated animals, probably those of a fish," in the Yellow Sandstone of Drumdryan Quarry, south of Cupar.

In 1829, in a paper "On the Insufficiency of the Evidence of the Supposed Change of Climate of the Arctic Regions,"* he gave proof of his characteristic sagacity by showing the unsoundness of the deductions concerning the ancient climates of the globe, which are based on analogies only in the species of the entombed fossils. His argument, that animals nearly related in form and structure may possess a widely dissimilar physical and geographical distribution, has formed a wholesome check to geologists in their reasonings respecting the earth's former climates. The paper went too far, however, in its scepticism, in calling in question the value of a correlation of organism in guiding us to the affinities of species, and it gave rise to a short controversy.

Advancing in reputation and in the esteem of his friends, Dr Fleming was presented by Lord Dundas to the parish of Clackmannan in 1832, where he was soon greatly valued by the congregation. He remained there, however, but a short period, for in 1834 he was nominated to the chair of Natural Philosophy in King's College, Aberdeen. His devotion to scientific research had meanwhile been as ardent as ever, as his numerous original papers fully show. To these he added, in 1837, a good article on *Mollusca* in the Seventh Edition of the "Encyclopædia Britannica."

* Edinburgh New Philosophical Journal, vol. vi.

After the formation of the Aberdeen Philosophical Society in 1840, his communications to it were frequent, his most important contribution being a "Description of a Species of Skate, new to the British Fauna." Akin to matters of social, no less than of scientific interest, he wrote, while at Aberdeen, "On the Expediency of Forming Harbours of Refuge on the East Coast of Scotland, between the Moray Firth and the Firth of Forth."

In 1845 Dr Fleming was made Professor of Natural Science in the New College, Edinburgh, under the auspices of the Free Church, which he had joined at the Disruption. In this position, so congenial to his favourite studies, he laboured enthusiastically until his death in November 1857. In this latter period of his useful life he maintained an active and friendly correspondence with nearly all the most eminent geologists and zoologists of Great Britain, by whom his zeal for truth, and untiring spirit of scientific inquiry, appear to have been much admired. From the establishment of the "North British Review," in 1844, till the time of his death, he contributed valuable papers to that journal, some of them enriched with matter derived from his own observations. One of the last productions of Dr Fleming's pen is his essay entitled "Lithology of Edinburgh," which was on the eve of publication when he died, and which is printed in the same volume with the memoir of his life, each occupying about 100 pages.

The first of the eight chapters of which this essay consists is devoted to a "History of Edinburgh Lithology." As a synoptic sketch of a very important part of the history of geology, in a field made classic by the ability of the men who explored it, and by the fundamental character of the questions they discussed, this outline, by one who himself took a share in theoretical controversies, cannot fail to to be read with interest and instruction by geologists at a distance. It is evidently written with an effort at candour; but the author was obviously too closely mixed up with the contentions of his day, was too ardent a partizan, and too prone to question the fidelity of his opponents' observations, always to do justice to those from whom he dissented.

In this historical sketch he admits to the unmerited neglect bestowed on the first attempt to unfold the principles of geology in Scotland by Professor George Sinclair of Glasgow. Allusion is then made, but with stinted praise, to the immortal labours of Hutton, who communicated his "Theory of the Earth" to the Royal Society of Edinburgh, first in 1785. Passing to Playfair, he says that "The most eminent and successful of Dr Hutton's supporters was the amiable and accomplished Playfair," who gave, in the "Illustrations of the Huttonian Theory of the Earth" (Edinburgh, 1802), a luminous exposition of the geological tenets of his friend, and thereby contributed in a very great degree to render these intelligible and popular. But the illustrator of Huttonianism laboured under the same defects as its founder. He had never studied Mineralogy, so that his knowledge of rocks was necessarily imperfect, nor had he even applied himself to the task of marking their more ordinary gradations of character, their interjacencies, and their contents. He appeared, therefore, as a *special pleader* anxious to conceal the weaker points of the case of his client, to overrate the statements which were tenable, and ever seeking to turn the attention of the reader, where practicable, to the inaccuracies of his antagonist.

Dr Fleming also does justice to the experimental researches of Sir James Hall, which assisted so much to strengthen the speculations of Hutton, and he cites the labours of Mr Thomas Allan, as the most important contributions to our knowledge of Edinburgh Lithology made by any partizan of either Hutton or Werner, and mentions the communications of the Earl of Cathcart to the Royal Society of Edinburgh as among the last productions of the Huttonian school relating to the locality. Besides these writers, three others are mentioned as having enlarged the bounds of the geology of Edinburgh. These are Dr Walker, at one time Professor of Natural History in the University; Williams, who in his "Natural History of the Mineral Kingdom," published in 1789, described the coal measures of the neighbourhood; and Townson, who, in "Remarks on the Mineralogy of the Environs of Edinburgh," illustrated the character of the Calton Hill, Salisbury Craigs, and Arthur's Seat, in a manner highly creditable to his discernment as an observer. The published contributions to the geology of Edinburgh by Professor Jameson are also specified, as are those of Dr Hibbert, the late Mr William Nicol, Mr Rhind, Mr David Milne, now Mr Milne Home of Milnegraden, and as the last of the series, the excellent "Sketch of the Geology of Fife and the Lothians," by Mr Maclaren, published in 1839. While too many of the Essays reviewed by Dr Fleming are mentioned without analysis, or named with a grudging praise, the treatise last alluded to is acknowledged to abound with detailed descriptions, and to have aided, to a very great extent, the researches of the private student.

In the second chapter, "On the Origin of the picturesque Scenery around Edinburgh, Valleys of Abrasion, Craig and Tail," &c., Dr Fleming makes it very clear that water in motion has been the agency which has shaped the features of the surface, and that its course was easterly. He looks upon the structure called *Craig and Tail* as proving—and we think justly—that neither the ordinary oceanic currents, nor the tides of the sea, could have imparted to the surface its present shape. In the third chapter, "On the Remains of Abrasion—Rubbed and Scratched Surfaces," &c., several interesting citations are given to prove that fragmentary rocky matter propelled in water has the power to groove and fur-row the solid rocky floor over which it passes, and to impart even a striation to the surfaces of the rolled blocks.

In the next chapters the materials which rest above the dressed and striated rocky floor of the region are enumerated and classified. Rejecting the nomenclature employed by Sir Charles Lyell for the later Tertiary formations, Dr Fleming refers these superficial deposits to what he terms the *Modern Epoch.* They are arranged by him in three groups. To the lowest or first, reposing immediately on the dressed rocky surface, and composed of materials left by violent aqueous action, he applies the term *Taragmite Series;* to the second group, chiefly laminated clays and sands, implying the assorting power of water acting tranquilly, the name *Akumite Series;* and to the third set of deposits, or those produced by known agencies in ordinary operation, the title *Phanerite Series.* Dr Fleming does not essay to explain the origin of the Taragmite deposit, or boulder clay, though he says that it will hardly admit of a doubt "that a debacle of a singular kind has taken place," and he rejects, we think very justly, the hypotheses of "droppings of melting icebergs," and the "moraines of glaciers," with their adjuncts of submergence and elevation, as leaving too many residual phenomena unexplained.

This essay on the Lithology of Edinburgh is clearly written, and full of minute local descriptions of the phenomena, but it is deficient in generalization, or in that wide discussion of the physical laws, without the application of which we cannot hope to solve the difficult questions suggested by the study of the superficial strata. Like most of Dr Fleming's later writings, it exhibits much acuteness in the detection of the defects of the theories of the day, but is timid in advancing conclusions to take the place of the generalizations which it assails.

The Master Builder's Plan, or the Principles of Organic Architecture, as indicated in the Typical Forms of Animals. By George Ogilvie, M.D., Lecturer on the Institutes of Medicine in Marischal College and University, Aberdeen. 8vo, pp. 196. London: Longman & Co.

The subject of typical forms in the animal kingdom has been ably treated by authors of no mean note. The researches of Owen, Goodsir, and Forbes have brought the subject prominently under the notice of the scientific world. From its interesting nature it has also occupied the popular mind, and treatises such as that of M'Cosh and Dickie, have been eagerly studied by all classes. The present is a contribution in the same direction.

The author professes "to bring forward in a popular form the views now generally held by philosophical naturalists in regard to the common plan of construction traceable in each of the primary divisions of the animal kingdom." He has fulfilled his task well. He gives a sketch of the leading plans of construction which prevail in the animal kingdom. In his work he does not make any great pretension to originality. His object is not to advance new truths, but rather to gain additional currency for such as have a fair claim to be already established, and, in particular, to convey an idea of the laws of organization to those who, without making natural history a special object of study, may wish to have a right comprehension of its general scope. He gives a view of the various plans on which animals are formed, and shows that while no single plan of construction is applicable to all animals, there is, nevertheless, a certain uniformity of organization observable in each primary division. He then proceeds to consider the vertebrate type in all its systems, then the articulate type, the molluscous type, and, finally, the Radiata and Protozoa. He points out the marked relations of the leading types of organization, and examines the bearing of the subject on natural theology. We commend the work to the notice of those who wish to have a condensed and popular view of this interesting subject.

Experimental Researches in Chemistry and Physics. By MICHAEL FARADAY, D.C.L., F.R.S. Reprinted from the "Philosophical Transactions" of 1821–1857, and other Publications. London, 1859.

This work is a reprint of all the author's non-electrical researches, his electrical papers having been already republished in two octavos. We have thus, within the compass of a single volume, all the purely physical and chemical inquiries which have been made public by the distinguished author during the long period of six-and-fifty years. Taken alone, they constitute a marvellous memorial of the labour and genius of Faraday: taken along with his researches in electricity, they represent an amount of thought, work, perseverance, and skill, such as only a few other men of like genius have successfully expended on the advancement of physical science.

The work is not one which calls for criticism. We can but remind our readers that they will find in this handy volume all the investigations of the author, from his first analysis of Native Caustic Lime, made in 1816, to his latest speculations on the Nature of Force, of date 1858. The curious history of the famous liquefaction of chlorine; the elaborate inquiry into the best mode of producing steel; the protracted experiments on the manufacture of optical glass; the examination of the chlorides of carbon, of sulpho-naphthalic acid, and of the bicarburet of hydrogen,—showing that Faraday, had he selected organic chemistry as his favourite field of inquiry, would have been as distinguished in that as in the inorganic department of the science; the important essay on the existence of a limit to vaporization; the remarkable observations on the relations of light to the metals and on regelation; besides the denunciation of table-turning, and the striking lecture on mental education, with its noble confession of religious faith,—may be read singly for their individual interest, or together, as illustrating the history of recent science and the character of the author.

The convenient form of this reprint tempts us to ask, whether it would not be well for the scientific societies to abandon the quarto form in their publications. The quarto is time-honoured, and our associations and predilections are all in its favour; but it is heavy and unwieldy, and separate copies of papers are crushed and folded when sent by post. On the whole, neatness and convenience are best realized by the octavo, in which form we hope all our Societies' Transactions will yet be published.

PROCEEDINGS OF SOCIETIES.

British Association for the Advancement of Science. Meeting at Leeds, September 22 *to* 28, 1858.

(*Continued from page* 158.)

ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

Dr Wright read a report from Professor Kinahan, *on the Crustacea of the Dublin District.* The following species were recorded as being found on the Dublin coast, and as not having occurred in any other part of Ireland:—*Crangon Allmanni, C. trispinosus, Pandalus leptorhynchus*, and *Iphimedia Eblanæ.* Of ninety Irish Decapodous species, Dublin affords sixty. Of the thirty species not found in Dublin Bay, the majority live in deep water.

Sir J. Richardson read a paper from Dr John Davy, *on the Fishes of the Lake District.* (This paper has appeared in the last No. of this Journal.)

Dr Carrington *on the Geological Distribution of Plants in some Districts of Yorkshire.*—The chief tract taken for illustration was that part of Craven included between Gordale and Kingsdale, and cut off on the south by the magnificent line of scars known as the Craven fault. The physical and geological peculiarities of the district were minutely described. The origin of the present vegetation was referred to different periods; the more ancient portion, including plants of boreal type, being probably a remnant of the Pre-Glacial Flora. The species found in Craven are 600 flowering plants, and about 500 mosses and lichens. After considering the present state of our information as to the geognostic relations of plants, the following classification of strata was recommended, each group being characterized by a peculiar Flora:—1. Calcareous formations, highly absorbent, acted on by the elements chemically rather than mechanically (the carbonic acid in water dissolving the lime), forming a dry, scanty, but fertile soil; 2. Arenaceous formations, disintegrating freely, and producing an abundant sandy deposit, on a large scale, forming absorbent, barren stations; 3. Argillaceous formations, subject to rapid abrasion, forming clayey deposits, comparatively impermeable, and hygroscopic. In practice we find these often mingled together, *e.g.*, shales with sandstones; and the soils frequently differ in nature from the rocks they cover, having been derived from distant sources. The practice of agriculture has especially tended to mingle and equalize the soils of various districts. The prevailing rock of Craven is the scar limestone. It supports the greenest pasturage, and most of the rare species are found on it, *e.g.*, *Actæa spicata*, *Draba incana* and *D. muralis*, *Cardamine impatiens*, *Hutchinsia petræa*, *Hippocrepis comosa*, *Dryas octopetala*, *Saxifraga oppositifolia*, *Hieracium Gibsoni*, *Bartsia alpina*, *Primula farinosa*, *Epipactis ovalis*, *Cypripedium Calceolus*, *Lastrea rigida*, and many characteristic mosses and lichens, especially important from growing directly on the rocks. *Limestone.*—The prevailing lichens are species of Collema, such as *C. nigrum*, *stygium*, *fluviatile*, &c., *Parmelia crassa*, *P. calcarea*, *Lecidea lurida*, *candida*, *immersa*, *saxatilis*, *calcarea*, &c., *Verrucaria immersa*, *Gagei*, *Dufourii*, *plumbea*, and *epipolœa*. The sandstones are restricted to the millstone-grit, capping Ingleborough and other summits, upwards of 2000 feet high. They are covered by a coarse brown vegetation of ling, heath, crow-berry, bilberry, *Juncus squarrosus*, &c. *Sandstone.*—The lichens are brown and golden coloured, *e.g.*, species of *Umbilicaria*, *Parmelia atra*, *olivacea*, *saxicola*, *badia*, *mucorum*, *Lecidea lapicida*, *confluens*, *prominula*, and *fuso-atra*, *β rupestris*. The argillaceous rocks are represented by the Yoredale shales and Lower Silurian slates, exposed in Ribblesdale and Chapeldale. They afford damp, dripping stations, supporting a scanty glaucous vegetation of Equiseta, rushes, and Carices, *e.g.*, *Sedum Rhodiola* and *S. Telephium*, *Saxifraga aizoides*, *Carduus heterophyllus*, *Equisetum hyemale* and *variegatum*, *Allosurus crispus*, *Hymenophyllum Wilsoni*, *Scolopendrium ramosum*, &c. *Slate.*—*Parmelia conspersa*, *P. sulphurea*, *Sticta herbacea*, *sylvatica*, *scrobiculata*, *Nephroma*, *Lecidea confervoides*, *geographica*, *polytropas*, *rivulosa*.

The Rev. H. H. Higgins *on the Death of the Common Hive Bee, supposed to be occasioned by a Parasitic Fungus.*—The occurrence of a fungus was considered as the cause of the death of a gallon of bees in a hive. On examining some of the insects there was found on the abdomen, and partly on the clypeus, a white fungus, consisting apparently of spores arranged in a moniliform manner, like the filaments of a penicillium.

Mr Nunneley *on the Structure of the Choroid Coat of the Eye, and more particularly on the Character and Arrangement of its Pigmentary Matter.*—The choroid coat is the dark tissue interposed between the delicate sentient retina and the hard dense sclerotic, and coextensive with the latter. It begins at the entrance of the optic nerve by a round aperture with a distinct edge, in close apposition with the nerve, but not organically connected with it, and passing forward as far as the junction of the sclerotic and cornea, where as choroid proper it terminates. It there comes in connection with the ciliary circle or muscle, the ciliary body and the iris. The choroid is essentially a vascular membrane, being made up of blood-vessels, colouring matter, and a modified white fibrous tissue. The choroid universally provides the pigmentum nigrum, and is of a deep bronze colour approaching to black. The pigment was described as consisting of two distinct forms of cells—on the inner surface, the choroid of true hexagonal cells, and in the tissue and on the posterior surface, of stellate cells. He did not admit, however, that they were true cells. The use of these cells was to destroy the light as soon as it had acted on the retina, and they were the most perfect absorbers of light of any substance in nature that he knew of. From the account he gave of the arrangement of the pigment, it afforded what he considered a satisfactory anatomical explanation of an abnormal condition of the eye which had hitherto not been understood, viz.,—*Muscæ volitantes.* The figures of those motes he believed to resemble exactly portions of the choroid coat when teazed out; and they might be expected to disappear with the varying condition of the vessels arising from disordered stomach or the cerebral circulation, and be cured by whatever corrects those conditions; or the muscæ might result from different organic changes in the choroid coat which are incapable of being removed.

Communication on the Homology of the Skeleton, by G. M. Humphry, Esq., Surgeon to Addenbrooke's Hospital, Cambridge.—Having been lately engaged in writing on the human skeleton,* the author has carefully investigated the whole subject of its homology, in connection with the skeletons of the other vertebrate classes, and in connection with its mode of development and its relation to the nervous system. The conclusions at which he has arrived differ, in some particulars, from those of Professor Owen, more especially with regard to certain bones of the skull, such as the temporal bone and the components of the anterior cranial vertebræ. His views, and the terms he employs, are shown in the accompanying table I.; in table II. the bones are arranged according to the system of Professor Owen, the differences between the two plans being indicated by italics. He considers that the pelvis is composed of the hæmal parts of two sacral vertebræ; that the scapula is composed of the hæmal parts of two cervical vertebræ; and that the limbs are appendages diverging from the points of junction of the hæmal spines with the hæmal alæ. The key to the exact comparison of the fore limbs with the hinder limbs, which has proved a source of much difficulty to anatomists, he thinks is furnished by the fact, that they are placed, the former near the anterior, and the latter near the posterior,

* See Treatise on the Human Skeleton, by G. M. Humphry. Cambridge, 1858.

TABLE OF CRANIAL BONES.—TABLE I.

Sense Bones.	Auditory.			Optic.	Nasal.		
	Tympanic and petrous parts of temporal.	Ossicular auditus.	External cartilages.	Tarsal cartilages.	Turbinate bones.	Cartilage of septum.	External cartilages.

CRANIAL VERTEBRÆ ARRANGED HOMOLOGICALLY.

	Central parts.			Neural.			Transverse.			Hæmal.		
							Process.		Ala.			
Vertebræ	Central.	Supra-Central.	Infra-Central.	Ala.	Spine.	Articulating processes.	Superior.	Inferior.		Ala.	Spine.	Diverging appendage.
1. Occipital	Basilar part.		Pharyngeal tubercle.	Side of foramen magnum.	Expanded part of occipital.	Condyles.	Jugular process.		Mastoid.	Lesser cornu of hyoid.	Body of hyoid.	Great cornu of hyoid.
2. Post-sphenoid	Post-sphenoid body.	Posterior clinoid Hinder part of olivary tubercle.	Hinder part of Rostrum.	Great ala of sphenoid.	Parietal.		External pterygoid.	Internal pterygoid.	Squamous.	Condyle of lower jaw.	Ramus of lower jaw.	Angle of lower jaw.
3. Pre-sphenoid	Pre-sphenoid body.	Fore part of olivary tubercle.	Fore part of Rostrum.	Small ala of sphenoid.	Frontal.		Laminæ on sides of sphenoid sinus.		Palate.	Superior maxilla.		Malar and Lacrymal.
4. Æthmoid	Median plate of æthmoid.	Crista Galli.	Vomer.	Cribriform plate of æthmoid.	Nasal.		Lateral portion of æthmoid.			Intermaxillary bone.		

Table II.

