PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY

OF

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ROYAL PHYSICAL SOCIETY.

SESSION CVIII.

Wednesday, 20th November 1878.—JOHN FALCONER KING, Esq., President, in the Chair.

The CHAIRMAN delivered the following opening address:

It has been my good fortune on more than one occasion to have occupied a place at this table, and heard from the lips of retiring Presidents, on the occasion of their reading the opening address for the session, the most pleasant and interesting accounts of the proceedings of the Royal Physical Society in by-gone years. These reminiscences, although in all ways interesting, have had for me both a dark and a bright side. There can be no doubt, for example, that the Society at one time was in a much more flourishing state than it has been for the last few years; and although it may be very pleasant to hear, and from the lips of the very men who themselves have experienced what they describe, such graphic accounts of the palmy days of the Royal Physical Society, still it must be conceded that there is always a tinge of sadness inseparably connected with such recitals, as, however unreflecting and unsentimental one may be, we cannot help contrasting, in some slight degree at any rate, these grand days of brilliant sunshine in which the Society at one time basked, with the somewhat overcast and cloudy weather it has in later years been experiencing. On the other hand, however, the reading of these "leaves of the past" have even for us a bright side—I mean not as warranting or permitting us to rest on our oars, and gaze with complacency on what we once were, but bright as being an example and incentive to us, and as calculated to inspire us with hope and confidence. What the Society has been before it may be, and let us trust and determine it will be, again. Now, gentlemen, it is not in my power to interest you, or either to grieve or gladden you by giving a description of the doings, or by reading an account of the state of the Society in by-gone years, as my connection therewith has been of comparatively recent date. I have prepared, therefore, as this source of an interesting address does not exist for me, a very brief account of what I may call the origin and early progress of that science of which I am a humble student.

In accordance, however, with a time-honoured and very proper custom, it is my duty, before reading the few remarks I have prepared, to recapitulate very briefly our doings and progress during last session; and in taking this retrospective glance I think we shall find that the session which has just closed has been in no way inferior to any of its immediate predecessors.

We had many excellent communications, among which may be mentioned the various welcome Ornithological Notes of Dr Smith, and the exceedingly interesting remarks on Actinia by Dr M'Bain, which he made with reference to the well-known specimen "Granny" now in his possession, and which he was good enough to exhibit at the meeting. Professor Duns submitted a well-illustrated paper on Evidence of Prismatic Structure in Stones of Vitrified Forts; and our indefatigable Secretary as usual favoured us with notes on the subject on which he is so well qualified to speak. Mr Peach also read a characteristic paper on Hydroid Zoophytes. Then came an exceptionally interesting paper from a source, the products of which are always peculiarly welcome to us—I refer to the article on the Marine Denudation of the Friesian Islands, by our late Secretary, Dr Robert Brown. Mr Grieve favoured us with an enjoyable notice of a visit to the Remains of a so-called Tropical Forest; and from Professor Williams we had an interesting note on the Extirpation of the Kidney of a Cat. From Mr Ferguson we had a well-illustrated paper on some Raised Beaches in the West of Scotland—a communication I listened to with peculiar pleasure, as many of the localities to which Mr Ferguson referred, and so graphically described, are well known to me. From Dr Traquair we had notes on the subject he treats so ably—the Fossil Fishes; and Mr Etheridge as usual contributed some valuable Geological Notes. From Mr Harvie-Brown and Mr Scot-Skirving we had interesting notes on the Snowy Owl and Wild Goose. Of chemistry notes I am very sorry to say we had not many. Mr Hunter read a note on Uranium Salts, with special reference to the new salt discovered by Stillman; and Dr Drinkwater submitted an analysis and remarks on a sample of Phosphorite from Kichinev. From Dr Lyon we had a paper giving us some curious results of his observations of instances of Hereditary Transmission; and from Mr Gibson we had interesting papers on the Rearing of the Emu in Scotland, and on the Skull of the Narwhal.

During the session which has just closed, the Society, I am happy to be able to announce, has increased greatly, both as regards membership and funds. During that period 37 new members have joined, which makes the total membership at present 224. We are also now, I am happy to say, passing rich, being in the comfortable position of having a substantial balance at our bankers. We have all, no doubt, contributed a little to bring about this happy state of affairs, but beyond all question our thanks are mainly due to our excellent Secretary, whose untiring efforts to raise the Society to its proper place have been productive of such admirable results. Such rapid progress indeed has been made under his management, that I almost begin to hope that my day-dream, in which I have indulged so long, of seeing the Society comfortably quartered in rooms of its own, with library, etc., all at hand, is yet to be realised. I have of course no desire to anticipate rashly, but I think I am quite justified in saying that if we have one or two more years as successful as the last, we will, at all events, require in some way to secure greater accommodation than we now possess. Whether that should be done by purchasing or renting will be a matter for consideration, although I am inclined to think, judging from my own experience, which has been tolerably extensive in these matters, that the former would be the cheaper and more preferable plan.