	Centrum.			Neurapophysis.	Neural spines.	Zygapophysis.	Diapophysis.	Parapophysis.	Pleurapophysis.	Hæmapophysis.	Hæmal spine.	Diverging appendage.
1. Occipital	Basilar part.			Side of foramen magnum.	Expanded part of occipital.	Condyle.		Jugular process.	*Scapula.*	*Coracoid.*	*Episternum.*	*Fore limb.*
2. Parietal	Post-sphenoid body.			Great ala of sphenoid.	Parietal.			*Mastoid.*	*Styloid.*	*Lesser cornu of hyoid.*	*Body of hyoid.*	*Great cornu of hyoid.*
3. Frontal	Pre-sphenoid body.			Small ala of sphenoid.	Frontal.			*External angular process of frontal.*	*Tympanic.*	*Condyle of lower jaw.*	*Ramus of lower jaw.*	*Malar and Squamous & Pterygoid.*
4. Nasal	*Vomer.*			*Median and cribriform plates of æthmoid.*	Nasal.				*Palate.*	*Superior maxillary.*	*Intermaxillary.*	

part of the trunk; and that consequently, the opposed surfaces of their upper segments, as well as the opposed surfaces of the pelvis and scapula, are made to correspond; that is, the anterior aspect of each hinder limb corresponds with the posterior aspect of each fore limb. This disposition of the parts takes place during development. At first each limb is nearly straight; the hands and the feet bend out from the sides of the trunk; the palms and the soles look downwards; and the thumb and the great toe are directed forwards. Subsequently, each limb undergoes a quarter turn; but in opposite directions. The anterior limb is rotated on its long axis, backwards; and the hinder limb is rotated, in a similar manner, forwards; the ilium and the femur slant forwards from the hip; and the scapula and the humerus slant backwards from the shoulder; the knee bends forwards; and the elbow bends backwards. In the anterior limb, however, the rotation of the distal segments during pronation is in an opposite direction to that of the proximal segments; and pronation is the more easy and habitual position.

Mr J. C. Eyton *on the Arrangement of Birds.*—Mr Eyton proposes to divide birds into the following orders:—1. Raptores. 2. Noctivores. 3. Volitores. 4. Lapsatores. 5. Prehensores. 6. Seansores. 7. Eruacivores. 8. Insessores. 9. Bipositores. 10. Rasores. 11. Cursores. 12. Littores. 13. Grallatores. 14. Natatores.

Mr Joshua Alder *on Three New Species of Sertularian Zoophytes.*—The new species are *Plumularia Halecioides*, *Halecium labrosum*, and *Halecium nanum.* The first and second have been found on the Northumberland and Durham coasts, and a specimen of *Halecium labrosum* has also been obtained in the Moray Firth, but the third is only found on the Gulf-weed.

Dr Geo. Harley read a paper entitled *Notes of Experiments on Digestion*, embodying the results of experiments he had made during last summer upon the nature and properties of the more important of the digestive fluids—the salivary secretion, the gastric juice, the bile, and the pancreatic fluid. The celebrated chemist, Bernard, had affirmed that in the saliva there was no iron, and that it did not before decomposition contain sulpho-cyanide of potassium; but his (Dr Harley's) experiments had in both particulars demonstrated the opposite. He had likewise ascertained that a person nine stones weight secreted $2\frac{1}{4}$ lbs. of saliva in twenty-four hours. He next proceeded to a consideration of the oft-discussed question, why did not the digestive fluids digest the stomach itself? After refuting the various explanatory theories, he affirmed that the walls of the stomach were not preserved from destruction by the epithelium cells, as Bernard supposed, but by a layer of mucus of a thick brownish character, which is deposited upon those cells. That portion of Dr Harley's paper which seemed to be regarded by the audience as the most important, consisted of the reference made to the pancreatic secretion, which is the most valuable of all the digestive fluids, inasmuch as it unites in itself the functions of the salivary, the gastric, and the biliary secretions. This, Dr Harley remarked, was an invaluable substance to those suffering from indigestion; in fact, if they could determine the active principle of that secretion, they would gain the power of digesting anything they pleased. He had been labouring some time in the preparation of such a substance, but he had not yet got it in a pure state. The preparation was such as his own stomach could receive, but he had no need of it, as his digestion was unimpaired. However, if they could succeed in discovering that substance, it would prove the greatest boon ever conferred upon suffering humanity.

Mr R. H. Meade *on the Anatomy of the Spinning Organs of the Araneidæ.*—The tegumentary covering of the abdomen in true spiders consists of three layers, viz.,—1*st*, An external, horny, transparent membrane, more or less densely clothed with hairs; 2*d*, An intermediate soft stratum of pigmentary matter; and 3*d*, An expanded network of muscular fibres, which will enable the spider to compress the contents of the cavity. The spinnarets, seated near the apex of the abdomen, at the under side, are, mostly six in number, placed in three pairs,—an anterior, a posterior, and an intermediate pair. The posterior pair is often prolonged and triarticulate, when the spinners composing it have been called *anal palpi.* There is a fourth pair of spinnarets in Mr Blackwall's family of the "Cinifloridæ," situated in front of the ordinary anterior pair. They are short, compressed, and inarticulate. The spinnarets are connected with the surrounding integument by means of diverging bands of muscular fibres, which enable them to move in various directions. In the interior of the abdomen, nearer the base than the apex, there is a point (opposite the orifice of the oviduct in the female), from which several muscular bands radiate in various directions, keeping the different abdominal organs in their places. Some are inserted into the integument on both the dorsal and ventral surfaces of the abdomen; others run backwards in straight parallel bundles, and pass into the interior of the spinnarets. These last bundles have their fibres strongly striated, like the strong muscles connecting the legs with the cephalo-thorax. The other muscles mentioned are only faintly marked. The interstices between the organs in the abdomen are filled with adipose matter, connected into lobules by fine cellular tissue. This serves as a reservoir of nutriment, and enables spiders to bear very long abstinence. The glandular organs, which secrete the silk, consists of a number of sacs or bags, and convoluted or branched tubes, of very various sizes and shapes,—each furnished with a distinct excretory duct, which terminates separately on the surface of the spinnaret; so that there is no communication between one and another. The spinning glands may be divided into four varieties. The first consists of a large number of exceedingly minute cells, each containing a kind of nucleus, and furnished with a very fine duct. These are only found in the family of the Cinifloridæ, and are placed immediately beneath the integument, near the supplementary spinnarets, with which they are connected. These glands evidently secrete the fine silk, which forms the flocculus in the web of *Clubiona atrox* and *ferox.* The next group of spinning glands is the most numerous and most constant of all the varieties. It consists of an immense collection of small oval or fusiform cells, with fine elastic ducts, which terminate principally in the anterior and posterior pairs of spinners. These probably secrete the fine threads, which weave the more delicate parts of the webs, and construct the cocoons in which the eggs are deposited. The third variety of silk glands contains several cartilaginous sacs, or convoluted tubes, of a firm or even hard consistence, brittle and transparent. These are often of a large size, especially in the different species of Epeira. They have fine but inelastic ducts. Perhaps these secrete the adhesive lines, which are placed on the geometric webs of spiders. The last and most interesting kind of glands are membranous sacs and tubes, some vermiform, others clavate, others furnished with branched cæca. They vary in size, some being very large. All have thickened and apparently fibrous walls,—and they are all furnished with elastic ducts, having a fibrous external coat, composed of distinct rings, which breaks up into separate pieces when the duct is stretched. From their construction, these sacs and ducts must possess a strong contractile and expulsive power. They probably secrete the stronger threads which are stretched between distant points, and form the framework of the webs; and they must also produce the gossamer of the aëronautic spiders, for they are exceedingly large and numerous in *Lycosa saccata* and *Thomisus cristalus*—common aërial species—which require them for no other purpose, as they do not spin ordinary webs, being erratic in their habits. In most other species of Lycosa, also, the spinning organs are very slightly developed. The ducts from both the cartilaginous and membranous glands terminate in all the three ordinary pairs of spinnarets; several from the latter may be traced into the long triarticulate spinnarets of *Angelena labyrinthica.*

Mr W. B. TEGETMEIER *on the Formation of the Cells of Bees.*—"Having recently been engaged in making a series of experiments with a view to determine the typical form of the cells of bees, and having arrived at some interesting results, I am desirous of bringing them before the members of the British Association. My first experiment consisted in placing a flat parallel-sided block of wax in a hive containing a recent swarm. In this, cells were excavated by the bees at irregular distances. In every case where the excavation was isolated it was *hemispherical*, and the wax excavated was added at the margin, so as to constitute a *cylindrical* cell. As other excavations were made in contact with those previously formed, the cells became flat-sided, but from the irregularity of their arrangement not necessarily hexagonal. When the block was covered with vermilion the employment of the excavated wax in the formation of the sides of the cells was rendered more evident. The experiment has been repeated with various modifications as to the size and form of the block of wax, but always with the same results,—namely, that the excavations were in all cases hemispherical,—that the wax excavated was always used to raise the walls of the cells,—and that the cells themselves, before others were formed in contact with them, were always cylindrical. Mr Charles Darwin, to whom I communicated these facts, has repeated the experiments with similar results. When these experiments are taken into consideration, in connection with the facts that in the commencement of a comb the rudiments of the first-formed cells are always hemispherical, and that in a small extending comb the outer sides of the bases of the external cells are always circular, they appear to lead to the conclusion, that the typical form of a single cell is cylindrical, with a hemispherical base; but that, when the cells are raised up in contact with one another, they necessarily become polygonal, and if regularly built, hexagonal. On this supposition alone can those numerous cases be accounted for in which one-half of a cell is cylindrical, the other polygonal. In all such cases it will be found that, in the cell adjacent to the cylindrical side, there is not room (owing to some irregularity of the comb) for a bee to work,—consequently, the cylindrical development is not interfered with. The formation of the small cylindrical cell surrounding the queen cell appears to admit of no other explanation. The mode in which the circular bases, situated at the thin edge of a comb in the process of enlargement, become converted into polygonal cells as new bases are formed on their outer sides, has been beautifully shown by Mr Darwin. In repeating, with many ingenious modifications, my original experiments, he coloured, with vermilion and wax, the circular edges of the bases of the external cells in a small comb. In replacing this in the hive, he found that the walls of the cells were not raised directly upon these circular bases, but that, as other cells were built external to them, the coloured wax was remasticated and worked up into the polygonal sides of the cells; consequently, the colour, instead of remaining as a narrow line, became diffused over a considerable portion of the sides of the cells. These observations have been much facilitated by the employment of a hive having each side formed of four parallel plates of glass, with thin strata of air between. As thus formed, the escape of heat is so effectually prevented that the bees work without the necessity of covering the hive with any opaque material, and thus they are always open to observation without being disturbed by the sudden admission of light into a hive previously dark. Crude and imperfect as these experiments may be, they appear to me to have an important bearing on the theory of the formation of cells; and my desire that they may be repeated and extended by other observers must plead my excuse for bringing them before the notice of the Association."

Dr Edward Smith read a paper describing the results obtained from an extended inquiry into the quantity of carbonic acid evolved from the lungs under the influence of various agents. He had conducted a series of experiments extending over several months, and found, by his new instrument, the "Respirometer," that the quantity of carbonic acid expired varied most materially under the influence of different kinds of food, different states of the atmosphere, &c. The paper went into an inquiry—first, as to the quantity of carbonic acid expired in twenty-four hours, with the variations hour by hour; second, the influence of season; and third, the influence of nearly all ordinary articles of food and of a few medicines. During the summer respiration is always feeble, as compared with the colder months of the year; and although the skin exercised most important functions, he found that it was not vicarious for the lungs in the expiration of carbonic acid; for while the lungs expired 600 grains, the skin threw off only six grains. The increase in the quantity of carbonic acid was greater and more enduring after eating oatmeal and rice, than after partaking of arrow-root; whilst wheat produced the greatest quantity, though the increase was less enduring than with oatmeal and rice. Tea, coffee, and cocoa were found to be respiratory exciters, and consequently increased the waste of the system; they could not be classed as food; but as tea induced perspiration, it was most valuable as a remedy against the action of heat. Tea caused the evolution of much more carbon than it supplied. Tea would also be useful in cases of drowning and interrupted pulsation. Brandy, sometimes administered in cases of drowning, had the very opposite effect to that desired, being a non-exciter of pulsation; whereas tea increased the action of the lungs and skin. If the object were to prevent the waste of the system, then alcohol might be useful, and tea would be improper; but if they wished to refresh themselves, tea should be taken. The experiments made showed that those who were more susceptible of injurious influence by heat were the least able to bear any change of climate; and if this were borne in mind, it would be found of service to those who might contemplate going abroad—to the East or elsewhere.

Mr Tuffen West *on some Condition of the Cell-Walls in the Petals of Flowers, with Remarks on some so-called external Secondary Deposits.*—The attention of the author was first attracted to the subject by a desire to understand the structure of the familiar and beautiful microscopic object, the petal of the geranium. He found, by an extensive series of investigations carried over two years, that the brightness of the colour of flowers, due in the first place to the perfect purity of the vegetable colouring matter, is enhanced by two curious, and, as they might be called, highly artificial contrivances. The first of these being the separation of the colour into symmetrical spots, arranged with perfect regularity by its being contained in little "cells," a device adopted by the miniature-painter for the same reason; the second, the elevation of the centre of each cell into a papilla, specially noticeable on the front of the petal. These papillæ produce to the naked eye the rich velvet pile surface of many flowers, and from considerations respecting their form and lens-like action upon light, the author believes them to have the effect of magnifying the colour contained in them precisely as the colour is increased by the bull's eye condenser of a railway signal-light, or by the large bottles with coloured fluids in a chemist's window. Examples of papillæ of both these types of form described are readily to be met with. The author then discussed the nature of certain minute dots and linear markings on hairs from various flowers. These dots have hitherto been considered to be deposited upon the smooth surface of the hairs as a subsequent formation; but the author adduced several examples to prove that such was not the case, and that they were caused by external bulging or "corrugation" of the cell-wall, with the effect of greatly adding to its strength without any addition of material. In conclusion, the importance of a correct determination of their nature was insisted on, from the light they throw upon the real meaning of dots upon the Diatomaceæ (siliceous Infusoria of Ehrenberg).

Professor Owen next read a long and interesting paper, prepared by Mr G. H. Lewes, entitled "The Spinal Chord a Sensational and Volitional Centre." The spinal chord, the author stated, was formerly believed to be nothing but a great nerve-trunk; and even now its functions have been limited to the transmission and reflexion of impressions. It can conduct impressions to the sensorium and reflect them on the motor nerves, producing muscular contraction; but this is all that physiologists are willing to allow. Doubts having long rested on his mind upon this point, he had made a series of experiments which had led him to a clear conviction; and that conviction, and the experimental evidence upon which it was formed, he had embodied in the paper. Before detailing the evidence for the sensorial functions of the chord (the paper continued) it will be necessary to fix on some broad and palpable signs, such as unequivocally indicate the presence of volition. We have such signs in spontaneity of actions, and choice of actions. It will scarcely be disputed that an animal manifests volition—and its act is voluntary—when the act occurs spontaneously. By "spontaneously," I mean prompted by some inward impulse, and not excited by an outward stimulus. Spontaneity and choice are two palpable characteristics of sensation and volition; and it is these we must seek in our experiments. Those who for the first time perform or witness experiments on decapitated animals, find it very difficult to believe that the animals have no sensation; but their doubts are generally settled by a reference to the admitted hypothesis of the brain being the exclusive seat of consciousness. On the strength of this hypothesis the striking facts recorded by Legallois, Prochaska, Volkmann, and others, have been explained as simple cases of the reflex action of the chord. Against this hypothesis of the brain being the exclusive seat of consciousness I have for some years gathered increasing strength of conviction, preferring the hypothesis of the sensorium being coextensive with the whole of the nervous centres; and I have been able, by experiment, to constitute three separate and entirely independent seats of consciousness in the same animal. From the mass of evidence furnished by experiments, all bearing on the same point, the sensational function of the chord acquires in my mind the force almost of a demonstrated truth. From that mass a few cardinal cases may be selected. If they do not carry conviction, there can be little hope in any accumulation of such cases. Place a child of two or three years old on his back, and tickle his right cheek with a feather, he will probably first move his head aside, and then, on the tickling being continued, he will raise his right hand, push away the feather, and rub the tickled spot. So long as his right hand remains free, he will never use the left hand when the right cheek is tickled, or *vice versa.* But if you hold his right hand, he will rub with the left. The voluntary character of these actions is indisputable, in spite of their uniformity; they are prompted by sensation, and determined by volition. Let us now contrast the action of the sleeping child, under similar circumstances, and we shall find them to be precisely similar. Children sleep more soundly than adults, and seem to be more sensitive in sleep. I tickled the right nostril of a three year-old boy. He at once raised his right hand to push me away, and then rubbed the place. When I tickled his left nostril he raised the left hand. I then softly drew both arms down, and laid them close to the body, embedding the left arm in the clothes, and placing on it a pillow, by gentle pressure on which I could keep the arm down without awakening him. Having done this, I tickled his left nostril. He at once began to move the imprisoned arm, but could not reach his face with it, because I held it firmly, though gently, down. He now drew his head aside, and I continued tickling, whereupon he raised the right hand, and with it rubbed the left nostril—an action he never performed when the left hand was free." The simple and ingenious experiment of Pflüger establishes one important point, namely, that the so-called reflex actions in sleep are not unaccompanied by sensation and volition. The sleeping child behaves precisely as the waking child behaves, except that his actions are less energetic; and we are forced to assume the presence of dim cerebral consciousness to escape the conclusion that the spinal chord is also a seat of consciousness. The actions of the sleeping and the waking child are so similar that both must be credited with sensation and volition (and if not both, then neither must be so credited); in like manner, I shall show that the actions of animals, before and after decapitation, exhibit no more difference, as respects sensibility, than the actions of the waking and the sleeping child; so that here again, unless both actions are credited with sensation and volition, neither of them can put in a claim. Experiment leads decisively to this alternative, namely, either animals are unconscious machines, or decapitated animals manifest sensibility and will. [Having detailed a series of experiments with a water-newt, to show that the animal's actions were precisely the same before and after decapitation, and arguing that they displayed spontaneity of action, the paper proceeded]. After allowing a quarter of an hour to elapse, in order to a more complete reinstatement of vigour, I touched the flank, as before, with acetic acid. The movements at first were very disorderly. It ran about in great uneasiness, just as it had done before its head was off. In vain I waited for it to rub itself against the side of the box: it curled itself up, and seemed about to die. Some time afterwards I again touched it with the acid; it again became disorderly, and I then pushed it towards the side of the box; but it did not move until I pushed it slowly forwards, so that its flank might come in contact with the wood. This succeeded; this seemed to supply the very remedy it wanted, for it continued crawling slowly and with intervals of rest, its body curved outwards so as to continue in contact with the wood, and its hind leg pressed close to the tail; and thus, as before, it rubbed away the acid. There are two points noticeable here: first, the readiness with which a sensation of contact suggested a means of relief; secondly, that this was the only newt which, in my experiments, ever hit upon this plan; and this one did so as well without its head as with it. The repetition of the act precludes the idea of its being an accident. It is unnecessary to trespass on your time by citing the observations of numerous physiologists testifying to the spontaneity of decapitated animals. You will all remember such cases. I divided the chord of a newt between the fifth and sixth cervical vertebræ. The convulsions which followed were almost as severe as those which follow decapitation; but in this case it was the fore-legs which were tetanic, and the hind-legs pressed close to the body. After a few minutes it tried to rise, but failed. Bubbles of carbonic acid were constantly expired. After fifteen minutes it turned completely round, and crawled five steps forward, dragging the hinder segment after it like a log, the hinder legs not moving at all. This was repeated several times. In fifteen minutes more sensibility was detected in the hinder segment. Here was a case which would have been pronounced very simple. Division of the chord had seemingly destroyed all power of voluntary movement in the limbs below the section. The hind legs seemed paralyzed. When the anterior segment was irritated, the animal crawled away, dragging the motionless posterior segment after it. When this posterior segment was irritated, the animal did not crawl, but simply withdrew the limb or tail. If I touched the tail or hinder leg with acetic acid, the whole of the posterior segment (in which volition was said to be destroyed) began to move, and the legs set up the crawling action, attempting to push the whole body forward, which could not be effected, because the anterior segment was perfectly motionless. The hind legs, which never moved when the anterior segment was irritated, moved now in obedience to the spinal volition; and the anterior segment, which before seemed so energetic in its voluntary movements, was now perfectly unmoved. Each centre rules its own segment. If the motionlessness of the hind legs when the animal crawled is a proof that voluntary power was destroyed in those legs, the motionlessness of the fore legs when the hind legs moved is equally a proof that voluntary power is destroyed in the fore legs. The real truth seems to be, that each segment has its own volitional centre, and that the one is never affected by the other. I have at this moment a newt with the chord divided near the centre of the back. The operation was performed four days ago, and the animal has so far recovered from it that no spectator could distinguish between the voluntary power of its two segments. When the flame of a wax match is brought near the cerebral segment, the fore legs set to work, and the animal crawls away, dragging the hinder segment along. When the flame is brought near the final segment, the hind legs set to work, and the body moves sideways, the anterior segment remaining perfectly quiescent. All other stimuli produce similar results. I venture to submit that the explanation here proposed of two independent volitional centres is far more consistent with the phenomena than the explanation offered by the reflex theory, unless the actions of the posterior segment of the newt are evidences of sensation and volition, I know of no kind of evidence for the existence of such properties in the cerebral segment. . . . . I will not occupy the attention of this meeting with the recital of other experiments. Those already cited suffice to indicate the nature of the evidence on which I found my positions. And indeed I might rest on one simple fact as proof that the spinal chord is a sensational centre, namely, the fact that whenever sensibility is destroyed, all actions cease to be co-ordinated. Every one present knows how greatly our muscular sensibility aids us in the performance of actions; but it has apparently been forgotten that if sensibility be destroyed in a limb, by section of the posterior roots which supply that limb, the power of movement will be retained so long as the anterior roots are intact; but the power of co-ordinated movement will be altogether destroyed. With diminishing sensibility we see diminishing power of co-ordination, the movements become less and less orderly; and with the destruction of sensibility the movements cease to have their co-ordinated harmony. Now, in the cases I have cited it is clear that this power of co-ordinating movements—sometimes very complex movements—was nearly, if not quite, perfect in the decapitated animal; therefore, if co-ordination implies sensibility, the conclusion seems inevitable, that the spinal chord is a centre of sensibility. The whole case may be summed up thus:—1*st.* Positive evidence proves that in decapitated animals the actions are truly sensorial. 2*d.* Positive evidence, on the other hand, shows that in human beings with injured spines the actions are not sensorial, but reflex. 3*d.* But as the whole science of physiology presupposes that between vertebrate animals there is such a general concordance that whatever is demonstrable of the organs in one animal will be true of similar organs in another; and inasmuch as it is barely conceivable that the spinal chord of a frog, a pigeon, and a rabbit, should have a sensorial function, while that of man has none, we must conclude that the seeming contradiction afforded by human pathology admits of reconcilement. No fact really invalidates any other fact. If the animal is such an organized machine that an external impression will produce the same actions as would have been produced by sensation and volition, we have absolutely no ground for believing in the sensibility of animals at all; and we may as well at once accept the bold hypothesis of Descartes—

that they are mere automata. If the frog is so organized, that when he cannot defend himself in one way the internal mechanism will set going several other ways,—if he can perform, unconsciously, all those actions which he performs consciously, it is surely superfluous to assign any consciousness at all. His organism may be called a self-adjusting mechanism, in which consciousness finds no more room than in the mechanism of a watch.

Mr Nunneley read a paper *on the Form of the Eye-ball, and the Relative Position of the entrance of the Optic Nerve in different Animals.*—It was well known, he observed, that the orbits are much larger than the eye-balls, and that their axes diverge considerably in an outward direction, while those of the two eyes are perfectly parallel. The eye-balls lie in the fore part of the orbits, and according as they are more or less prominent, and more or less covered with the lids, do they appear to be larger or smaller. The eye of the infant is larger, in proportion to the size of the body, than that of the adult; but it is by no means certain that the eye of the male is larger, proportionately to the size of the body, than the eye of the female. By some anatomists the human eye was described as a spheroid, the diameter of which, from before to behind, is greater than in any other direction. He had measured a great number of eyes, of the human subject as well as of animals, and he found that, wherever there was a departure from the spherical figure, it was in the direction contrary to that which had been commonly stated. In some instances the difference between the diameters was scarcely perceptible; in all, where a distinction was observed, the transverse was the greatest. He had prepared a set of tables (which were printed) containing the result of the measurement of 200 eyes of various creatures. In conclusion, Mr N. said—The measurements, I think, clearly prove that whatever part of the fibres of the optic nerve play in the phenomena of vision,—and they, in all probability, only convey to the sensorium the impression received by the true retinal elements,—that the greatest number of them are distributed on that part of the eye-ball where there is the greatest range of vision, and that the largest expanse of retina is on that part of the ball opposite to where objects are placed, and, consequently, it is where the visual images of them must fall. Thus the extent of vision is always in conformity with the space of retina on that side of the optic nerve; and as the rods and cellules appear always to correspond in abundance with the fibres, that side of the retina which receives the greatest number of images is most exercised, or where the range of vision is the greatest, is always the largest. That this is a fact, I think a careful comparison of the position of the eyes in the head, the size of the eye-ball, and the exact position of the entrance of the nerve into it, with the mode of life and habits of various creatures, will render more obvious than a casual glance would do. To mention only a few instances as illustrations:—Man, from the erect position of his body, the horizontal placing of his eyes, and his habits, has a more panoptic range than any other creature (of course in this consideration all notions of the head, neck, and body of the animal must be excluded, and those of the eye-balls alone admitted). In him the optic nerve enters the ball not far from the centre, leaving, however, a somewhat shorter space on the inner and lower parts of the retina than on the upper and outer. Now, while man enjoys a free range of vision *above* the horizontal line, there are far more occasions for him to look at objects below than above this line, and thus more visual images are projected to the upper and outer sides of the entrance of the optic nerve than to the inner and lower sides of this spot. In the pig, which sees at no great range before it, and which seeks its food with the snout almost always in the ground, whose head and eyes are consequently for the most part downwards and near to the ground, the nerve enters the ball more outwardly and much lower than it does in man. The pig wants not to see far before it, but it does require while grubbing to look behind it from whence danger comes. So with the timid herbivorous animals: Look at the entrance of the nerve in the bullock and sheep, which pass so much time with the head in a dependent position near to the ground, with the eye directed upon the surface, in open plains, where danger usually comes from behind; in them the upper and inner sides of the retina are much larger than the lower and outer portions, while in the deer, which lives in more wooded places, where danger is also from the front, but which, like the bullock, has the head downwards in feeding, though the inner or anterior side of the retina is still larger than the posterior, it is so to a much less extent than it is in the bullock, while the upper portion still continues as proportionally large as it is in sheep and bullocks. On the contrary, in the horse, which is not so preyed upon, which carries the head erect, and observes all around, the nerve enters the eye more nearly in the axis. In birds, with few exceptions, the upper portion of the retina is much more considerable than the lower parts; but the anterior and posterior portions vary much in different genera. Those whose locomotion is performed principally by the feet, and whose range of habitation is very small, as the common fowl and turkey, have the inner or anterior portion very considerably greater than the outer or posterior; those birds whose range is greater, and which use the wings for progression, but do not wander very far, as the grouse and partridge, have a much less difference in the two portions of the retina; while in those birds whose flight is far and prolonged, as the crow, rook, swan, goose, and duck, the entrance of the nerve is very nearly in the centre of the ball. So in reptiles: in the turtle, which only requires to see immediately before and under it, the outer and upper portion of the retina are very much the larger. In the more active alligator, frog, toad, and chameleon, while the upper portion maintains its size, the outer and inner parts are more nearly equal. In those creatures whose habitation is for the most part under ground, as the shrew and the mole, the eyes are so small as to have led Magendie to assert that the mole is without the organs altogether, which is not the fact, for I have found all the essentials of an eye, even true retinal elements, optic nerve, and a well-developed choroid. Yet the organ is so minute and concealed by the skin and hair, as probably only enables the creature to discern the light, which is all that it requires; for, living under ground, where it seeks its prey, it obviously must depend upon the acuteness of other senses rather than of sight for its living. Though in the individual there is usually some proportion between the size of the eye and the body, taking different classes and genera, the size of the animal is very little guide to that of the eye, the proportions between the two being determined by other considerations than that of the bulk alone of the creature; for though, as a whole, the eye in fish bears a larger proportion to the whole body than it does in other divisions of the animal kingdom, and the eyes of the birds are, as a class, much larger than those of mammalia or reptiles, yet amongst the different genera of all these classes there are very great differences, determined, apparently, by the following considerations, amongst others not so obvious:—When the creature lives in feeble light, yet moves actively about, and is guided in its locomotion by the sense of sight, as in nocturnal birds and animals and in fish, the eye is very large, apparently to take in a large quantity of the feeble light; on the contrary, where the creature is guided in its movements by other senses, then the eye is very small, as in the bat, the mole, the shrew, and the eel. Where vision penetrates to a long distance, and where the eye enjoys great power of overcoming the aberration of parallax, the eye is large, as in rapacious birds. When the brain and intellect are more developed, the size of the eye diminishes, and the two eyes become more parallel, as in man and the higher mammalia. Where animals are feeble, timid, have but little defensive power, and are preyed upon, the eye is usually very large, as in the hare, the conies, the whole deer tribe, and many of the other ruminants. Where the animal is not predaceous, and its size and strength are such as to protect it from being preyed upon, the eyes are commonly small, as in the whale and the elephant: in the latter the eye is even smaller than it is in the horse, and scarcely larger than in the eagle.

GEOGRAPHY AND ETHNOLOGY.

Mr John Crawfurd *on the Effects of Commixture, Locality, Climate, and Food, on the Races of Man.*—The writer gave a comprehensive review of the commixture of various nations, its effects on the mental faculties of the different populations, their physical characteristics, and language, &c. He glanced next at the effects of a change of climate upon any particular race. It did not appear, he said, that colour and the more prominent physical attributes, or mental capacity, had any necessary connection with climate; nor did he think that climate altered the physical form and mental faculties of a race transferred from its original locality to a new one. After quoting the opinion of Baron Humboldt, showing that heat had very little effect on the European constitution, Mr Crawfurd applied this portion of his paper to disprove the statements, which he said had been repeatedly asserted, that the British possessions in India were unfit for the permanent residence of Englishmen. He pointed out at some length that the varieties of climate had a great influence upon the mental powers of a people, and proceeded to consider, under the last head of his paper, the question of diet in relation to the physical and mental character of a people. The physical character of a race, he said, did not seem to be in any respect altered by the nature of the vegetable diet of which it partook, provided the quantity were sufficient and the quality wholesome; but when the question of the diet of a people related to mental development, the quality assumed an important aspect. No race of man, it might be safely asserted, ever acquired any respectable amount of civilisation that had not some cereal for a portion of its food.

Professor Tennant alluded to the difference in the value of the gold obtained in Australia and California, and that which had been found in British Columbia. He said that Australian gold was worth L.4 an ounce; Californian, L.3, 15s.; and that got from the Frazer River district, L.3, 11s. He strongly urged that attention should be directed to the importance of procuring other metals besides gold, such as copper, tin, silver, &c., which were frequently to be found in the ore from which gold was obtained, and which would prove equally as remunerative as what was generally considered the more precious metal.

Mr A. Whitney (of New York) *on the Formation of a Railway from the Atlantic to the Pacific Ocean through the British Possessions of North America.*—The writer commenced his paper by explaining at some length the reasons why he was convinced that the United States would never attempt the construction of any such line of railway, and then observed that, had his plan been adopted, the work could have been commenced on the western shore of Lake Michigan, where there was timber, materials, and easy communication with settlement and civilization, and everything to facilitate settlement on its line, the lines to connect with it from the Atlantic, passing through but two states, could from necessity have been made tributary to its operation and management from the Lake to the Pacific. Congress then had the power over it. and all the streams could have been bridged, so that an uninterrupted communication from ocean to ocean would have been had for ever after. A cargo of merchandise could have passed from the Atlantic to the Pacific without transhipment; and as the road from the lake to the Pacific would have been free, except tolls necessary for operations and repairs, the charge for transit would have been so low, together with the great saving in time, that the commerce of Europe with Asia would have been forced over it. This was now all lost to the United States. The author of the paper continued by saying, he had never believed that a railroad to the Pacific could ultimately benefit either Europe or the Atlantic slope of America, unless the commerce of Europe with Asia could be made to pass over it, leaving England with her present manufacturing and commercial position and relations, and augmenting her power over both. The immense business which the commerce and intercourse between Europe and Asia would give to the road must, as a natural result, form a foundation for the employment of a densely-populated belt from ocean to ocean, and, as far as the soil and climate might suit, mostly an agricultural people. This belt would take the surplus population from Europe, and make the producers of food to exchange for English manufactures on one side, and Asiatic products on the other, thus benefiting to a vast extent the population of both Europe and Asia, by giving to each the means to consume more largely of the other's products. If these great results could not be attained, what benefit to England, or to the United States even, could be looked for from a railroad to the Pacific. When he was last in England (in 1851) he found many warm advocates for the construction of a railway over British territory. It was then, as now, his firm belief that this work could not be accomplished through a wilderness so vast, except by a system of settlement and civization to be connected with the work. He then found that on a line so far north the climate and lands would not be as well suited to settlement and culture as farther south on the territory of the United States; but he had since examined the subject more thoroughly, and found a large extent of country on the British side well adapted to settlement and culture. At the Selkirk settlement, farther north even than necessary for the line of the road, wheat, rye, barley, oats, potatoes, and even Indian corn were cultivated to perfection, the yield large and grain fine, and almost the entire line on this side would be a good grass country. The Pacific side for some parallels was 10 degrees milder. The British side was far the most favourable for constructing a railroad with much lower grades. From Lake Superior to the Rocky Mountain Range was almost a level country. Near 50 degrees parallel the stream divided, running north-easterly and south easterly, and north of 45 degrees parallel the mountains sloped to the Arctic Ocean, and nowhere north of 50 degrees did they elevate their peaks above 5500 feet, with many depressions practicable for a railway. Was not this, then, the route for the commerce between Europe and Asia? Mr Whitney pointed out that there was excellent harbour accommodation at Halifax, on the Atlantic side, and Puget Sound on the Pacific side, and observed, that these two places would form excellent depôts for the commerce of Europe, Asia, the American continent, and indeed the whole world. A cargo of merchandise might then pass from the Atlantic to the Pacific without transhipment or delay, and the actual distance from England to China would be some 2000 miles less than any route likely to be fixed upon by the United States. The Panama Railway and the projected railway across Mexico were truly great enterprises, but people were mistaken as to their probable results. They would certainly facilitate travel and intercourse with California, Oregon, and the Sandwich Islands, but not so with Australia, China, and India, because the sailing distance from England and Australia, China, India, &c., was less round the Cape of Good Hope than *via* Panama. The distance from Canton to London *via* the Cape of Good Hope was 2000 miles less than *via* Panama. The writer said, that the Panama railway had not in any way changed the position of the people of Europe or Asia, nor in any way given to them the means of consuming more of each other's products. The result of it, however, he believed would inevitably be the hastening of the great changes consequent upon the encircling of the globe with civilization and Christianity, and building upon the Pacific slope, a station which must control the commerce of all Asia. Let England, then, put forth her whole strength, and build a great highway for the world over her own soil. It could be accomplished in ten or fifteen years, and with modifications on the plan proposed by him to the United States. It could be accomplished nominally without outlay of money by the nation, creating by its connection with the settlement of its line the means for its own construction; it would add millions of wealth to the nation, and give to it the control, not only of the commerce of all Asia, but of that of the world also. With steam, the distance from London to China could then be performed in twenty-eight days, and merchandise even could be taken in from thirty to thirty-five days.

Lieutenant-Colonel James, R.S., Superintendent of the Ordnance Survey, delivered a brief address *on the Geometrical Projection of two-thirds of the Surface of the Sphere.*—The principal object of his remarks was to point out, that by constructing maps so as to show two-thirds of the sphere on each surface, instead of half a sphere, according to the usual plan, the geography of the world could be much better represented; and he exhibited a map made on this method, which, in reply to Mr R. Monckton Milnes, M.P., he said had been published by the Board of Ordnance at half-a-crown, and could be purchased of any of their agents.

Dr Norton Shaw read a communication from Mr William Lockhart, F.R.C.S., *on the Yang-tse-Keang and the Hwang-ho or Yellow River.* This river, it appeared, was called by the Chinese the Girdle of China, and it traversed the whole of the centre of the empire, rolling its flood of water to the sea through the richest and most fertile part of the country. Its importance to China could not be too highly estimated, and it might be safely asserted that there was no river in the world which had on its banks so numerous a population, amounting to at least one hundred millions of people, who were sustained by its waters in the pursuits of commerce and agriculture. There were more than 100 cities of the first, second, and third classes, and 200 towns and villages which could be approached directly from its water-way. From its origin in Tibet to its outlet at the sea, its course was about 3000 miles, the points being distant in a direct line 1850 miles, and the basin drained by its channel being nearly 800,000 square miles. The commerce of many of the places situate on the borders of the river was very important. Persons engaged in every variety of trade resorted to Han-Khow for the exchange of their respective commodities; men from the north and west, from Mongolia to Tibet and Sze-chuen, brought their wheat, rice, dried and salted vegetables of every kind, bamboo-sprouts, horses, sheep, furs, skins, coal, lead, jade or nephrite, gold in large quantities, rhubarb, musk, wax, and various drugs of northern growth, and exchanged them for tea, silk, camphor, opium, various southern drugs, and above all, for very large quantities of Manchester and Leeds goods. The quantity of long cloth and cotton goods that passed through Han-Khow was probably more than half of the whole brought to China, and access to this spot was of great importance. It had long been much desired by merchants that they should be able to inspect personally the trade of this place and take part in it, as from the accounts brought by native traders it would appear to be one of the most important, if not the most important, mart in all Asia. The paper referred to other places situate on the river, and described their principal features.

General Chesney, R.A., *on the Extension of Communications to Distant Places by means of Electric Wires.*—The special object of his paper, he said, was to urge the necessity of multiplying the telegraphic communications of this country with all parts of the globe, and especially to propose a new electric route between England and America. He regarded electric wires as the pioneers of vast social changes, and if this view were correct, those which at present existed would form but a small portion of that great net-work of "swift messengers" which, if Great Britain desired to maintain her present mercantile supremacy, must speedily connect the principal parts of the world. This country, in fact, must follow the example of other countries; for, if it was content to see one portion of the Anglo-Saxon race far in advance of itself, and America enjoying the lightning-like intercourse with every portion of her vast continent, it would probably not remain equally satisfied to see Russia turning her vast means to such an account as might secure to her in future what she had in the case of the late treaty with China—priority by fully a fortnight of the most important commercial intelligence. After pointing out the many respects in which a country derived advantages from being able instantly to send communications to distant places, the writer gave a summary of some of the principal lines of telegraph which have been made in various parts of the world, or are in the course of construction. When addressing this section of the British Association last year on the desirableness of railway communication with India, he endeavoured to show that one line of electric telegraph might be laid down from headland to headland, along the Red Sea, and another through Arabia, partly in the bed of the Tigris. Both had been commenced, and each would probably meet with difficulties, and even interruptions, but only for a time, as the Porte was prepared to give the necessary protection. Ere long, he hoped, both would be in full operation, and, by having a double line, the communication would be kept up by one set of wires, in case of any accident to the other. He suggested that, for still greater security, a third line should be carried to the Persian Gulf. He thought that, independent of the advantages of having three lines, in case of any interruption, sufficient employment would be found for all three. It was evident that it was equally important that electric messages from this country to America should not depend upon a single cable. Full employment would be given at all times to several sets of wires, and as it was now certain that submarine communications with America were quite practicable, at least two additional cables should be laid down across the Atlantic. He thought that the difficulty caused by the distance between Ireland and Newfoundland might be greatly lessened by taking another route to the latter, namely that of Iceland and Greenland, as by this line the greatest distance from land to land would not exceed 430 miles. The ice and the icebergs appeared to be the only difficulties likely to be encountered, and he thought they would not prove to be very serious.

ECONOMIC SCIENCE AND STATISTICS.

Mr Newmarch read some statistical returns of the mineral produce of Yorkshire for the year 1857, prepared by Mr Robert Hunt, F.R.S., keeper of mining records. The produce of the lead mines had been 12,405 tons 19 cwt. of lead ore and 7875 tons 12 cwt. of lead, being an increase of 231 tons 12 cwt. on the ore, and a decrease on the quantity of lead produced of 1110 tons 10 cwt. as compared with the year 1856, proving that the ores raised were less metalliferous than in the previous year. Of iron ore the remarkable district of the North Riding yielded 1,414,155 tons in 1857, showing an increase of 216,738 tons as compared with the preceding year. The quantity of clay iron raised in the West Riding, as far as returns had been obtained, was 207,500 tons. The cold blast furnaces of the West Riding appeared to have produced 63,000 tons of pig iron. The total produce of the West Riding was estimated at 117,000 tons; the North Riding, 179,838 tons; the total produce of pig iron in Yorkshire being 296,838 tons, against 275,600 tons in 1856. The production of coals from the different districts of the West Riding from 374 collieries had been 8,875,440 tons, showing a falling off of 208,185 tons as compared with 1856, in which year the coal production of the West Riding amounted to 9,083,625 tons. From returns received from 102 quarries in Yorkshire, producing stone of various kinds, the value of the stone raised in 1857 was estimated at L.105,374. Adopting the market value of the metals raised, and making this addition to the sum, the following would represent the amount added to our national wealth last year by the mining and metallurgical industries of Yorkshire:—Lead, L.173,250; pig iron, L.1,013,142; iron pyrites, L.1,572; coals, L.2,168,860; stone, L.105,374; making a total of L.3,462,198.

MECHANICAL SCIENCE.