Almost incredible as it may seem, to those, at all events, who have not paid much attention to the subject, the science of chemistry, which is, at least in respect of number of workers and rate of advancement, the leading science of the present day, was a little more than a hundred years ago hardly even deserving of the name of science, and was, indeed, as generally studied, little more than a species of black art, the majority of the men who were the representatives of chemistry in the earlier years of last century, being more unmethodical experimenters than anything else, and who could not in strictness be called men of science. The principal if not the sole object of their most unscientifically conducted researches, was the unscientific one of discovering the so-called philosopher's stone. As we understand it now, one of the essentials of the true mode of conducting scientific research is to let our results have all possible publicity—to the end that others may not only have the benefit of our labours to assist them in their work, but also that they may be warned from spending time on ground which has already been worked out. The very name of chemistry, however, shows that this scientific spirit did not prevail with these early cultivators of our science. The word chemistry, regarding the derivation of which so many conflicting opinions have been expressed, is now generally admitted to be of Egyptian origin. According to Plutarch, Egypt, in consequence of the black appearance of the soil, was called Chemia, and the same term was applied to the black of the eye, the very symbol of what is hidden and obscure. This fact of secret working, and also that of confining attention to the attempt to discover that which could never be discovered, no doubt exercised a most retarding influence on the progress of chemistry, and makes the extraordinary rapid rise of the science in later years the more wonderful.

The year 1774 may be looked upon as the date of the turning-point, or indeed as almost the natal year of chemistry, for on the first day of August of that memorable year, Joseph Priestley discovered oxygen gas—a discovery, as we all know, of the most vital importance, one indeed of such moment at that time, that in the then state of chemical matters, it was absolutely necessary that it should be made in order that the science should be put upon a proper foundation, and should be arrested, so to speak, in its backward course. Previous to the time of Priestley's famous discovery, the most erroneous ideas were entertained regarding the most elementary chemical changes, and although Priestley to the day of his death was a firm believer in the absurd phlogistic theory, he did more than any one else to bring about its destruction, and to pave the way for the entrance of truth where gross error had erewhile reigned supreme.

Going back some ten centuries from the time of Priestley, we read of a highly cultivated Arabian—who possessed, unfortunately, a somewhat unpronounceable name, but which, however, has been supplanted by the more manageable one of Geber—who seems to be the first chemical author whose works have, to any extent, been handed down to the present day. Where Geber—who has been called the founder of chemistry—obtained his information, is not very clear; but wherever it was derived, it was for the eighth century by no means scanty, although it must be admitted that a great deal of error was intimately alloyed with the grains of truth which he possessed. Thus he was tolerably well acquainted, in some respects, with the metals—gold, silver, copper, iron, tin, lead, and mercury; but he regarded the first six of these as being compounds of mercury and sulphur in different proportions. Gold and silver, he said, contained more pure mercury than the others, and in that way he explained the different behaviour of these two metals, and that of the others when exposed to heat. These two—the gold and silver—he affirmed remain unchanged in the fire in consequence of so much of the pure metallic quality entering into their composition; while the others, as they contain more sulphur and impure mercury, are readily affected by heat. He was also of opinion that the baser metals might, by having their constituents purified, be changed into gold and silver. What an amount of fruitless labour the holding and promulgation of this unfortunate opinion may have caused, it is difficult to conceive. Besides the metals just named, Geber was acquainted with some of the salts of the alkalies, and succeeded in carrying out an operation, an extension of which forms one of the great chemical industries of the present day, viz., the conversion of the carbonates of the alkalies, or at all events, the conversion of one of these, carbonate of soda, into caustic soda, by boiling a solution of the carbonate with quicklime. He also succeeded in preparing nitric acid, although by a somewhat tedious process, and from the nitric acid he obtained *aqua regia*, which, we are told, he used for dissolving gold. Other compounds with which we work every day he was also possessed of, one of which was the famous red precipitate, or oxide of mercury, which Dr Priestley used nearly a thousand years after in his celebrated experiment, in which he prepared oxygen gas for the first time, and which therefore has always, since that experiment was made, been invested with a peculiar interest to students of chemistry. There can be little, indeed almost no doubt, that Geber obtained many of the processes he described from some previous worker in the same field, but still he is entitled to all praise as being a patient and apparently an enthusiastic investigator. He was, of course, completely on the wrong track when he employed his time and talents in the almost childish and absurd work of searching for the means of transforming the baser metals into gold and silver; but while we are inclined to regard with feelings of pity not unmixed with contempt the spectacle of a man devoting his life to such a pursuit, we must not forget that while Geber thus plodded on in murky darkness, he obtained some really useful results, and practised processes so serviceable, that they were employed by his successors for centuries after his death.