Mr C. F. WHITWORTH illustrated his recent improvements in railway signals by two models. One of these represented a line of rails in the neighbourhood of a station with the distant signal. By slightly inclining a particular pair of rails, and fixing a communication between them and the signals, the train announces itself as soon as it passes over the permanent way; and the signal, exhibited for the information of succeeding engine drivers, announces that a train has just passed, and that it would be dangerous for them to continue their journey until the obstruction is removed. Mr Whitworth also exhibited a model of a railway signal intended to be attended by an ordinary signalman. The new principle in it was the use of a wheel instead of a lever. This wheel, like the wheel of a vessel, moved the arms of the signal, and registered the fact of its having done so by ringing a bell both at the station and at the wheel itself. In misty weather, consequently, the signalman would be perfectly aware when he had discharged his duty, and when the proper signal was displayed.

Mr JOHN MACKINTOSH read a paper *on Constructing and Laying Telegraph Cables.*—In the ordinary process of expressing the gutta percha through dies in a fluid state, the covered wire as it issues from the die is caused to pass into a long trough containing water for the purpose of setting it; but great difficulty is found in causing the perfect union of the different coatings, which renders the insulation liable to leakage. In order to obviate this difficulty, he coated the wire with gutta percha by means of rollers mounted on parallel axes, and revolving in contact with each other. Each of these rollers is grooved in its periphery, and these grooves meet to form an eye the sizes of the covering desired. Against these rollers are placed hoppers in which gutta percha or Indian rubber is placed in the state in which it comes from the masticator. This Indian rubber or gutta percha enters and fills up the grooves of the rollers, and where they come together the gutta percha or Indian rubber in the grooves is brought together in one piece enclosing the conducting wire. The longitudinal strength is obtained by embedding fibres of hemp, flax, or cotton in an outer layer of insulating material; this is done with great pressure. The covering is subsequently subjected to treatment which enables it to resist tropical heat, and affords quite sufficient protection against ill-usage. The shore ends of the cable, or those for shallow water, are protected with strong wire. In place of sulphuric acid for expressing the gutta percha, he would use chloride of sulphur, mixed with a solvent bi-sulphuret of carbon. Add to this from 2 to 4 per cent. of chloride of sulphur, and then pass the wire through it. The speed at which the covered wire passes through the liquid is so regulated as to allow of its remaining therein for about three seconds; and this process closes up the pores thoroughly, and renders the wire much less likely to be injured by heat or abrasion. His method of submerging cables was to pass them through an apparatus containing water and hard wood balls, which would allow of the accomplishment of the work without injuring the electrical condition of the ropes.

Mr Newell, C.E., was of opinion that Mr Macintosh's plan was more theoretical than practical, and he sketched the plan that ought to have been adopted with respect to the Atlantic cable. The conductor was too small for the purpose, in the first place. It was very little larger than that used by his firm in laying the Black Sea wire. This Black Sea wire, put down by order of the British Government, was coated with thick wire at the shore ends, and so was the "rope" laid to Algeria, and also that from Malta to Corfu. This last cable was 1000 miles in length, and had to traverse the same depths as occurred in the Atlantic, and yet his firm had no difficulty about it. They had no difficulty either in laying it, or in speaking through it: it was a single conductor, and formed of seven wires in a strand, and was coated outside with iron wire. He thought it was probable that the Atlantic cable, in consequence of its "slack," had "kinked" to some extent, and that these "kinks" had caused the mischief which now existed. The copper and the iron wire had no doubt—as Mr Varley also thought was the case—formed a galvanic bar which prevented the currents of electricity from being intelligibly interpreted. The copper wire had probably been laid bare by some rough handling. It would be a difficult matter to repair it. There was 22 per cent. of "slack" in it, and he had found that in cables so laid there were generally "kinks." He had a great many beautiful specimens of "kinks," which he had found in cables hauled in from the sea, because they were totally useless. Mr Brett made two attempts to lay a cable, and lost both the cables; but some of the rope had been recovered by himself (Mr Newell) by the help of a steam engine a couple of months ago, and it was recovered from the depth of 1000 fathoms of water.

Royal Society of Edinburgh.

Monday, 6th December, 1858.—Professor Kelland in the Chair, who read an Opening Address. The following communications were read.

1. *On the Peculiar Appendage of Appendicularia, named* "Haus," *by Mertens.* By Professor Allman.

In this communication the author called attention to the fact of his having discovered, in April last, in the Clyde, near Rothesay, numerous specimens of an Appendicularia, invested with the remarkable appendage named "Haus," by Mertens, who originally described it in specimens captured in the North Pacific, near Behring's Straits, but which no one since his time had seen, though Appendicularia had become a subject of careful and elaborate investigation in the hands of several of the leading zoologists of the present day.*

The appendage under consideration agreed in its more essential details with that originally described by Mertens, except that no trace

* Dr S. Wright has since informed the author, that during the past autumn he observed Appendicularia in the Firth of Forth, invested with its "Haus."

could be detected of the remarkable vascular network which Mertens describes as constituting so striking a feature in the specimens examined by him. There were also some differences in details of less importance, such as in the size of the "Haus," which was here much smaller than in the Behring's Straits specimens, and in the number and shape of the bodies named "horns," by Mertens,—differences, however, which Professor Allman thinks may be referred to a difference of species in the specimens. The author also stated, that he had never witnessed the rapid renewal of the "Haus" after complete destruction—a phenomenon described by Mertens as constant.

Notwithstanding, however, these differences, Professor Allman had not the least doubt that the structure now described is the same, except specifically, with that originally described by Mertens.

2. *Additional Observations on the Morphology of the Reproductive Organs in the Hydroid Polypes.* By Professor ALLMAN.

This communication was intended by the author to be in continuation of a former paper on the same subject, read before the Society during the previous session, and contained the following additional notices:—

Sertularia polyzonias, Linn.

The gonophore of *Sertularia polyzonias* consists of an oval capsule slightly corrugated transversely, with a short tubular, obscurely four-toothed aperture, and having its axis occupied by a blastostyle, bearing in all the specimens examined a single sporosac.

The sporosac is produced at first as a lateral bud from the blastostyle, but soon acquires an apparently terminal position, being borne on the summit of an axile peduncle formed by the portion of the blastostyle which intervenes between it and the base of the gonophore, while the distal portion of the blastostyle seems to become more or less atrophied. The sporosac is furnished with a large simple manubrium, between whose ectoderm and endoderm the ova or spermatozoa are developed, the ectoderm retreating from the endoderm more and more as the intervening generative elements increase in volume; while the endodermal portion of the manubrium, with its cavity, continues to occupy the axis of the sporosac, extending into the middle of the mass of ova or spermatozoa. For this endodermal portion of the manubrium, round which the generative elements are developed in the sporosacs of the hydroid polypes, I have already proposed the term *spadix*;* while to the ectodermal layer, which now constitutes a sac immediately confining these elements, we may give the term *endotheque*, as distinguishing it from the ectotheque, or external investment of the sporosac.

The ova and spermatozoa are of the usual form; and in the male sporosac the spermatogenous tissue may be observed in various stages of development. Towards the centre of the sporosac, where the tissue immediately surrounds the spadix, we find it in the condition of a thick mass of mother-cells filled with "vesicles of evolution;" but as we recede from the centre towards the walls of the sporosac, the spermatogenous

* British Association Reports for 1858.

tissue may be seen to have advanced in maturity, the mother-cells having burst and liberated their contents; while in immediate contact with the endotheque is a zone of active spermatozoa, which, when liberated, are seen to be of the usual form of minute caudate corpuscles.

The generative elements are not absolutely confined to the sporosacs; they also exist between the ectoderm and endoderm of a slightly dilated portion of the peduncular blastostyle, immediately below the sporosac. I have, however, never seen them here except in a very immature condition; and it is probable that from this situation they subsequently pass into the cavity of the sporosac.

As the gonophore advances towards maturity, the sporosac is elevated towards the summit of the capsule, both by its own increase of size and by the elongation of its peduncle; and we now find in the female gonophores that the contents of the sporosac become discharged through the aperture of the gonophore into an external oval sac, which at the same time makes its appearance on the summit of the capsule; the now empty and contracted sporosac, with its spadix, remaining behind in the interior of the capsule, on the extremity of its elongated peduncle.

This extra-capsular sac communicates through the aperture of the gonophore, by means of a short tubular neck, with the cavity of the sporosac. Its walls are composed of two layers; the external one shows no trace of structure, and looks like a gelatinous investment of the sac; but it is probably a delicate membrane, separated from the internal by a rather wide interval, which is filled with a liquid; while the internal one, or that which immediately surrounds the mass of ova, may be plainly seen to be composed of nucleated cells connected with one another by a structureless intercellular substance. The internal layer would seem to be a simple extension of the endotheque of the sporosac, which now becomes protruded, in the form of a hernia, through the aperture of the gonophore. The connections of the external layer are more obscure; but it will probably be found that this membrane is an extension of the endotheque of the sporosac.

The ova which now occupy the cavity of the extra-capsular sac are each found to be enveloped in a special sac, consisting of a very delicate structureless membrane, which closely embraces the ovum, and is then continued by a narrow elongated neck towards the aperture of the gonophore, through which it is probably further continued into the sporosac; but I was unable to trace it beyond this point.

The ova in the extra-capsular sac are in a more advanced stage of development than in the sporosac; segmentation has begun, and all traces of germinal vesicle and spot have disappeared. After segmentation has been established, the ovum may be easily broken down into distinct cells, with granular contents, but with no evident nucleus. It soon acquires a more elongated form, exhibits a manifest contractility of its walls, becomes clothed with vibratile cilia, and, finally, by the rupture of the confining structures, escapes as a free locomotive embryo into the surrounding water.

I have not as yet met with any instance of the occurrence of the extra-capsular sac in a male gonophore; and it would thus seem to constitute a kind of marsupial appendage, into which the ova are introduced from the interior of the gonophore, in order to undergo a further development previously to their final liberation as free larvæ. It occurs, with slight modifications, in several other species, and ought to have a place in the descriptive terminology of the group. I therefore, in allusion to its position on the summit of the gonophore, propose for it the name of *Acrocyst.*

We must be careful not to confound the acrocyst with an extra-capsular, medusa-like sporosac, which in certain species shows itself in a similar situation, but with which it is in no respect homologous, the acrocyst being in an entirely different morphological category from that of the sporosacs.

Sertularia pumila, Linn.

The gonophores in this species are compressed, urn-shaped bodies, generally containing a single sporosac.

From the enlarged opercular summit of the blastostyle there extends into the interior of the gonophore a variable number of cœcal tubes. Some of these are in the form of short, simple, cylindrical processes, while others extend to a greater distance, become more or less branched, and may be traced in contact with the inner surface of the walls of the capsule to within a short distance of the attached end of the gonophore. Brown corpuscles, similar to those in the interior of the blastostyle and cœnosarc, may occasionally be seen in active motion within these cœca.

The sporosac originates as a lateral bud from the blastostyle, and contains a large, simple spadix, surrounded by the ova or spermatozoa.

The generative elements, however, are not confined to the sporosac. In the blastostyle itself numerous ova may be detected; but these are always smaller, and evidently less mature, than those in the sporosac. They are produced in the walls of the blastostyle, apparently between the endoderm and ectoderm, and are very minute towards the summit of the blastostyle, but gradually increase in size towards the point of attachment of the sporosac, and are probably thence conveyed into the cavity of the latter, where a further development awaits them.

In the condition now described, the gonophore continues during the early part of the season; but at a later period there makes its appearance in the female gonophores a spherical acrocyst, in which the ova undergo further development previously to escaping as ciliated embryos.

The young gonophore has the form of a compressed cone attached by its narrow end to the branch, and with its free end wide and slightly concave. In this state it is merely an offset from the cœnosarc of the branch, hollowed out into a cavity, which is only an extension of the common cœnosarcal cavity, and having a delicate chitinous polypary moulded over its surface.

Plumularia falcata, Linn.

The gonophores in this species are of an oval form, with a tubular apical orifice, which is closed by an opercular fleshy plug.

They commence as a minute bud, which soon presents the form of a little inverted cone, having its axis traversed by a blastostyle, which dilates at the wide or distal extremity of the cone into a hollow opercular enlargement. From the blastostyle a single sporosac is produced as a lateral bud, which ultimately, by the arrest of that portion of the blastostyle between it and the operculum, acquires a terminal position, being now supported on the summit of a very short peduncle which springs from the base of the gonophore, and which is nothing more than the proximal extremity of the original blastostyle. From this point the sporosac extends towards the summit of the gonophore, which has acquired an oval form, and which at last it completely fills. From the cavity of the opercular body which closes the summit of the gonophore several more or less branched cœcal tubes are given off into the interior of the gonophore, where they may be seen running for some distance along the inner surface of its walls towards its attached extremity.

The generative elements are produced, as usual, between the ectoderm and endoderm of the manubrium of the sporosac; and by their increase of volume, and consequent pressure, occasion, at least in the female sporosacs, the gradual absorption of the spadix, which is ultimately represented by a small irregular tubercule in the bottom of the sac.

The germinal vesicle and spot are very distinct in the young ova, and the spermatozoa present the usual form of caudate corpuscles. The larva is a ciliated, leucophrydiform body.

Laomedea flexuosa, Hincks.

The usual conformation of the gonophores, and their contents, have been described in the former paper; but there still remains to be considered a remarkable modification of the reproductive system in this species.

We not unfrequently find, especially in specimens gathered late in the season, that on the summit of the capsule, and altogether external to its cavity, there are borne certain peculiar sporosacs, with a structure presenting some interesting points of difference from that of the ordinary or intra-capsular sporosacs.

It was to these extra-capsular sporosacs as occurring in *L. flexuosa*,* that Loven long ago called attention, when he supported and developed the doctrine just then announced by Ehrenberg, of the sexuality of polypes, a doctrine which, though in its mode of statement not absolutely correct, was nevertheless full of significance.

The extra-capsular sporosacs, with their investigating ectotheque, are attached by a short peduncle to the summit of the blastostyle, where the latter expands into a sort of operculum for the capsule. Two or three of them, in different stages of development, may generally be seen on a single capsule. They are nearly spherical bodies, and contain either a variable number of ova, or else a mass of spermatozoa, the generative elements in either case surrounding a central spadix. The ectotheque contains thread-cells, and there is developed from this membrane, upon the summit of the sporosac, a little crown of short cylindrical processes like rudimental tentacula. The whole body bears thus a resemblance, by no means remote, to a medusa with the opening of its umbrella contracted; but I could never find in it the four radiating canals described

* The species on which Loven's observations were made is named by him *Campanularia geniculata.* His figures, however, are undoubtedly those of *Laomedea flexuosa*, whose distinctness from *Campanularia* (or Laomedea) *geniculata* of Linnæus has been fully proved by Dr Johnston, and from *L. gelatinosa* of Pallas, with which Johnston confounded it, by Mr Hincks.

by Loven, nor any other representative of the gastrovascular system of a medusa. When the contents have attained a sufficient degree of maturity they escape, as has been already shown by Loven, through an aperture which makes its appearance in the centre of the tentacular crown.

If we follow the development of these extra-capsular sporosacs, we shall find, as Loven has already pointed out, that they are originally produced within the capsule. They are here undistinguishable from the ordinary intra-capsular sporosacs, and originate, exactly like the latter, as buds from the blastostyle. The blastostyle, however, instead of remaining stationary, as in the ordinary gonophores, grows upwards through the aperture of the capsule, carrying out with it the most mature sporosacs, or those which are formed nearest its summit, and which thus become extra-capsular, developing from their ectotheque, while in this situation, their little tentacular crown, and, after the discharge of their contents, withering away, to be replaced by others.

Notwithstanding the resemblance which the extra-capsular sporosacs, with their investing ectotheque, bear to a medusa, they will far more easily admit of a comparison with the ordinary intra-capsular sporosacs. Of the two membranes composing their walls, the internal is undoubtedly the endotheque, while the external is just as obviously an ectotheque, differing, however, from that of an ordinary sporosac, in its being provided, for the liberation of its contents, with a definite orifice surrounded by rudimental tentacles.

We have not here, more than in the intra-capsular sporosacs, any representative of an umbrella; and I confess myself quite unable to understand the radiating canals figured and described by Loven. If this excellent zoologist has not been deceived as to the existence of such canals, they will probably be identical with the cœcal processes from the spadix which I have already described as occurring in the sporosacs of several species of hydroid zoophytes.

Sertularia tamarisca, Linn.

Sertularia tamarisca, like most of the hydroid zoophytes, is strictly diœcious, but it further presents the remarkable character of having its male and female gonophores totally different from one another in form, an important fact as regards the zoographical characterization of the species.

The male gonophores appear to be those figured by Ellis in his description of this species. They are very much compressed, somewhat obcordate bodies, with a short tubular aperture.

The female gonophores are far less simple in form. They are oval for about the proximal half of their length, and then become trihedral, with the sides diverging as they pass upwards, while the whole is terminated by a three-sided pyramid. The sides of the pyramid are cut into two or three short teeth along their edges, and each of their basal angles is prolonged into a short spine.

The trihedral portion, with its pyramidal summit, is formed of three leaflets, which merely touch one another by their edges, without adhering, so that they may be easily separated by the needle. They consist of the same chitinous material as that which invests the rest of the gonophore, formed originally, doubtless, upon the surface of an ectodermal lamina.

The male gonophore is traversed by a blastostyle, which gives origin to one or more lateral sporosacs containing the spermatogenous tissue surrounding a large spadix from which no gastro-vascular cœca are developed. The spermatozoa are unusually large, and their body, instead of presenting the more common spherical or pyramidal form, is in the shape of an elongated cylinder, with the caudal filament projecting from one end.

On laying open the female gonophore, we find that the oval or proximal portion of it is occupied by a blastostyle, which gives origin to one or more sporosacs with well developed spadix, and entirely resembling the male sporosac, except in the nature of their contents, which are here ova instead of spermatozoa.

The oval portion of the gonophore terminates upwards by closing round the distal extremity of the blastostyle, which it here encircles with a ring furnished with tooth-like processes. This oval portion constitutes the *proper capsule* of the gonophore, and is the only portion developed in the male. From the summit of the blastostyle, and apparently communicating with its cavity, several irregularly-branched cœcal tubes are given off. They lie altogether external to the proper capsule, and embrace a delicate sac, within which are one or more ova in a more advanced stage of development than that presented by the ova which are still within the capsule. These extra-capsular ova are each enveloped in a special sac, very delicate and structureless, which is continued by a narrow neck towards the summit of the blastostyle, but I failed in my attempts to trace its connections beyond this point.

The extra-capsular ova, with their investing sacs, and the surrounding cœcal tubes, would thus lie entirely exposed, were it not that they are protected by the three leaflets already mentioned as constituting the trihedral portion of the gonophore. These leaflets are given off from the external surface of the oval portion, or proper capsule, near its summit, and, being in contact by their edges, completely enclose a space which is occupied by the structures just described.

Though I have not succeeded in discovering the exact connection between the common extra-capsular ovigerous sac and the structures in the interior of the capsule, nor the precise mode by which the ova gain access to it, I have no hesitation in viewing it as a true acrocyst in which the ova undergo a further development, previously to their liberation as free embryos.

In the following three species, the gonophores contained, in all the specimens I examined, *medusæ*, and never sporosacs. These medusæ have been more or less investigated by Van Beneden, Gegenbaur, Dalyell, Gosse, Hincks, Wright, and other observers; and I here give the results of my own independent examinations, as partly confirmatory of the observations of these naturalists, and as partly supplementary to them.

Eudendrium ramosum, Van Beneden.

I obtained this species in fine condition, attached to an old buoy in the harbour of Derryquin, on the Kenmare River, County Kerry, in September 1858.

The gonophores are *simple*, and are borne upon the ultimate ramuli, where they may be seen springing from the upper and lateral surfaces of the ramulus along its whole length. They are obovate, or fig-shaped bodies, each supported on a distinct peduncle, and invested by a delicate chitinous extension of the polypary.

When the gonophore reaches maturity, the ectotheque and its chitinous investment become ruptured at the summit, to allow of the escape of the medusa as an independent free-swimming zooid.

The medusa, on escaping, is provided with a deep umbrella, which measures about $\frac{1}{20}$th of an inch across its base, where it is furnished with a well-developed velum.

The manubrium is of moderate size. It is a sub-cylindrical body, somewhat dilated at its base, and having its oral extremity surrounded by four short tentacles. These manubrial tentacles have the cells of their endoderm so disposed as to give rise to the appearance of a transverse segmentation of their cavity, and the extremity of each is surrounded by a little capitate group of thread-cells. The cavity of the manubrium is lined with cells containing red granules.

From the base of the manubrium four gastrovascular canals radiate towards the margin of the umbrella, to open there into a distinct circular canal.