Passing from the time of Geber over a period of three or four centuries, during which interval the schools and other educational institutions of Arabia showed their power and value by giving to the world some eminent men, but which does not seem to have been very prolific in chemical discovery, we come to the time of the German alchemist, Albertus Magnus, who was born in 1193, and who became Bishop of Ratisbon about sixty years after. This worthy bishop, we are told, was not only a theologian and alchemist, but also a magician, and many wonderful stories are related describing his powers in the magical art. Albertus followed Geber in his idea that metals were composed of mercury and sulphur, and he also seemed to believe that the different metals were produced by the different combinations of these two substances. This, of course, he could not prove, so he did not do much good in that direction. He certainly, however, made a decided step in advance when he proved experimentally that sulphide of mercury was composed of sulphur and mercury. This he accomplished synthetically by causing a mixture of these two substances to sublime. He also showed a very simple, but quite effectual mode of separating the two metals, gold and silver. His plan was simply to treat the alloy or mixture of the two metals with nitric acid, when the silver, being soluble in that liquid, disappeared, leaving the gold behind in an insoluble state.

Albertus was a somewhat voluminous author, and among other subjects on which he employed his pen, he wrote on that never-failing one, the philosopher's stone, and also on the origin of metals.

As a magician he seems to have outstripped his professional brethren of later years, as among many other feats of magic, he is said, in conjunction with a pupil, to have made a statue of brass, which he succeeded in animating by means of his elixir. This statue, it seems, was for a time very useful as a domestic servant, but unfortunately, like some of its modern flesh and blood counterparts, it was very talkative. Its excessive loquacity, indeed, proved its ruin; for on one occasion it so annoyed a mathematical pupil, who was deeply engaged in studying a proposition, that he took a hammer and smashed it to atoms, to the great grief of Albertus.

Contemporary with the great German alchemist just noticed was Raymond Lully, who lived in Spain, and who, we are aware, was a voluminous writer, but who does not seem on the whole to have contributed much to the common stock of chemical knowledge.

Coming nearer home, we find during the life of Albertus Magnus, a celebrated alchemist, and a great countryman of our own—Roger Bacon—being tried at Oxford on a charge of magic. To this charge he replied in his well-known treatise, in which he showed that what had been ascribed to supernatural agency was really due to the ordinary operations of nature.

Bacon, there is little doubt, was in advance of his time in regard to scientific matters in general; thus he is said to have invented, or at least improved, the telescope, and also the camera obscura, and to have made many other discoveries. The proof regarding many of the inventions ascribed to him is no doubt a little defective, but we have certainly sufficient evidence to show that he at all events was possessed of great learning, and of many accomplishments which in his day were very rare.

With all these, however, he does not seem to have done very much for chemistry, although to him must be given the honour of having first pointed out the difference which exists between what I may perhaps call theoretical alchemy, or alchemy—or, more properly speaking, chemistry—studied for its own sake or for the advancement of the science, and practical alchemy, or the pursuit of alchemical operations for the purpose of personal gain. Whether Bacon invented gunpowder is not very certain; it is probable he did not. It is tolerably plain, however, that he was in some degree acquainted with it, and he was no doubt the first in England who possessed any real information regarding it. Thus he speaks, though somewhat obscurely, it must be admitted, of a compound of saltpetre which possessed extraordinary properties. By mixing this salt with certain other ingredients, which, although they are not directly named, are evidently sulphur and charcoal, he says you can make thunder and lightning if you know the method of mixing them. And he furthermore speaks of a kind of matter of which a quantity not larger than a man's thumb can be made to produce a horrible noise and a sudden flash of light. This matter thus darkly hinted at was no doubt gunpowder, and yet, although thus early known by one man, was not used till the year 1346, or about sixty years after the death of one who, if not the inventor, was at least well acquainted with its properties and powers. Bacon unfortunately had had bitter experience of the evil effects of speaking too plainly, and he consequently adopted an obscure style in his writings, which, no doubt, as it made his meaning often difficult to understand, and not unfrequently hid it altogether, retarded very seriously the early progress of chemical science.