At each of the four points where the radiating canals open into the circular canal, is a large bulbous dilatation of the gastrovascular system. Its cavity contains red pigment granules, and while at its proximal side it is in communication with the radiating and circular canals, it sends off from its distal side two filiform contractile tentacula; the margin of the umbrella being thus furnished with eight tentacles, arranged in four equidistant groups of two each. At the root of every tentacle is a black "eye-speck." The velum is moderately developed.

From an ordinary-sized specimen of this eudendrium, kept alive in an 8 oz. phial of sea-water, the medusæ were thrown off in such multitudes as to give a milky cloudiness to the water. They continued active with me for more than a week; but during that time no further change of form occurred, and no generative elements were developed in them.*

If we endeavour to trace the development of the gonophore from its earliest appearance to the complete formation of the medusa, we shall find that it originates as a minute solid bud from the side of the branch. In this bud a cavity may be seen communicating with the cavity of the cœnosarc, from which it thus forms a simple *diverticulum*. We next find that the bud has become differentiated into a peripheral and a central portion, the latter containing the diverticulum from the cavity of the cœnosarc. A further differentiation is soon seen in the central portion, which is now manifestly composed of two layers,—an ectoderm and an endoderm,—while the peripheral portion becomes enveloped externally by a delicate chitinous investment. This peripheral portion is to become the ectotheque of the simple gonophore.

* Gegenbaur has already referred the medusal genus, *Bougainvillea*, to eudendrium as its "nurse" form; and it is evident that the little medusa here described needs only that the number of tentacles and ocelli composing each marginal group shall become multiplied, and the oral tentacles become bifurcated, in order that it may be converted into a true Bougainvillea. This change I have not witnessed, for my continued observation of the medusæ was here interrupted; but Dr Strethill Wright, who obtained the same species of eudendrium in the Firth of Forth, informs me that he has traced its medusæ into the adult Bougainvillea, with the generative elements developed in the base of the manubrium, as is well known to be their situation in this genus.

From the summit of the central portion, which will afterwards become elongated into the manubrium of the medusa, four thick cylindrical cœca may be now seen to be given off; their cavities are simple continuations of the diverticulum, and they extend, with their sides in close contact with one another, towards the distal extremity of the gonophore. They are at first mere tubercles, but they gradually increase in length, becoming developed quite in the same way as the tentacles on the ordinary alimentary polype. After they have attained a certain length, the gonophore continuing at the same time to grow larger, they become separated from one another laterally, and the intervening spaces are now seen to be occupied by a web-like membrane, which extends from the base of the cœca to within a short distance of their extremities, and here terminates by a defined margin.

This membrane is composed of transversely elongated cells, and is plainly a lateral extension of the ectoderm of the cœca. Close to its free margin a narrow tube may be seen extending transversely between the four cœca, connecting them together, and becoming more and more elongated as the cœca continue to separate from one another.

In the four cœca it is now easy to recognise the radiating canals of the gastrovascular system of the developing medusa, and in the transverse tube, the circular canal of this system, while the connecting membrane is plainly the rudimental umbrella.

The distal extremities of the cœcal tubes project slightly beyond the margin of the umbrella, and here become dilated into bulbous terminations, which converge towards the axis of the gonophore, where they lie in contact with one another, and soon become very conspicuous by the accumulation in them of red pigment. From each bulb two short tentacles may now be seen to sprout, and as these continue to grow longer, they may be seen hanging into the concavity of the umbrella, where they then lie somewhat confusedly within the confined space there allotted to them.

In the meantime, a velum has become developed from the margin of the umbrella, while the central portion of the gonophore containing the diverticulum from the cœnosarc has become elongated between the four radiating canals, and may be seen projecting in the axis of the umbrella, as a wide cœcal process, with distinct ectoderm and endoderm. It is easy to recognise in this process the manubrium of the medusa; an oral aperture soon becomes formed at its extremity, and the little medusa, now expanding the margin of its umbrella, and everting its tentacula, escapes from the confinement of the ectotheque, and enters upon the free phase of its existence.

Laomedea dichotoma, Linn.

Fine specimens of this zoophyte were obtained on the south coast of Ireland, in the beginning of September, loaded with gonophores, containing medusæ in various stages of maturity. The gonophores are compound, and consist of a blastostyle carrying numerous medusæ, which increase in maturity as they approach the summit of the blastostyle, the whole being invested in an external capsule.

The medusa, on its escape from the capsule, has a thin umbrella, which is capable of passing through almost every degree of convexity, from that of a nearly flat disc to that of a dome, embracing about ⅓d of a sphere, while it is often completely everted, so as to present the appearance of a wide hand-bell without the clapper, the manubrium then representing the handle of the bell. This last condition is that which it always assumes when swimming, the manubrium being then invariably turned *from* the direction of motion.

The base of the manubrium presents a hemispherical dilatation, and on its free extremity is borne a mouth with four well-developed lobes. Four radiating canals extend from the base of the manubrium to the margin of the umbrella, where they enter a distinct circular canal. The margin of the umbrella carries sixteen filiform tentacula,* one of these tentacula being always situated at each junction of a radiating canal with the circular canal. The tentacles are thickly set with thread-cells, and their cavity presents the septate appearance found generally in the group. Close to the base the ectoderm becomes thicker, and the cavity of the tentacle here loses the appearance of being transversely divided by septa.

At the inner side of the base of every second tentacle is situated a sessile "lithocyst;" and at the inner side of the base of *every* tentacle may be seen a transparent oval space, having the appearance of a vesicle. The lithocyst consists of a spherical capsule, with a spherical, highly refractile otolite. No pigment spots occur.

A narrow velum extends round the margin of the umbrella.

Exactly in the middle, between each pair of radiating canals, may often be witnessed an appearance like a bundle of delicate fibres, extending from the base of the manubrium to the marginal canal, where it loses itself, by appearing to break up into its component fibres. I believe this appearance is due to mere folds in the inner surface of the umbrella.†

Towards the end of October I again visited the locality where I had previously obtained the Laomedea in great abundance and perfection, but found nothing but dead specimens, from which the gonophores had all fallen.

Campanularia Johnstoni, Alder.

This species was dredged in September, loaded with gonophores, whose contents were in every instance medusæ.

The gonophores may be described as cask-shaped, or of the form of a regular oval, truncated at both extremities. They are corrugated transversely, so as to present a series of regular rings. They are situated on the creeping stolon of the zoophyte, to which they are attached by a short peduncle. They consist of a blastostyle, with medusal buds and investing capsule, and never carry sporosacs.

The medusa, on escaping from the gonophore, has a diameter of about $\frac{1}{180}$ of an inch. The umbrella is very convex, embracing about two-thirds of a sphere. From the base of the manubrium four radiating canals extend to the margin of the umbrella, to unite with the circular canal, and at each point of union arises a tentacle. The tentacle com-

* Eighteen may frequently be counted, but this is probably abnormal.

† The medusa of *Laomedea dichotoma*, as here described, is probably only the young state of Gegenbaur's *Eucope polystyla* (Zeit. f. Wiss. Zool. Band. 8), a species which this naturalist informs us he has traced to the gonophores of one of the Campanularidæ.

mences with a wide base, which passes rather abruptly into a very extensile filament, which in its completely contracted state I have always found coiled into a regular spiral. The base of the tentacle presents a large cavity, which communicates freely with the marginal canal of the umbrella.

Between each of the four tentacles are two lythocysts. They consist each of a spherical transparent colourless vesicle, containing a spherical highly refractile otolite, which is itself immediately invested by a very delicate vesicle, of which it looks like the nucleus. Between each lythocyst the margin of the umbrella is extended into a slight projection, having all the characters of a rudimental tentacle.

There is a very wide velum, and in both it and the umbrella muscular bundles are largely developed.

In no instance were generative sacs developed in the specimens which came under my examination. Gegenbaur, however, has found them well developed on the course of the radiating canals in certain species of his genus *Eucope*, a genus to which he would refer all such forms as those here described in *Laomedea dichotoma*, and *Campanularia Johnstoni*, and which, he tells us, he has traced to gemmation from the Campanularidæ. In the undoubted medusæ of *Campanularia Johnstoni*, they have been seen in a similar situation, but not fully determined, by Mr Gosse; while the detection in them of distinctly formed ova by Mr Hincks, and more especially by Dr T. S. Wright, who has figured and described them, has so far completed the observations needed on this point.

General Conclusions.

To the general conclusions contained in the previous paper, the following generalizations may now be added.

Besides the ordinary development of the ova in intra-capsular sporosacs, we find—

1. That in certain species bearing capsular gonophores (*Sertularia polyzonias*, &c.), the ova, after attaining in the interior of the capsule a definite stage of development, are transmitted into an extra-capsular sac (*acrocyst*), where they undergo a further development previously to their liberation as free embryos, and that this sac is formed (at least in the species where its connections were most satisfactorily traced) by a hernial protrusion of the endotheque (and ectotheque?) of an intra-capsular sporosac through the summit of the capsule.

2. That in certain other species (*Campanularia flexuosa*, &c.) the final development of the ovum, previously to liberation, takes place in a peculiarly formed medusa-like *extra-capsular sporosac*, which, however, must not be confounded with a true medusal zooid. It originates as an ordinary intra-capsular sporosac, and subsequently becomes extra-capsular by the elongation of the blastostyle.

The most important steps in the development of the true medusal buds are the following:—

(1.) The formation of a hollow process from the cœnosarc or blastostyle. (2.) The differentiation in this process, of a peripheral portion (ectotheque), and a central portion (manubrium); the latter becoming further differentiated into two layers, ectoderm and endoderm. (3.) The emission from the hollow central portion of four cœcal tubes (radiating canals), composed of ectoderm and endoderm, which, simultaneously with their elongation, have their ectodermal layer expanded into a web-like membrane (umbrella), connecting the tubes laterally with one another. (4.) The further connection of the radiating tubes with one another by lateral branches (circular canal), and the development of a velum from the margin of the umbrella.

From the above processes, it follows that the development of the medusa admits of an easy comparison with that of the alimentary polype, the radiating canals being developed from the central manubrium in the medusa, exactly as the tentacula are from the body of the polype; but that, while in the polype they continue free, in the medusa they are united laterally by an extension of the ectoderm and by lateral branches.*

A comparison of the two kinds of reproductive zooids (sporosacs and medusa) and of the alimentary (zooid) polype, results in the following parallelism :—

SCHEME OF HOMOLOGOUS PARTS.

MEDUSA.	SPOROSAC.	POLYPE.
Ectotheque,	Ectotheque,	0
Manubrium,	Endotheque + Spadix	Body of Polype.
Ectoderm† of Manubrium confining the generative elements (Medusa of *Tubularidæ*),	Endotheque,	Ectoderm of Body.
Generative Elements [in walls of Manubrium (Medusa of *Tubularidæ*); in walls of radiating canals (Medusa of *Campanularidæ*)],‡	Generative Elements,	0
Endoderm of Manubrium surrounded by the generative elements (Medusa of *Tubularidæ*),	Spadix,	Endoderm of Body.
Umbrella,	0	0
Radiating canals,	Cœcal processes from Spadix,	Tentacles (posterior tentacles in Tubularia).
Circular canal,	0	0
Marginal tentacles,	0	0
Velum,	0	0
Mouth,	0	Mouth.
Oral tentacles,	0	Oral tentacles (Tubularia).

Cœnosarc.

* In the remarkable species *Laomedea acuminata* (Alder) the tentacles of the polype are actually united, as Mr Alder has shown, for a considerable distance from their origin, by an intervening membrane.

† Professor Huxley's important demonstration of the composition of the proper radiata out of two membranes, must be carefully borne in mind in all our attempts to establish relations of homology in this group.

‡ It is highly probable that the medusæ, whenever produced among the

Monday, 20th December 1858.—Professor CHRISTISON in the Chair.

The following communications were read:—

1. *On the First Properties of Matter—Inertia, Gravitation, Elasticity —referred to a common Law.* By JOHN G. MACVICAR, D.D.

2. *On the Structure and Functions of the Branchial Sac of the Simple Ascidiæ.* By ANDREW MURRAY, Esq.

The chief portion of this paper is occupied with an inquiry into the truth of Milne Edwards' theory, that the branchial sac of the Ascidians is perforated throughout by apertures, or what he called branchial stigmata.

Some experiments and observations made by Mr Murray last season has induced him to regard this view with doubt. In considering the question, he first examined the evidence that was recorded in support of it. Putting aside those writers who had taken M. Edwards' theory on trust, he could only find four observers who seem to have critically tested it, viz.,—Dr Lister, with whom the idea originated: who, while stating that the walls of the sac appeared to be traversed by open spaces, yet states that at times he thought he saw something like a veil stretching across them, and that the particles in suspension in the water were observed to course past these spaces without entering; which would appear to be inconsistent with the idea of the water entering, for the course of the water, and of the particles floating in it, must necessarily be the same. The next author was Milne Edwards, who announced the open passages as a fact, without going into any reasoning or proof upon it. He however started with a bias; for he alludes at the outset to Dr Lister having established the fact, which, it will be observed, is stating the results of his observations much too strongly. M. Coste followed, and took the directly opposed view, holding that the branchial spaces were all closed by a more or less diaphanous membrane. Van Beneden seems to have halted between the two opinions. But Huxley, the last and most formidable of them all, takes Edwards' idea up *in toto*, and has informed Mr Murray, that he thinks he has seen the currents of water passing through the stigmata in at least two *Ascidiæ*, viz., *Perophora*, and *Appendicularia*.

Mr Murray's observations consisted in feeding the Ascidiæ with coloured sea-water, in injecting them, and in actual examination of their structure. In those fed with indigo, the coloured material was never found on the exterior of the sac, but always deposited on its inner wall. Injection by the mouth into the sac failed to push the injection through its walls except by rupturing them. Mr Murray thought that, under a high power of the microscope, a diaphanous membrane was to be seen

Tubularidæ, will be found to have their generative elements formed between the endoderm and ectoderm of the manubrium; while, on the other hand, in the medusæ of the Campanularidæ and Sertularidæ the generative elements will originate in the walls of the radiating canals, here also between endoderm and ectoderm. In the former, therefore, the medusæ would approach the type of *Sarsia*, in the latter that of *Thaumantias*, or more exactly that of *Eucope*, Gegenb. Perhaps, however, until a greater number of instances are accumulated, it would be hardly safe to insist on the validity of this generalization.

stretching across the branchial stigmata; but if so, the membrane was so thin as to be scarcely perceptible.

According to Mr Murray, the mode in which the water which enters at the oral aperture passes to the anal aperture would therefore appear to be still to seek.

Mr Murray narrated, also, his dissections of the ciliated sac or valvular aperture which lies at the top of the dorsal fold, which at one time he had been disposed to think (with the elder Carus) might furnish a mode of egress, but satisfied himself that it was rather a blind sac, or at least a sac terminating in a very small blood-vessel.

In the course of his investigations Mr Murray made the curious discovery, that in *Phallusia Virginea* the chylaqueous fluid is strongly acid. He had not found this quality in any other species which he had yet examined, but he thought it probable it might be found in *P. Mentula, P. oblonga,* and those other species which are allied to *P. Virginea.*

Another observation made by Mr Murray in relation to this matter, and one which promises to furnish interesting results was, that in none of the mollusca (and indeed in none of the invertebrate animals) on which his experiments had been made, was the food digested by gastric acid. He had never found acid in the stomach. The mode of digestion in the invertebrata would appear therefore to be probably conducted on a different system from that in the vertebrata.

Incidentally Mr Murray alluded to the Notodelphs and small crustacea found in the stomachs of Ascidiæ. He differed from those authors who thought them parasitic, as he had found many dead, and in all stages of apparent digestion, in the respiratory sac of *Phallusia Virginea.*

With regard to the homology of the parts in question, he pointed out that the facts he had brought forward all tended to show that the sac is homological with the pharynx rather than with the tentacular crown of the Polyzoa.

Royal Physical Society.

Wednesday, 24th November 1858.—Professor Balfour, President, in the Chair.

Professor Balfour gave an opening address.

The following communications were read :—

1. *On New Protozoa.*—(1.) Lagotia producta. (2.) Zooteirea religata. (3.) Corethria Sertulariæ. (4.) *On* Stentor Mulleri *and* Stentor castaneus. By T. Strethill Wright, M.D.

2. *Observations on British Zoophytes.*—(1.) *On the Reproduction of* Turris neglecta. (2.) *On the Development of* Hippocrene (Bougainvillea) Britannica (?) *from* Atractylis (Eudendrium) ramosa. (3.) *On the Development of* Hydra Tuba (Strobila) *from* Chrysaora. By T. Strethill Wright, M.D.

(These papers will probably appear in a future number of this Journal.)

2. (1.) Dr John Alexander Smith *exhibited specimens of the Lantern Fly of British Honduras, the* Fulgora laternaria, Linn.

(2.) Dr Smith exhibited a specimen of a *fossil plant from the Upper Old Red Sandstone of Roxburghshire;* which is found in the Denholm Hill quarry, in the white rock of its upper beds. The plant was apparently a *Fucus* or sea-weed. Dr Smith also exhibited another *fossil* from the same *Upper Old Red,* in this instance of Berwickshire; it was found in a red sandstone quarry, opened on the side of the Black Hill, at Earlston, and was the only specimen of a fossil, as far as he could learn, that had ever been discovered there. He sent it to Mr Hugh Miller a few months before his death, and received in reply the following:—"Your fossil is the Old Red *Ctenodus* of Agassiz (his Coal Measure *Ctenodus* belongs to a different genus); but though he gives *it* (his Old Red *Ctenodus*) a generic standing of its own, it is in reality a portion of the previously described Dipterian genus. The *Dipterus* had two triangularly arranged groups of teeth on its palate, and your specimen is a remarkably distinct impression made by one of these. I could show you groups of teeth, were you to do me the pleasure of looking in upon me here, that would fit into your impression well nigh as exactly as a seal would into the wax which it had stamped. Your specimen is the second of *Dipterus* which I have seen from the *Upper* Old Red Sandstone. The first,—a gill cover,—is in the collection of Mr Patrick Duff of Elgin."

3. *Contributions to the Natural History of the Hudson's Bay Company's Territories. Part II.—(Mammalia continued).* By Andrew Murray, Esq.

(This communication appears in the present number of this Journal.)

Wednesday, 22d December 1858.—William Rhind, Esq., President, in the Chair.

Mr Rhind exhibited a specimen of black shale, displaying a branch of *Lepidodendron* several inches in length, with the *Lepidostrobus* attached to its extremity, which was found by Mr R. H. Traquair, in the beginning of August last, in a stratum of very fissile black shale exposed in the bed of the Water of Leith, a little below the church at Colinton.

The following communications were then read:—

1. *On the* Cnidæ *or Thread-cells of the* Eolidæ. By T. Strethill Wright, M.D.

Dr Wright, after describing the anatomy of the respiratory, digestive, and hepatic organs in the Eolidæ, stated that, in his Memoir on *Hydractinia echinata,* read before the Society, November 26, 1856, he had observed, "Hydractinia is infested by a small species of Eolis (*Eolis nana*), which peels off the polypary with its rasp-like tongue, and devours it,—possessed, I suppose, of some potent magic, which renders all the formidable armament of its prey of no avail. Now, each of the dorsal papillæ of the Eolidæ contains at its extremity a small ovate vesicle, communicating, through the biliary sac, with the digestive system, and opening externally by a minute aperture at the end of the papillæ. This vesicle is found crowded with compact masses of thread-cells; which masses, in *Eolis nana*, consist of aggregations of small and large thread-cells, identical in size and shape with those of Hydractinia,—on which this Eolis preys,—not contained in capsules, but cemented together by mucus. When we consider that each of the vesicles is in indirect communication with the stomach, I think we may, without presumption, suggest that the masses of thread-cells found in *Eolis nana* are *quasi* fæcal collections of the thread-cells of Hydractinia, which, protected by their strong coats, have escaped the digestive process. In corroboration of this view, I may mention that the thread-cells of *Eolis papillosa*, as figured in the work of Alder and Hancock, have a perfect resemblance to those found in the Actinias, which last animals furnish an Abyssinian repast to these carnivorous mollusca." Dr Wright afterwards found that, as to the above idea, he had been anticipated by his friend Mr Gosse, who, in his "Tenby," after noticing the existence of the thread-cells in the papillæ, remarks:—"The inquiry I suggest would be, How far the presence of thread-cells might be connected with the diet of the mollusc? And whether, seeing the forms of the missile threads vary in different genera of zoophytes, the forms of the corresponding organs in the papillæ of the Eolides would vary if the latter were fed exclusively first on one and then on another genus of the former." He afterwards found that Mr Huxley had also doubted, previously to Mr Gosse and himself, whether the thread-cells of the Eolidæ were not adventitious. Here were three independent observers to whom the idea has suggested itself; Mr Huxley had first hinted it; Mr Gosse suggested it, and how it might be found to be true; Dr Strethill Wright also had suggested it, and given two instances in corroboration of his opinion, and to-night he proceeded to detail observations which would, he hoped, entitle it to be enrolled as a proved fact in the records of science. 1*st*, A specimen of *Eolis nana* was brought home from Morison's Haven, on a shell covered with Hydractinia, taken from a rock-pool, in which was a profuse growth of *Campanularia Johnstonii.* The papillæ of this Eolis contained the two kinds of thread-cells which are found on Hydractinia, together with the large threadcells which occur within the reproductive capsules of *C. Johnstonii.* 2*d*, An *Eolis coronata* was taken at Queensferry, on a massive specimen of *Coryne decipiens*, which was very abundant there. The thread-cells of *C. decipiens* were very distinctive, being very large, oval, and containing a four-barbed dart. The thread-cells of the Eolis and Coryne were carefully compared together, and were found to be identical. 3*d*, Dr M'Bain and Dr Wright found an *Eolis Drummondii* on a fine specimen of *Tubularia indivisa.* They first carefully examined the thread-cells of the Tubularia, and found four kinds, two (large and small) of a nearly globular shape, each containing a four-barbed dart, and two (large and small) of an almond shape, the larger one containing a thread, furnished with a lengthened brush of recurved barbs. They then examined the papillæ of the Eolis, and found the ovate sacs filled with an indiscriminate mixture of all the four kinds of thread-cells found on *Tubularia indivisa.* 4*th*, Dr M'Bain and Dr Wright found a specimen of *Eolis Landsburgii* on *Eudendrium rameum. Eudendrium rameum* was furnished, as to the bodies of its polyps, with very large bean-shaped thread-cells, in which an unbarbed style could be detected, while the tentacles of the polyps are covered with exceedingly minute cells. They compared the thread-cells of the Eudendrum with those found in the sac of Eolis, and found both kinds identical. *Lastly*, Dr Wright had kept the specimen of *Eolis Drummondii* above-mentioned, fasting for a long time, and then introduced it to a large specimen of *Coryne decipiens* fresh from the sea. The next morning every polyp of the zoophyte had vanished, and the ovate sacs of the Eolis were packed with the distinctive thread-cells of the Coryne, mixed with a few thread-cells of *T. indivisa*, the remains of its former feast. He also found the thread-cells of *C. decipiens* in the alimentary canal. It was at one time supposed that thread-cells, or Cnidæ, as Mr Gosse had named them, were only to be found in the hydroid and helianthoid polyps and the Medusæ; Professor Allman afterwards discovered them in a species of Loxodes, a protozoan animalcule; and Dr Wright had the good fortune to find them on the tentacles of an annelid, *Spio seticornis*, and also on the tentacles of Cydippe, one of the Ctenophora. Since then he had observed them on the very minute tentacles of Alcinöe, another of the Ctenophora. In all these classes of animals thread-cells were developed within the ectoderm or skin of the animal, and in many, such as in *T. indivisa*, each within a distinct and very apparent sac, and not in connection with the digestive system. The type of structure, moreover, of the thread-cell in the Protozoon, the Polype-medusa, the Annelid, and the Ctenophore, was essentially different for each class; and this fact alone would lead one to doubt as to the origin of the thread-cells of Eolis, which so exactly resembled those of the polype-medusæ in their structure. Nevertheless, it was certainly a very strange fact, for a fact the author firmly believed it to be, that one animal should be furnished with apparatus for storing up and voluntarily ejecting organic bodies derived from the tissues of another animal devoured by it, and that these should still retain their distinctive functions unimpaired; and he stated that his friend Mr Alder, one of the highest authorities on the Nudibranchs, still hesitated to assent to the doctrine sought to be proved by the present communication, on the ground of its extreme improbability.

2. *Notes on a Skull of the* Troglodytes niger (*Desm.*), *the Chimpanzee of Africa, from Old Calabar.* By JOHN ALEX. SMITH, M.D.

This skull was sent home by Mr Archibald Hewan, the Mission surgeon at Old Calabar, who took it from an old devil-house at the Guinea Company's villages, some hundred miles or so up the country from the mouth of the Old Calabar River. It is the skull of an adult chimpanzee, indicated by its general appearance, the partially obliterated sutures, and the full complement of teeth well ground down on their summits. These teeth are similar in number to those of man. The skull measures 19 inches in circumference in the line of the alveolar processes of the incisor teeth in front, and the occipital protuberance behind, and rather more than 7 inches in length between the same points in a straight line. The skull of an adult male is described as measuring $8\frac{1}{2}$ inches in length; this is probably, therefore, the skull of an old female,—the muscular ridges not being very strongly marked; the *diastema* or space between the incisor teeth and the canines is very slightly developed, measuring little more than 1-10th of an inch. The characteristic high superciliary ridge of the chimpanzee is very prominent; it shows at a glance the vague character of any deductions as to the amount of brain, to be drawn from the extent of what is called the facial angle in a cranium such as this. This formidable animal stands some 3 feet 10 inches high, the male reaching the height of 4 feet from the top of the head to the sole of the heel in a straight line. The chimpanzee is found in various parts of the western coast of tropical Africa, in the Guinea coast, and coast of Angola, and also between these distant places, as in this instance, on the Calabar River, showing a pretty extensive range.

4. *Notice of a Hybrid between the Capercailzie and Blackcock.* By Dr J. A. Smith.

This bird (the *Tetrao medius* of some authors) was got about the end of November, by Major J. W. Wedderburn, near Loyal House, Alyth, Perthshire. The bird is a male; it is intermediate in size between the capercailzie and the black grouse, measuring 28½ inches in length, and weighed 5 lbs. 10 oz. The general appearance of the plumage is darker than the capercailzie; the bill is black, like the black grouse; the neck and head, which shows the bearded throat of the capercailzie, is of dark colour, with rich reddish purple reflections, especially brilliant on the breast; there are a few white feathers on the lower part of the breast and abdomen, as in the capercailzie, and the tail has the lateral feathers the longest, as in the blackcock,—the external of these being slightly curved outwards. The stomach was filled with buds of heather, and not of the pine, which is the favourite food of the capercailzie.

Dr Smith also exhibited specimens of *Lanius excubitor*, killed near Dunbar; of *Querquedula caudacuta*, shot near Kirkcaldy; of *Buteo lagopus*, shot at Stobo, Peeblesshire.

5. *Notice of a large Pike, in whose stomach a Water Hen and Water Ouzel were found.* By Mr Archibald Stirling.

Wednesday, 26th January 1859.—T. Strethill Wright, M.D., President, in the Chair. The following Communications were read:—

1. *Contributions to the Natural History of the Hudson's Bay Company's Territories* (Mammalia)—Part III. *Sorex, Arvicola.* Aves.—Part I. By Andrew Murray, Esq.

(This paper appears in the present number of the Journal.)

2. *Observations on some of the Birds received from the Hudson's Bay Company's Territories.* By Sir William Jardine, Bart.

3. *Notices of the Hen Pheasant assuming Male Plumage; with an Examination of the Ovaries.* By J. A. Smith, M.D.

Two specimens exhibited the characteristic male plumage, and their ovaries showed the atrophied state which is its common accompaniment. Another specimen of the Bohemian, or light coloured variety of pheasant, with male plumage, had however the ovaries perfectly healthy, showing numerous ova, some nearly as large as peas; it was killed in the beginning of April, and it would be of some interest if the period of the year was stated, when birds of this kind were examined. This bird had also red warty cheeks, resembling those of the male; but, like all the others, wanted the spurs, and had the slender legs of the female.

4. *Observations on British Zoophytes:*—(1.) Coryne margarica (*new species*). (2.) Bimeria vestita (*new genus and species*). (3.) Garveia nutans (*new genus and species*). By T. STRETHILL WRIGHT, M.D.

(This paper will appear in a future number of the Journal.)

5. *On Peculiar Forms of Spines on two Species of Star-Fishes* (Gen. Ophiocoma). By CHARLES W. PEACH, Esq., Wick.

During my residence at Peterhead, I met with a very delicate Ophiocoma,—probably *O. neglecta,*—which I was very desirous of naming; for this purpose I placed it alive in sea-water under the microscope, and found that one of the spines had a notch of some width running down the whole length of it; this, I thought, had been caused by accident. On farther examination, I found that each lower spine had a similar opening;—the edges of the openings serrated, the whole covered with short pointed protuberances. I also saw the pinnated cirrhus protruded. Not finding this notch mentioned by Forbes, or any other writer on star-fishes, I have been led to examine others, and have been rewarded by finding on the brittle star, *Ophiocoma rosula* of Forbes, in addition to the " beautiful long tapering rough spine," which, he said, " might serve as a model for the spire of a cathedral," on the under side of each row *a jaw-like hooked one* furnished with teeth; they are transparent, and formed of the same material as the other spines. These jaw-like spines extend the whole length of the rays, and are arranged with the spines and cirrhi. Two of the straight spines of each group have also hooks on their tips, directed, as are the teeth of the jaw-like ones, towards the disc. I have seen these jaw-like spines on specimens *in all stages of growth,* some not one-fourth of an inch over. When describing *Ophiocoma Goodsiri,* Forbes mentions " difficulties connected with the tracing of the connection between species and species;" and though he found in *O. Goodsiri* " a beautiful link between the scaly and plated brittle stars," he farther says, " before I saw this species I had some doubts as to the propriety of retaining these two variations of character in the one genus, and suspected that *Ophiocoma rosula* might be the type of a separate group." Had he seen these jaw-like spines, he would, I think, have separated it, especially as at page 20 he farther says,—" the sources of specific character are derived from the spines of the body and arms." In his work the only hooked spines mentioned are those found on *Comatula rosacea,* and the pick-like one on *Ophiocoma filiformis.* Dr Carpenter, in his work, " The Microscope and its Revelations," at page 559, gives a sketch of the hooked spine of the Euryale; and now, in all probability, the true connection between it and *Ophiocoma rosula* will be better seen. These observations were made on specimens found at Peterhead and Wick, N.B. I have since had *Ophiocoma rosula* from Mr King of Torquay, Devonshire. Dr Dickie of Belfast has also kindly sent it from Ireland. *All show the hooked spine,* and other characters, as those from Scotland. Dr Dickie added to his kindness by forwarding part of an arm, marked

Ophiocoma minuta, by the late Mr Thompson, and which formed part of that lamented gentleman's collections, and on this I find similar hooked spines of both sorts; and if this (*O. minuta*) is a good species, I have several specimens from Peterhead and Wick, and thus have another addition to our list. Should *Ophiocoma rosula* be found without these jaw-like spines, the one now described will be, if nothing else, a new species.

6. *Notice of the Ukpam, a large species (probably new) of Sting Ray* (Trygon, Cuv.), *found in the Old Calabar River, Africa.* (Two young specimens were exhibited). By JOHN ALEXANDER SMITH, M.D.

Dr J. A. SMITH exhibited a specimen of the *Passer montanus*, the tree sparrow, shot near Dunbar.

Botanical Society of Edinburgh.

Thursday, 11*th November* 1858.—Dr SELLER, President, in the Chair.

Dr Seller delivered an opening address.

The following communications were read:—

1. *On the Pauchontee, or Indian Gutta Tree of the Western Coast, Madras Presidency.* Transmitted by Dr HUGH CLEGHORN, Conservator of Forests, Madras.

This tree, which is interesting in an economical point of view, is common in the densely crowded tracts of Coorg, the eastern part of Wynaad, Anamally mountains, and Cochin territories, from lat. 8 deg. 30 min. to lat. 10 deg. 30 min., and at an elevation of 2500 feet to 3000 feet above the level of the sea. It attains a height of 80 to 100 feet, and a diameter of 2 to 4 feet, and it rises up to a great height without giving off any branches. It is the Pauley tree of Wynaad, and the Pauchontee tree of Cochin; it belongs to the natural order Satapoceæ, and has a close affinity to the gutta-percha tree of the Malayan peninsula. It yields a milky juice which concretes, and is brittle at an ordinary temperature. It softens by the heat of the hand and mouth, and may be moulded between the fingers. It readily melts by the application of heat, and becomes very sticky. This stickiness is gradually destroyed by contact with water. It forms a paste with coal-tar, naphtha, and oil of turpentine. The substance has excellent insulating powers, and may be used successfully for coating the wires of telegraphs. It is probable that at present several thousands of these trees fall annually under the axe of the wood-cutter, as the government forests in Wynaad give way to the extension of coffee planting, and the private forests in Malabar to raggee cultivation.

2. *Notes on the Vegetable Oils of the Madras Presidency.* By Lieut. HAWKES. Communicated by Dr CLEGHORN.

Although the number of oil-producing plants in Southern India is very large, yet it will be found that of them but few are cultivated to any great extent, the large proportion consisting of trees, shrubs, or herbs growing in a wild state, the fruits of which are gathered by the poorer classes, and the oil pressed as necessity requires. The oils are classed under the following heads:—1. Oils procured from plants which are cultivated for the sake of their products, such as Coco-nut oil (*Cocos nucifera*), Gingely oil (*Sesamum orientale*), Castor oil, often called lamp oil (*Ricinus communis*), Ground-nut or Manilla-nut oil (*Arachis hypogæa*), Linseed oil (*Linum usitatissimum*), Ramtil oil (*Guizotia oleifera*), Mustard oil, much used for anointing the body (species of *Sinapis*) Poppy oil (*Papaver somniferum*). 2 Oils procured from plants which grow spontaneously, and are found in sufficient quantities to admit of the produce becoming an article of inland trade:—Such as Margosa or Neem-oil (*Azadirachta indica* and *Melia Azedarach*), Solid Bassia oil, used for candles and for butter (*Bassia longifolia* and *butyracea*), Pinacotay oil (*Calophyllum inophyllum*), Kurinj oil (*Dalbergia arborea*), Coorookoo oil (*Argemone Mexicana*), Cat-amunak oil (*Jatropha Curcas*), Piney tallow (*Vateria indica*), and Gamboge oil (*Garcinia pictoria*). 3. Oils procured from plants which grow spontaneously, but to a limited extent, in many parts of the country. These oils are sometimes extracted by the poorer classes for home consumption:—Safflower oil (*Carthamus tinctorius*), Belgaum walnut oil (*Alcurites triloba*), Poorana oil (*Sarcostigma Kleinii*), Jungle almond oil (*Hydnocarpus inebrians*), Addale oil (*Jatropha glauca*), Cress oil (*Lepidium sativum*), Cucumber, Melon, and Gourd oil (species of *Cucumis* and *Cucurbita*), Coorgapilly oil (*Inga dulcis*), a common hedge plant. 4. Oils procured in small quantities from plants, and used chiefly for medicinal purposes, and for perfumery, such as Soap-nut oil (*Sapindus emarginatus*), Cashew oil (*Anacardium occidentale*), Cotton oil (species of *Gossypium* and *Bombax*), Croton oil (*Croton Tiglium*), Bryony oil (species of *Bryonia*), Colocynth oil (*Citrullus Colocynthis*), Fenugreek oil (*Trigonella Fœnum Græcum*), and others. Mr Hawkes then referred to the use of fats and oils in currying and buffing leather, in burning in lamps, in lubricating, in preparing woollen cloths, in paints and varnishes, in the manufacture of candles and soap, and as articles of food.

3. *Mascological Excursions to Ramsheugh and Glenfarg, Ochil Hills, Perthshire, and Habbie's How, Pentland Hills, in September* 1858. By Mr JOHN SADLER.

4. *On a mode of Protecting Timber from Fire.* By F. A. ABEL, Esq. Communicated by Dr CLEGHORN.

After mentioning various methods which have been adopted to render wood less combustible, by saturating it with solutions of phosphate of soda, and muriate or sulphate of alumina and chloride of calcium, the author remarks that all that can be reasonably expected from the most efficient protective coating or impregnating material is—1. That it should considerably retard the ignition of wood exposed for some length of time to the effects of a high temperature, or of burning matter in its immediate vicinity. 2. That if the vapours which the wood emits by continued exposure to heat become ignited, the flames thus produced shall not readily affect the fibre of the wood, and shall cease almost directly on the removal of the wood from the source of heat. 3. That the prepared surfaces of wood when in actual contact with burning unprepared wood shall have little tendency to ignite, and thus cause the fire to spread. The plan proposed is to impregnate wood with silicate of soda, and to coat its surface with a silicate. The impregnating of the wood is effected by putting it in a solution of the silicate. The surface of the wood is then washed over with a somewhat diluted solution of the silicate of soda. After an interval of at least two hours, a coating of thick lime wash is applied over the silicate; and finally, on the following day, a strong solution of the silicate is applied over all. In this way a protective covering is given to the wood. The process may be used with benefit in the case of timber employed for wooden huts.

5. *Observations on Vegetable Morphology.*—By J. M. Norman, M.D., Christiana.

Mr M'Nab exhibited Forked and other varieties of *Blechnum boreale* from Glenalmond, and of *Pteris aquilina* and *Athyrium Filix Fœmina*, from Mr Jackson of Barnstaple. Mr M'Nab also exhibited specimens of *Ceterach Officinarum*, gathered by himself on an old wall near Renton, Berwickshire.

Thursday, 9th December 1858,—Andrew Murray, Esq., F.R.S.E., in the Chair.

The following Communications were read:—

1. Professor Balfour read the following notice from Mr Gair relative to the cones of *Cupressus Lambertiana*, from a plant grown at the Kilns, near Falkirk; "The plant from which these cones are taken is of the hardy spreading variety of the species known as *C. Lambertiana*. It is only about eight and a-half feet high, and seven and a-half feet through at the widest part, and the stem near the ground is about one foot in circumference. It was got from Messrs Lawson's nurseries in the spring of 1853, then a small plant about eighteen or twenty inches high, and raised from a cutting. It was grown here for two years, in a very exposed situation, and was then transplanted to the place where it still grows, which is not quite so much exposed, but still open. The soil is rather poor, with a gravelly subsoil. The plant has always been healthy, but more stunted in its growth than others of the same variety grown here, probably from its being a poorer soil, and it has a closer and denser appearance than most of those varieties which have the spreading habit. The foliage is of a rich deep green. The plant has never been injured by frost, while others of the same spreading habit, got at the same time, have been severely injured here; and many of the upright growing species, generally known as *C. macrocarpa*, have been completely killed by frost and exposure. The plant stands fully exposed to the south. There are twenty-three cones upon it, and it is remarkable that they are all on

the northern side of the tree, and generally on that part of the tree which is between two or three feet from the ground. There are two clusters of four cones, one cluster of three, two clusters of two, and the rest are single cones. They are all towards the extremity of the branches, as in the specimen sent."

2. Mr Robertson of Golden Acres Nursery sent a dried specimen of *Œnothera tetraptera*, grown from seeds fifty years old, which had been enclosed in gum. The seeds had been received from Mr J. E. Hussey Taylor, with the following letter:—"Thinking that it may be interesting to you physiologically to endeavour to bring about the germination of some seeds preserved in gum fifty years ago, I send you in their envelopes, just as I found them, some packets I have come across while looking over the papers of Mr Hussey Delavel, a man once well known in science. I believe he received them from Sir Joseph Banks. I myself never before heard of gum being used for this purpose, and it is certainly putting the experiment to the most severe test now, after so great a lapse of time. Should you think it worth your while to attempt their growth, perhaps you will some time or other let me know should you be successful." Mr Robertson says—"The seeds were soaked in cold water about twenty hours before they were sown, and they were afterwards placed in heat until they grew. The gum above referred to contained seeds of poppies, lentils, acacias, mesembryanthemums and convolvulus, but none of the sorts grew except the *Œnothera tetraptera*, which seems to come up very freely. I think that nearly every seed which was sown germinated."

3. *Account of an Excursion to Switzerland with Pupils.* By Professor Balfour.

The botanical party consisted of Messrs Balfour, Barclay, Bell, Buchan, Dubuc, Fayrer, Fraser, A. Graham, P. Graham, Hill, Johnston, Jones, Logan, D. and R. Maclagan, Maverick, Meintjes, Radford, Ramsbotham, Rodger, Sconce, Soper, Turnbull, Williamson. They went by steam from Leith to Rotterdam; thence they proceeded to Utrecht, Cologne, up the Rhine to Castel, Mayence, Frankfort, Heidelberg, Basle, Berne, Thun, Interlacken, Brienz, Giessbach, Meyringen, Grimsel, Brieg, Visp, Zermatt, Riffel, Sion, Martigny, and Geneva. They were absent from Edinburgh twenty-six days. The chief botanical ground which they examined was at the Grimsel and Zermatt, where they made a large collection of Alpine plants. Among them may be mentioned species of Ranunculus, Arabis, and Cardamine, Viola, Arenaria, Gypsophila, and Silene, Astragalus, and Oxytropis, Potentilla, Epilobium, Sedum and Crassula, Saxifraga, Achillæa, Gnaphalium, Arniea, Artemisia, Aster, Erigeron, Chrysanthemum, Hieracium, Senecio, Campanula, Phyteuma, Rhododendron, Gentiana, Veronica, Linaria, Pedicularis, Androsace, Primula, Salix, Orchis, Tofieldia, Juncus, Luzula, Carex, along with numerous grasses, ferns, mosses, and lichens. There were observed in all between 500 and 600 species. Professor Balfour remarked that it is of importance for the student of botany to see the floras of different countries. It is thus only that he can acquire a clear view of the geographical distribution of plants, and correct his notions regarding the species found in his own country. Mr Bentham says—"There is probably not a single species of flowering plants peculiar to our islands.

Those which are confined to our western counties and to Ireland may generally be traced down the western departments of France to Spain and Portugal; the mountain plants of Scotland are mostly to be found in greater abundance in Norway and Sweden, and often, though at great elevation, on the Alps and Pyrenees; in our eastern counties there are occasionally found a very few of the east European species, which, although extending over the Scandinavian Peninsula and Denmark, do not in Central Europe spread much to the westward of the Rhine; our southern coasts here and there shelter the extreme northern representatives of species common in the warmer regions of southern Europe; whilst the bulk of our flora, the more common inhabitants of our lower hills, plains, and sea-coasts, are, in similar situations, more or less spread over the continent of Europe and that vast portion of temperate or northern Asia now under the Russian dominion, extending frequently beyond eastern Siberia to the shores of the Pacific." During the excursion the party met with a great number of plants belonging to the British flora. In the Alpine districts, which were particularly examined, they met with many of the rare species of the Scottish mountains; while on the less elevated districts the flora of the British Islands, called *Germanic* by Forbes, was seen. By an examination of the same species in different parts of the world, and by a careful study of the variations which it undergoes in different localities, botanists are enabled to come to a correct conclusion in regard to its limits, and are thus less likely to be led into the error of constructing species on a contracted view of the flora of Britain. British botanists who have travelled much on the continent of Europe have generally shown a tendency to reduce the number of species in our flora, while those who have limited their excursions to our own islands have often multiplied species. Thus, in the case of the recently published British Floras, whilst the last edition of Babington's Manual contains 1708 species (exclusive of Chara), that of Hooker and Arnott's Flora contains 1571, and Bentham's Work 1285. Both Arnott and Bentham have been continental travellers, and have examined European plants *in situ*. Professor Balfour noticed the general distribution of plants on the Alps visited by the party, dividing them into different regions:—1. The region of the plains or lower hills, on which the common Germanic flora occurs. 2. The lower mountain region, extending to about 2000 or 2500 feet, called by botanists the zone of the Chestnut. 3. The upper mountain region, from about 2000 to 4000 feet, characterized as the zone of the Beech, and including the Ash, Cherry, Oak, and Maple. 4. The sub-Alpine region, from 4000 to 6500 feet, where many coniferous plants occur, as Fir, Spruce, Larch, and herbaceous species, such as *Alchemilla alpina*, *Gentiana verna*, *Dryas octopetala*, *Saxifraga oppositifolia*, &c. 5. The Alpine region, from about 6000 to 7000 feet, where shrubs, such as *Rhododendron ferrugineum*, with Juniper and Dwarf Alder, occur. 6. Subnival region, from about 7000 to 8500 feet, in which the plants which attain the highest elevation are seen belonging to the genera already enumerated. Some of these plants extend to 10,000 or even 11,000 feet. Some of the Gentians, Saxifrages, Aretias, Silenes, and Ranunculuses have been found at 10,700. *Chrysanthemum alpinum* and *Phyteuma pauciflorum* have been gathered at the Lys Glacier, on Monte Rosa, at the height of 11,352 feet. 7. The

Nival or snowy region, destitute of all vegetation. Professor Balfour gave full details of the various adventures of the party, and explained the requisites for such an expedition. He illustrated the paper by specimens of the plants collected, by maps showing the route and the comparative height of the mountains, and by drawings of the places visited by the party.

Thursday, 13th January 1858.—Professor Balfour in the Chair.

The following papers were read:—

1. *Remarks on Abies bracteata.* By Andrew Murray, Esq., F.R.S.E.

2. Professor Balfour, read the following communications:—
   (1.) *List of Plants found at Tayport, Fife,* in *September* 1858. By Professor Lawson, Kingston, C.W.
   (2.) *Extracts from Dr Lawson's Account of his Voyage to America.*

3. *On the growth of the Bamboo-Cane in the new Palm-House at the Royal Botanic Garden.* Communicated by Mr M'Nab.

In this notice Mr M'Nab gave a detailed account of the growth of the bamboo, taken every third day until the plant attained the height of 15 feet, with the mean temperature of the external air during each successive three days from 3d July to 14th August 1858. The average temperature of the internal air during the period of growth ranged from 65° to 70°.

Date.	Mean temperature open air.	Growth during three days.
July 3 to 6	54°	$1\frac{1}{2}$ inches.
6 ... 9	46	$2\frac{1}{2}$,,
9 ... 12	43	$3\frac{3}{4}$,,
12 ... 15	48	7 ,,
15 ... 18	50	$9\frac{1}{2}$,,
18 ... 21	45	$10\frac{3}{4}$,,
21 ... 24	44	$13\frac{3}{4}$,,
24 ... 27	51	17 ,,
27 ... 30	54	$18\frac{1}{2}$,,
30 ... 2 Aug.	52	$19\frac{3}{4}$,,
Aug. 2 ... 5	47	$17\frac{1}{2}$,,
5 ... 8	47	$18\frac{1}{2}$,,
8 ... 11	43	$19\frac{1}{2}$,,
11 ... 14	45	$20\frac{1}{2}$,,

From the 14th of August to the 24th of September, the extra height reached was 25 feet, being an average of 2 feet for every three days. On the 24th of September the extreme height of the shoot was 40 feet, the growth of 81 days. The plant was shifted into its present tub during the spring of 1858. The soil used was turf loam; about 4 inches of bruised bones covered the drainage previous to the plant being retubbed.

4. *Measurement of certain Coniferous Trees, taken at St Font, Fife.* By GEORGE PATTON, Esq., Advocate. Communicated by Mr M'NAB.

Cryptomeria Japonica (in cone)—height, 21 feet; circumference of stem, 14½ inches. *Taxodium sempervirens*—height, 13½ feet; circumference, 10 inches. *Abies Cephalonica*—height, 14½ feet; circumference of stem, 20 inches.

5. *On the Uses of the Bamboo, with Illustrations.* By ALEX. HUNTER, M.D., F.R.C.S.E., H.E.I.C.S.

After alluding to the characters of the bamboo and the various species described, the author remarked, "the bamboo varies prodigiously in size in proportion to the supply of water and the richness of the soil. In dry hilly localities it grows only to 8 or 10 feet, while in moist jungles and in swamps, particularly on the banks of sluggish rivers, it attains the height of 90 to 100 feet. It has been known to grow as much as 18 inches in 24 hours. The largest bamboos are probably those found in Burmah, where they occasionally grow to 10 inches in diameter, each joint being from 20 to 24 inches in length. The plant is often cultivated in clumps, and to form ornamental archways for avenues and gardens; also as a hedge, being bent over and interwoven so as to combine the qualities of both a hedge and a paling. There is probably no plant with which we are acquainted that is put to so many and such opposite and diversified uses as the bamboo. The leaves, when young and tender, are eaten by animals. The grain is given in the form of a decoction as a remedy for fever in cattle. The young shoots of the female or hollow plant are used for making arrows, those of the male or solid plant are largely exported to Europe for making the tips of fishing-rods. The pointed lateral shoots are used when young as pins. The stems are employed for props, palings, roofing, flooring, doors, and blinds. Some houses are built entirely of bamboo. Paper and cloth are manufactured from the plant. The tender shoots are used for pickles, and they form one of the ingredients of the celebrated preserve called Chow-chow. Baskets and boxes of various kinds are made from the bamboo. The lacquered boxes and cups of Burmah are peculiarly beautiful." Among the other uses of the plant were noticed the following:—Poles for palanquins, for carrying water, and for pushing boats, floating rafts, swinging poles at feasts, light bullock-carts, ladders and fire-escapes, fishing-rods, boat-poles, spear-shafts, garden-chairs, plant-stands, distilling-tubes, hookahs, bows and arrows. The joints are employed for water-pails and bottles; also for holding letters, for musical instruments, and blow-pipes. The author concluded by stating that he did not know of any one plant that had been put to such varied uses as the bamboo. "God, who has supplied to each country or race of mankind the necessaries and luxuries of life, has implanted in man also the power to use them, and we frequently find that barbarous and half-civilised nations excel others in ingenuity and natural taste. The bamboo might be much more extensively used in the arts, manufactures, and commerce, if we would take a lesson from the natives of the East. If they thus give us much practical knowledge, we ought to try to give them in exchange some of the blessings which we have derived from our civilization. Let us see that while we borrow from them hints that may improve our manufactures, we give them return something that will elevate, improve, and enlighten their understandings, as well as raise them in the scale of civilization. We already owe to India the ideas for some of our best and most lucrative manufactures, and it is the duty of our merchants and manufacturers to make some return."

6. *On the Economical Uses of the Roots of Coniferous Plants.* By Mr M'Nab.

The donations of Mrs Millar, prepared from the roots of the *Abies nigra,* received from the Hudson's Bay territory, and presented at the last meeting of the Botanical Society; also the donations of Mr Jeffrey, prepared from the *Abies Menziesii,* from the Oregon territory, suggest the idea that something might be done in this country by a more extensive cultivation of these trees. Both species delight in open brown peat soil. Perhaps the finest specimens in Great Britain of the *Abies Menziesii* is to be seen on Keillar Moor, Perthshire, where it is growing vigorously in deep brown peat. This species differs from most of the other conifers in being easily propagated by cuttings, which, if stuck into the spongy peat, root, and form trees. The *Abies nigra,* like *A. Menziesii,* also rejoices in peat soil. I have not as yet been able to ascertain the state of the roots of these trees when grown in peat, but I have no hesitation in saying, that from the appearance of the roots now exhibited (grown in loam and clay), they must run freely amongst open brown spongy peat. Judging from the strength and durability of the articles now shown, I would venture to suggest that the roots of thinnings, of these as well as other coniferous trees, might, if found suitable, afford employment to the labouring population in the upland districts of Scotland, who might prepare these roots for baskets, hats, and other useful articles, and thus turn to profitable account soils at present wholly unproductive. The object of the foregoing remarks is to induce as much as possible the turning to account the roots of the various Coniferæ (Scotch fir, spruce, larch) annually cut down for railway sleepers and other economic purposes. The roots of these trees are either allowed to rot in the ground, or if grubbed up, burned to get them out of the way. When we see the uses to which coniferous roots are put by the American Indians, we are entitled to conclude that something may yet be done with them in this country.

SCIENTIFIC INTELLIGENCE.

MISCELLANEOUS.

Shea Butter.—The nuts of the tree (*Bassia Parkii*) are allowed to ripen on the trees, and gathered from the ground in the morning by women and children. The pulp surrounding the nuts is rubbed off, and generally eaten. As a fruit it resembles an over-ripe pear; but it is too sweet to be much relished by Europeans. The nut is next dried by exposing it to a slow heat in large clay caldrons with perforated bottoms. This, besides carrying off moisture, causes the nut to shrink in its shell, of which it is divested in the next operation, viz., threshing. This is done on floors, or sometimes it is slightly bruised in large wooden mortars instead. The nut, now free, is next thoroughly pounded with pestle and mortar, then ground between stones: at this stage it looks just like black mud in paste. This mass is washed in cold water, then boiled till the butter rises white, and is skimmed from the surface. Shea butter remains hard at a high temperature when well prepared, and does not become rancid with age. It has a slight smoky taste, acquired during its preparation. Some of our people dislike it. We have used it in cooking, and I have often in the boat lived on it and yams without inconvenience. From specimens tested at home, the Shea butter is likely to fetch L.5 per ton more than palm oil. It can be produced here in any quantity; but it is a tree of the interior, and will reach European markets just in proportion as the navigation of this river is extended. A missionary teacher has beautifully observed that the Oil Palm is destined to effect an equality of races, and banish slavery. As the wants of civilization extend, I cannot help thinking that Bassia is designed to assist in the same cause.—*Letter from Mr Barter to Sir William Hooker.*

Aëroliths.—The attention of astronomers and natural philosophers in general has of late been turned to the frequency with which bolides, or fireballs, and similar meteors, now appear in the heavens, phenomena now generally admitted to be nothing else but aëroliths in a state of ignition. We mentioned sometime ago the fall, on 9th of December last, of two large aëroliths at Assun and Clarac, two communes of the canton of Montrejean, and noticed a paper addressed on the subject to the Academy of Sciences by M. Petit, astronomer at Toulouse. Further particulars have now been addressed to the Academy by MM. Filhol and Leymerie, from which it appears that the meteor was first seen at Muret and at St Gaudens, and was not remarked at Toulouse. The aërolith of Assun is calculated to have weighed 40 kilogrammes, but it was immediately broken to pieces by the inhabitants, and the largest fragments now existing do not exceed two kilogrammes in weight. The aërolith of Montrejean, for so the two of Assun and Clarac are now called, is brittle; its general colour is ash-grey; its texture is granular, presenting a multitude of little brownish particles on a whitish ground, with metallic needles interspersed; its density is 3·30, or somewhat more than that of flint-glass. It will attract the magnetic needle, but has no magnetic poles of its own. When exposed to the blow-pipe it immediately turns black, and emits a sulphureous smell. A fragment, carefully triturated, presents a mixture of various particles; those which are sensible to the magnet are easily separated from the others; the brownish globules are then found detached from the general mass, in which they leave the impression of their shape. They are of a stony texture, and may be scratched with a steel point. The metallic particles are, as usual, an alloy of iron and nickel, in the proportion of about eight of the latter to ninety-two of the former. When finely powdered the aërolith assumes a dark brown hue, and resembles pulverised sulphuret of antimony. Besides iron, nickel, and silex, of which latter the enormous proportion of 64 per cent. has been found in the aërolith, it also contains about 13 per cent. of magnesia, 2 per cent. of sulphur, and 2 per cent. of alumina. In a recent communication on the same subject M. Petit says:—"Among the meteoric bodies hitherto observed, there are some remarkable for their large dimensions and enormous velocities. That seen on the 4th of January 1857, for instance, was upwards of 2000 meters in diameter, and, at an altitude of sixty-eight leagues, moved with a velocity of 8000 meters per second. That of the 18th of August 1841 was 4000 meters in diameter; that of July 23, 1846, which was at a distance of only eleven leagues from our globe, moved at the rate of two leagues per second, and was 100 metres in diameter; and on the 6th of July 1850 there appeared one of a diameter of 200 meters, at a distance of thirty-two leagues from the earth, and moving with a velocity of nineteen leagues per second."—*Galignani's Messenger.*

A Catalogue of the Birds observed on the Island of Heligoland, in latitude 54° 10′ 46″, 51 north, and longitude 25° 32′ 43″, 5 east of Ferro. By Mr HENRY GATKE. These birds, with very few exceptions, are preserved, and may be seen in Mr Gatke's collection on the island.

Mr Gatke says, in a letter, "I have enclosed a catalogue of the birds which have, according to my observations, visited the island of Heligoland during the last fifteen years. If the small area of the island (scarcely half a square mile English) is borne in mind, the number of its feathered visitors will be admitted to be wonderful. The catalogue contains the names of some species which, I think, have not previously been recorded as having been found in Europe."

Falco peregrinus
,, subbuteo
,, candicans
,, islandicus
,, gyrfalco
,, æsalon
,, cheuchris
,, tinnunculus
,, rufipes
,, palumbarius
,, nisus
,, rufus
,, cyaneus
cineracius

Falco milvus
,, ater
,, buteo
,, lagopus
,, apivorus
,, nævius
,, albicilla
,, haliætos
,, brachydactyla
Strix otus
,, brachyotus
,, tengmalmi
,, noctua
,, flammea

Strix nyctea
,, nisoria
Corvus corax
,, { cornix }
,, { corone }
,, frugilegus
,, monedula
,, pica
,, glandarius
,, infaustus
,, caryocatactes
Lanius excubitor
,, minor
,, collurio

Lanius phoenicurus
„ rufus
Muscicapa grisola
„ luctuosa
„ parva
Bombycilla garrula
Sturnus vulgaris
„ roseus
Turdus viscivorus
„ musicus
„ solitarius
„ iliacus
„ pilaris
„ ruficollis
„ torquatus
„ merula
„ varius
„ saxatilis
„ rufus
„ lividus
Sylvia philomela
„ lucinia
„ {cyanecula
„ {leucocyanea
„ {ruficyanea }
„ rubecula
„ thitys
„ phœnicurus
„ erythrogastra (?)
„ hortensis
„ atricapilla
„ orphea
„ nisoria
„ cinerea
„ provincialis
„ turdoides
„ arundinacea
„ palustris
„ locustella
„ certhiola
„ aquatica
„ phragmitis
„ caligata
„ familiaris
„ hypolais
„ sibiliatrix
„ icterina (?)
„ trochilus
„ rufa
„ bonelli
„ javonica
„ bifasciata (mihi Regulus modestus)
(This bird I have obtained *eight* times in this island; four specimens being still in my possession.)
Sylvia virens (Wilson) (Oct. 19, 1858)
Regulus pyrocephalus
„ flavicapillus
Troglodytes parvulus
Cinclus aquaticus
„ pallasi
Accentor alpinus
„ modularis
Saxicola œnanthe
„ aurita
„ stapazina
„ leucura
„ rubicola
„ rubetra
Anthus Richardi
„ campestris
„ arboreus
„ cervinus
„ pratensis
„ ludovicianus
„ littoralis
„ aquaticus
Motacilla alba
„ lugubris
„ sulphurea
„ citreola
„ flava
„ citrinella
„ melanocephala
Alauda arvensis
„ alpestris
„ arboreus
„ cristatus
„ brachydactylus
„ calandra
Emberiza miliaria
„ citrinella
„ cirlus
„ aureola
„ hortensis
„ cæsia
„ melanocephala
„ schœniclus
„ pusilla (above 15 times)
„ rustica (twice)
„ lapponica
„ nivalis
Fringilla cœlebs
„ montifringilla
„ nivalis
„ carduelis
„ citrinella
„ chloris
Fringilla canabina
„ montium
„ linarea
„ spinus
„ coccotraustes
„ domestica
„ montana
Pyrrhula vulgaris
„ rosea
„ erithrina
„ enucleator
Loxia curvirostra
„ leucoptera
Parus major
„ ater
„ cœruleus
„ palustris
„ biarmicus
„ caudatus
Picus major
Certhia familiaris
Cuculus canorus
Yunx torquilla
Alcedo ispida
Merops apiaster
Coracias garrula
Oriolus galbula
Upupa epops
Caprimulgus europæus
Hirundo rustica
„ rufula
„ urbica
„ riparia
„ melba
„ apus
Charadrius auratus
„ virginicus
„ longipes
„ squatarola
„ vanellus
„ œdicnemus
„ morinellus
„ asiaticus (Pall.)
„ hiaticula
„ cantianus
„ minor
Tetrao cothurnix
Columba palumbis
„ œnas
„ livia
„ turtur
Rallus aquaticus
Crex pratensis
„ porzana
„ pusilla
„ pygmea

Fulica atra
,, chloropus
Grus virgo (once)
Ardea cinerea
,, purpurea
,, stellaris
,, minuta
,, ciconia
,, nigra
Ibis falcinellus
Numenius arquatus
,, phacopus
,, tenuirostris
Limosa melanura
,, rufa
Scolopax rustica
,, major
,, gallinago
,, gallinula
Totanus fuscus
,, calidris
,, glottis
,, glareola
,, ochropus
,, hypoleucos
,, (Tringa) rufescens
Phalaropus rufus
,, cinereus
Tringa alpina
,, minuta
,, Temminckii
,, subarquata
,, islandica
,, maritima
,, calidris
,, interpres
,, platyrhincha
,, pugnax
Recurvirostra avosetta
Hæmatopus ostralegus

Cygnus musicus
,, minor
Anser cinereus
,, ... (?)
,, segetum
,, albifrons
,, minutus
,, hyperborea
,, leucopsis
,, torquatus
Anas boschas
,, strepera
,, penelope
,, acuta
,, querquedala
,, crecca
,, tadorna
,, fusca
,, nigra
,, perspicilata
,, marila
,, fuligula
,, ferina
,, nyroca
,, clangula
,, glacialis
,, stelleri
,, molissima
,, spectabilis
Mergus merganser
,, serrator
,, albellus
Carbo cormoranus
,, graculus
Sula alba
Larus marinus
,, fuscus
,, glaucus
,, leucoptherus
,, argentatus

Larus canus
,, trydactylus
,, eburneus
,, ridibundus
,, minor
,, Sabinii
,, Rossii
Sterna cantiaca
,, anglorum
,, caspia
,, Dugallii
,, hirundo
,, macroura
,, leucoparia
,, nigra
,, minuta
Lestris cataractes
,, pomarina
,, parasitica
,, crepidata
Procellaria glacialis
,, Leachii
,, pelagica
,, cinerea
,, anglorum
Podiceps cristatus
,, ruficollis
,, cornutus
,, auritus
,, minor
Colymbus glacialis
,, arcticus
,, septentrionalis
Uria troile
,, trimgria
,, arra
,, grylle
Alca arctica
,, torda
,, alle

ABSTRACT OF THE METEOROLOGICAL REGISTER FOR 1858,

Kept at Arbroath, by ALEXANDER BROWN, Honorary Member of the Literary and Philosophical Society, St Andrews; Observing Member of the Scottish Meteorological Society, &c.

Latitude 56° 34′ N. Longitude 2° 35′ W. Distance from the Sea, ⅛ths of a Mile.
Height of the Barometer above the Sea, 80 feet; height of the Thermometer from the ground, 11 feet, and of the Rain-Gauge, 2 feet.
The number of "Rainy Days" includes those days on which snow or hail fell.

1858.	BAROMETER. Corrected to 32°, and reduced to sea-level.		THERMOMETER.							Days Ther. below 32°.	Rain in Inches.	HYGROMETER.		Fair Days.	Rainy Days.	WINDS, AT 8½ A.M.									
	8½h. A.M.	8½h. P.M.	8½ A.M.	7¾ P.M.	Mean.	Mean Max.	Mean Min.	Mean.	Spring Water.			Mean Dew Point.*	Degree of Humidity (complete Sat. 1·000).			N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Total.
January	30·05	30·05	37°·2	39°·0	38°·1	42°·6	33°·2	87°·9	48°·0	13	0·923	32°·0	0·839	22	9	—	—	—	—	6	4	13	7	1	31
February	29·99	29·98	34·5	36·2	35·3	40·4	31·9	36·2	47·0	11	1·037	30 7	·874	23	5	—	1	3	9	5	1	—	7	2	28
March	29·82	29·77	37·8	39·2	38·5	46·6	32·8	39·7	47·0	13	1·277	31·2	·803	22	9	8	—	2	1	3	3	7	9	3	31
April	29·92	29·90	43·4	42·8	43·1	50·5	36·3	43·4	46·5	7	1·287	35·8	·767	23	7	2	1	6	4	1	5	2	4	5	30
May	29·81	29·90	51·2	49·2	50·2	57·2	41·6	49·4	46·5	2	2·093	42·0	·734	16	15	2	3	1	3	6	3	4	5	4	31
June	30·03	30·00	60·8	59·6	60·2	66·8	50·7	58·8	48·5	—	1·513	51·6	·730	28	7	—	1	—	7	7	1	6	3	5	30
July	29·85	29·86	58·3	57·1	57·7	64·4	49·1	56·7	49·0	—	3·076	51·2	·797	18	13	2	2	2	5	4	2	6	6	2	31
August	30·03	30·01	58·5	57·6	58·2	66·2	49·8	58·0	50·0	—	2·270	52·2	·796	18	13	4	1	1	10	2	2	3	6	2	31
September	29·89	29·88	54·7	54·1	54·4	62·5	47·2	54·8	49·5	—	2·023	49·0	·831	20	10	1	—	2	1	2	6	10	2	6	30
October	29·87	29·88	43·0	43·1	43·0	50·9	37·4	44·1	50·0	7	2·665	38·6	·858	21	10	3	2	1	—	—	6	11	5	3	31
November	29·95	29·94	38·3	38·9	38·6	44·0	35·4	39·7	47·0	9	1·874	33·7	·854	21	9	2	—	5	2	2	2	2	10	5	30
December	29·68	29·70	37·8	38·8	38·3	42·1	34·1	38·1	48·0	9	4·315	35·1	·918	15	16	1	1	3	5	6	2	7	2	4	31
Mean	29·90	29·90	46·3	46·3	46·3	52·9	39·9	46·4	48·0	71	24·353	40·2	0·817	242	123	20	12	26	47	44	37	71	66	42	365
Do. 1857	29·80	29·79	48·2	47·9	48·1	54·2	42·0	48·1	48·2	59	23·739	43·2	0·851	234	131	31	17	54	31	29	52	76	36	39	365

Barometer at 8½ A.M. was highest on 6th November, 30·60.† Wind N.W.
Do. do. was lowest on 7th October, 28·86. Wind S.W.
Do. at 8½ P.M. was highest on 29th October, 30·55. Wind N.E.
Do. do. was lowest on 30th April and 27th Nov., 28·87. Wind N.W. & S.
Thermometer at 8½ A.M. was highest on 22d June, 71°. Wind W.
Do. do. was lowest on 2d February, 20°. Wind N.W.
Do. at 7¾ P.M. was highest on 22d June, 67°. Wind W.
Do do. was lowest on 2d February, 21°. Wind N.W.
Thermometer in night, highest, 22d June, 59°; lowest, 2d and 3d February, 19°.
Thermometer in day, highest, 22d June, 77°; lowest, 1st February, 25°.
Coldest day, 1st February, when average of Thermometer was 23½° for day and night.
Hottest day, 22d June, when average of Thermometer was 68° for day and night.
Coldest month of the year, February; hottest, June.
Wettest month of the year, December; driest, January.
Mean temperature of the year, 46·35 degrees.
Mean temperature of fifteen years, 45·757 degrees.

For twelve years the average daily temperature at 8½ A.M., at 7¾ P.M., and the mean of the daily extremes, are as follows, viz.:—

	8½ A.M.	7¾ P.M.	Mean of Extremes.
1847	45°·6	44°·7	45°·9
1848	45 ·1	44 ·4	45 ·0
1849	45 ·1	44 ·4	44 ·7
1850	45 ·5	44 ·9	45 ·5
1851	45 ·7	45 ·4	46 ·3
1852	46 ·0	45 ·9	46 ·2
1853	45 ·4	44 ·9	45 ·6
1854	46 ·3	46 ·4	46 ·3
1855	44 ·2	43 ·9	44 ·3
1856	44 ·9	44 ·5	45 ·0
1857	48 ·2	47 ·9	48 ·1
1858	46 ·3	46 ·3	46 ·4

The average temperature of the six months of chief vegetation, viz., those from April to September inclusive—for eleven years, is as follows:—

1848 ... 51°·7	1850 ... 51°·7	1852 ... 53°·0	1854 ... 53°·5	1856 ... 50°·9	1858 ... 53°·5
1849 ... 52 ·2	1851 ... 52 ·0	1853 ... 53 ·4	1855 ... 52 ·1	1857 ... 54 ·7	

* The dew-point thus found is obtained from observations of the Wet and Dry Bulb Thermometers, and deduced by Mr Glaisher's Hygrometrical Tables. The observations of the Wet and Dry Bulb Thermometers are made daily at 8½ A.M. The times of observation of the instruments stated in the Table are Greenwich mean times.

† The highest and lowest readings of the Barometer are reduced to sea-level, and otherwise corrected.

THE AMOOR RIVER.

A boundary treaty, signed early in July between the Governor-General of Siberia and the Chinese authorities, ceded to Russia the left bank of the Amoor, as well as the coast territory on the right bank of the Usiri, north of the 43d parallel of latitude. Extra-provincial China on the north is divided by Dr Williams, the author of the well-known work entitled "The Middle Kingdom," into "Inner Mongolia, Outer Mongolia, and Manchuria; the last territory, the cradle of the ruling race, is subdivided into Shingking, Kirin, and Tsitsihar. If the information furnished as above is correct, Russia has obtained the whole country extending from above *Yaksa*, in *Tsitsihar*, to the bend in the coast of *Kirin*, if not beyond that point to Corea, and bounded southwards by the Amoor and its important affluent, the Usuri. The navigation of these river boundaries will of course become as much Russian as Russia chooses to make it; and the Long Island, as the Chinese call it, known to European geographers as Tsokko, Tarakai, Sagalien, is, we presume, of necessity included in the concession. Japan asserts a claim to part, if not the whole of this; and the men-of war engaged in our cruise up the Gulf of Tartary in 1854 brought us word that the Japanese had re-established themselves along the Gulf of Aniwa in positions which the Russians had, but a short time before, compelled them to abandon."

The official Report of Mr Collins, United States' Commercial Agent to the State Department, of explorations successfully carried out by him along the course of the Amoor, may serve to show the importance of this acquisition. It is dated April 17, 1858:—

"The Amoor, it will be recollected, is a river second only to the Mississippi, which flows from the centre of Northern Asia into the Pacific Ocean not far north of Japan. The Report will give a general view of the interior commerce of Russia preparatory to the grand development of her Asiatic commerce and policy.

"Mr Collins obtained the appointment of commercial agent from President Pierce, for the purpose of making the exploration of the Amoor, and testing the practicability of its navigation. In order to do this, he was compelled to proceed by way of St Petersburg, to obtain the permission of the Russian Government to enter the Amoor country. To have attempted its exploration from the sea, without the assistance of steam, and alone, would have been worse than folly; therefore the necessity of entering Russia by way of the Baltic. This, of course, rendered the land journey across both Europe and Asia necessary; nor was this without policy or aim: it was to witness that great inland trade of Russia concentrating at Nijne Novgorod in Europe, and Kyachta in Asia, and to trace this line of commerce from the Baltic to the Pacific Ocean. If the Amoor could be ascended by steamers, this vast country could be opened to American commerce, and the very heart of Northern Asia made accessible to our merchants.

"Having obtained the appointment, he proceeded, early in the spring of 1836, *viâ* England and Denmark, to Cronstadt and St Petersburg. Owing to many circumstances, Mr Collins was detained in St Petersburg and Moscow until after the coronation of the present Emperor; it was not till after that event that he could obtain the necessary formal permission to prosecute his voyage. It was now too late to cross the two continents in order to reach the Amoor before winter would set in; he consequently remained in Moscow until winter fairly set in, and the roads were rendered good by a sufficient coating of snow. His detention was not without its benefits, because it gave him an opportunity to become familiar with the vast interior trade of Russia, the wealth of its great cities, and the internal resources of a vast empire, all of which was regularly communicated to the Department of State, and, in the meantime, to make himself familiar with the Slavonic language.

"Mr Collins passed overland from St Petersburg to the headwaters of the Amoor, where he awaited the approach of spring, and then, in a small boat with oars, and five Cossack soldiers, furnished him by General Mouravieff, the Governor-General of Eastern Siberia, proceeded down the three rivers Ingadah, Schilkab, and Amoor, to the ocean, a distance by water of some 2500 miles. As he proceeded entirely under the auspices of the Russian Government, he had every facility granted him in obtaining information and for exploration. Starting from Moscow mid-winter, Mr Collins had the rare opportunity of testing all the terrors of a Russo-Siberian winter upon an American constitution.

"Mr Collins now proceeded in a sleigh with post-horses by way of Vlademir, Nijne Novgorod, Kazan, crossing the Ural Mountains at Catherineburg, and thus on by Omsk, Tomok, and Kramoyank, to Irkoutsk, the capital of Eastern Siberia, 4000 miles east of St Petersburg. Spending some time at Irkoutsk, and being hospitably entertained by General Mouravieff, Mr Collins then visited the cities of Kyachta and Mai-mat-Tschin. These places are, by treaty between Russia and China, the only points where commerce can be conducted by the people of the two empires. They are situated about 350 miles south-east of Irkoutsk, and 1000 miles north-east of Pekin, on the frontiers of Mongolia and Siberia.

"Mr Collins had the rare opportunity of witnessing the opening of the great fair at the full or 'white moon,' in February. Grand feasts and entertainments were given in honour of the occasion: the town of Mai-mat-Tschin was filled with feasting, and illuminated with lanterns at night. The trade concentrated here is very important, said to be 20,000,000 of dollars annually. After finding its way on the backs of camels and by bullocks from Pekin, it is taken up by the Russian merchants in the winter on sledges, and in the summer by the rivers and waggons, and finds its way across Siberia to the foot of the Ural mountains, crossing which, it concentrates at the great fair at Nijne Novgorod, where the commerce of 1856 summed up to 300,000,000 of silver roubles.

"Upon the approach of spring Mr Collins crossed the Staunvey mountains, and fell upon the headwaters of the Amoor. Navigation not yet being opened, he made a full exploration of the gold and silver country of Nerchinsk, the mines of which are worked by the convicts from European Russia. The country is very rich in silver and gold.

"Returning from the tour, he awaited at Chetah the breaking of the ice in the Ingodah, whence he proceeded on his downward course to the sea.

"The country along the Amoor is fully described, much of which is susceptible of farming and grazing. But the great probability as to its navigability is fully solved. Mr Collins states, without hesitation, that steamers can ascend from the sea to Chetah, a distance of 2600 miles, which great fact opens up Siberia to our Pacific commerce through the Amoor. This fact, hitherto unknown, and not even guessed at, presents a new field for commerce, the ultimate limits of which can hardly be grasped by the most comprehensive mind. Mongolia, Manchuria, Northern China, all the Tartaries, Thibet, and Siberia, with a population of twenty to thirty millions, are approached by this river, and a new route to the Indies opened. The discovery of the north-western passage sinks into utter nothingness in comparison with the utility and practicability of this route. One most astonishing fact is elicited, which is, that that Irkoutsk, the capital of Eastern Siberia, can be approached with only about three hundred miles of land carriage.

"Mr Collins is the first foreigner that has ever descended the Amoor, and the first that has crossed the mountains dividing the waters of the Pacific from those of the Frozen Ocean.

"By way of Hakodadi, Japan, up through the sea of Japan to the Straits of Tartary, and into the mouth of the Amoor, the navigation presents no unusual difficulties; steam is wanted at the mouth of the Amoor to tow vessels to and from sea, the same as at the mouth of the Mississippi.

"Vessels approaching the Amoor will stop at De Castries for a pilot, where they can also get wood and water, and the supercargo or captain can proceed by way of Keezey, making a small portage in the Amoor, and thus anticipate his vessel at the mouth of the river.

"Since Mr Collins' visit to Irkoutsk and the Amoor, a company, called the 'Company of the Amoor,' has been organized in St Petersburg, and received the sanction of the emperor, and a capital of four millions of franks, to be increased to twelve milions, for the purpose of 'encouraging and developing the commercial and industrial activity of the Valley of the Amoor, to open trade through the Pacific ports with foreign countries, to trade with the Indians, to build and maintain steamers and sailing vessels, establish factories, magazines, &c.'

"After leaving the Amoor in the fall of 1857, Mr Collins visited Japan, Kamschatka, and the Sandwich Islands, and returned to Washington by way of San Francisco, California."

Another extract will show that Russia is not inert in providing for the security of her new possession.

"The Government of St Petersburg has just received from the Governor of the Russian possessions on the river Amoor a very favourable report on the military and commercial situation of the vast territory which has been there definitively annexed to the Russian empire. The extensive works of fortification of Nicolaieff, which is destined to become, in case of need, the centre of operations against China, have not been interrupted by the winter, which is very mild in those countries. Formidable batteries have been raised at the mouth of the Amoor, so as to be able to defend the entrance against hostile fleets. 'Commerce during the last year,' we are informed, 'has acquired an unexpected degree of development. A number of German, American, and Chinese merchants have formed establishments in the town, and a regular line of steamers has been established between Nicolaieff and San Francisco. The discovery of a mine of coal, of very good quality, in the Island of Sagalien, will contribute to extend the navigation of Russia in the Pacific Ocean."

We find the following additional intelligence in the *Times* of February 16th:—

"The *Gazette* of the Senate of St Petersburg publishes an ukase of the Emperor, dated December 8th, 1858, settling the government of the Russian possessions on the Amoor, in accordance with the proposition of the Governor-General of Eastern Siberia, and conformably to the advice of the Committee on Siberian affairs.

"1. The country of the Amoor is divided into two provinces, the first of which preserves its actual name of maritime Province of Eastern Siberia, and the other takes the name of Province of the Amoor.

"2. The Okhotsk district is detached from the province of Yakoutsk and united to the maritime province, which comprises six districts, viz.:—Nicolaievsk and Sophiisk, newly formed; Okhotsk, Petropaulovsk, Ghijiga, and Oudsk. The administration of the maritime province will remain on the same footing as heretofore, with the exception of a few changes prescribed by a special order of his Imperial Majesty.

"3. The province of the Amoor will consist of all the territories situated on the left bank of the Amoor from the confluent of the rivers Schilka and Argoune, or from the limits of the Transbaikalian provinces and of Yakoutsk, descending the Amoor to the confluent of the river Oussouri and to the new confine of our maritime province. The town of Blagovestchensk will be the capital of the province of the Amoor. The administration of the province is regulated by a special order annexed to the present ukase.

"4. The detailed settlement of the limits of each province is entrusted to the Governor-General of Eastern Siberia.

"According to the regulation annexed to this ukase, the superior administration of the province of the Amoor appertains to the Governor-General, and to the Superior Council of Administration of Eastern Siberia, and its immediate administration to a military governor of the province, who at the same time directs the civil administration. His residence is Blagovestchensk. The military governor has under his orders a military administration (board) for the regular troops and Cossacks, and a chancery and other functionaries for the civil government.

"A tribunal and notary are established at Blagovestchensk for the whole province. The sanitary service is entrusted to a medical man. A special police is organized for the town of Blagovostchensk. This Imperial ukase, and the annexes thereto attached, are promulgated by an ukase from the Senate, dated the 31st of December 1858."—*Church Missionary Intelligencer*, March 1859.

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The Lithology of Edinburgh. By the Rev. John Fleming, D.D. With a Memoir, by the Rev. John Duns, Torphichen.—*From the Editor.*

Journal of the Indian Archipelago and Eastern Asia, Vol. II., New Series, No. IV.—*From the Editor.*

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An Essay on Classification. By Louis Agassiz.—*From the Publishers.*

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END OF VOLUME NINTH—NEW SERIES.

Neill & Co., Printers, Edinburgh.

Fig. 3.

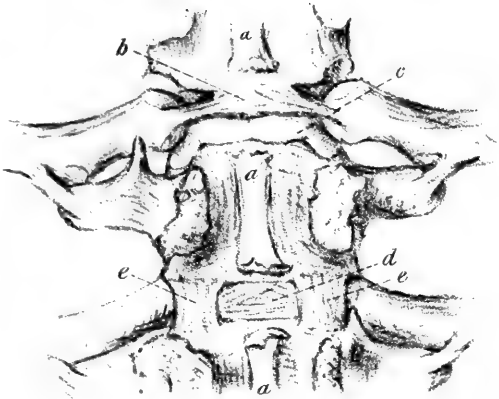
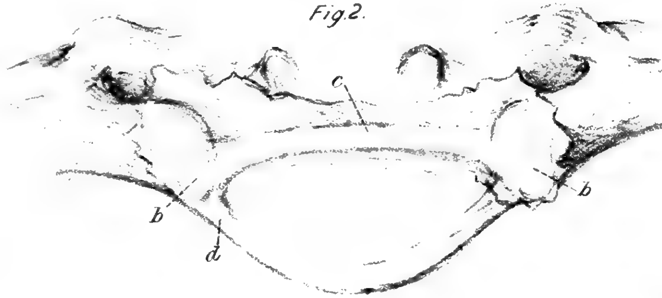


Fig. 1.

Fig. 2.



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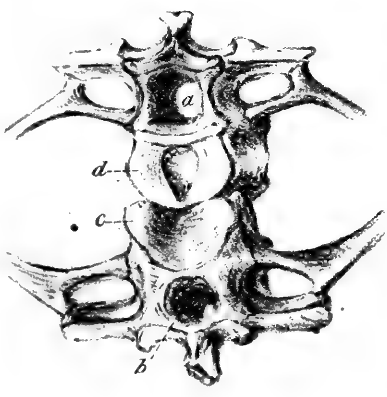
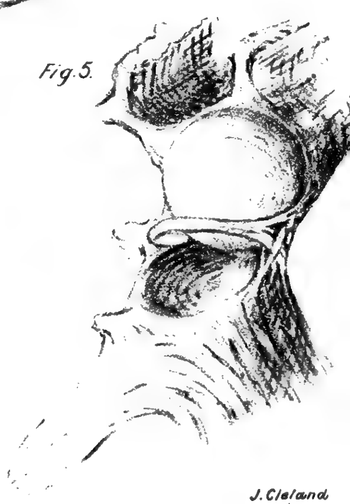


Fig. 5.



J. Cleland