When we come to consider the character of a man of the mental calibre of Bacon, and remember at the same time that he was a zealous alchemist and a believer in the possibility of the transmutation of the metals, we are fairly puzzled to account for the grounds on which this absurd belief was founded. A man of his stamp, even in these early unscientific days, must surely have had evidence of some kind on which to found his belief; and yet, from what we know, any evidence he could have possessed on this subject must have been of the most flimsy description. Alchemists, as is well known, believed in the possibility of discovering a substance which they called the philosopher's stone, and which they said would possess the power of transmuting the baser metals into gold and silver by merely being brought in contact with them when in a state of fusion. The only reason, and it is a very poor one, which, as far as I am aware, they ever had for believing in the existence of any power such as was said to be inherent in the philosopher's stone, was the fact that certain metals by being melted with other substances are changed in colour. Thus it was well known before Bacon's time that red copper by being fused with oxide of zinc was converted into golden yellow brass. This change, however, could not have deceived these early experimenters, for, as we have seen already, they knew quite enough of chemistry to be able to distinguish gold from other metals. What has always appeared to me to be supremely ridiculous in this chase after gold is, that the very attainment of the end in view would have defeated its object, for gold would then have become so plentiful as to have been of little value. Absurd, however, as the aspirations of the alchemists were in their attempt to produce the philosopher's stone and the water of life, they were not altogether without value, as frequently in these gropings in the dark they stumbled upon some valuable scientific truths, thereby acquiring an acquaintance, more or less perfect, with very many chemical compounds.

Passing on about a century and a half from Bacon's time, we come to Basil Valentine, who was born in the year 1394, and who in some respects deserves to be ranked as one of the most celebrated of the alchemists. He wrote very extensively, and was careful enough to take measures to ensure the preservation of his works. He buried them in the wall of a church at Erfürt—his native place—where they lay in safety for a long time, and were discovered ultimately, many years after his death, by the aid of a thunderbolt, which shattered the wall and exposed the treasures to view.

Valentine agreed so far with Geber as to say that the metals were composed of sulphur and mercury. He, however, added another ingredient, viz., salt—the metals, according to his ideas, being composed of these three substances.

Valentine was acquainted with many of our chemical preparations, such as acetate of lead, sulphide of arsenic, fulminating gold, nitrate of mercury, etc. He also, we are aware, knew how to manufacture sulphuric and nitric acids. To obtain the former he distilled sulphate of iron, a plan still practised in Germany for obtaining what is known as fuming sulphuric acid, a material much stronger than our English acid. Valentine's name, however, is principally identified with antimony, and his most important work is one devoted to the discussion of that metal and some of its compounds. He worked indeed so zealously, and to such good purpose, in this field, that up even to the beginning of the present century very little, if any, additional information had been gathered respecting antimony or its compounds. Valentine is said to have given the metal the name it now bears, which was derived from the result of a physiological experiment he had made. The story is told that on one occasion he administered a dose of antimony to some of his convent pigs, who thrived upon it, and became very fat. Observing this good effect, he decided, unfortunately, to extend the experiment so far as to try the effect of the metal on some of his brother monks. The antimony, however, had not the same effect on them as it had on the pigs, as they—instead of growing more sleek—all sickened and died. So, said Valentine, "though good for pigs 'tis bad for monks:" hence the name *antimony*, "adverse to monks."

In his otherwise, in great part, useless researches after the philosopher's stone, Valentine did good service to early medical science by investigating and describing, with considerable accuracy, the medicinal value of many of the compounds with which he was acquainted. One great fault Valentine possessed, for which perhaps, however, as it was the custom of the time with men of his calling, we must not blame him too much, was his absurdly operose and obscure style of writing, and his extensive employment of symbolical designs.

It is supposed that about the time in which Valentine lived, medical chemistry, if it was not actually founded, began, at all events, decidedly to take root. Hitherto men had apparently in their researches in this direction mainly devoted their time and their energies to the attempt to discover the *elixir vitæ*, which, as we all know, was supposed to be a panacea for every ill. This search, however, which had proved fruitless in many other instances, in Valentine's case led to the discovery of many potent medicines.

Paracelsus, who was born in 1493, about a century later than Valentine, may almost in strict justice be called the father of medical chemistry. Like Valentine, Paracelsus held the opinion that matter was composed of three constituents; he, however, went a step farther than Valentine did, and did not confine this theory to inorganic substances, as had been done previously, but held that organic substances were likewise composed of three kinds of matter; and on this basis he explained the nature of disease. As long, he said, as the three components of the body are present in their true and proper proportions, health will continue; but if these due proportions are disturbed, then disease will result. By pointing out the value of chemistry as an aid to medicine, there is no doubt that Paracelsus did good, both by bringing fresh workers into this field, and also by removing the attention of men from the vain pursuit of the philosopher's stone. Beyond his labours in connection with the union of chemistry and medicine, he does not seem to have done much original chemical work. Paracelsus was born near Zurich, and he spent a portion of his life travelling in France, Spain, Italy, and Germany, with the view of improving his medical knowledge; and it has been asserted that to some remedies with which he became acquainted in these journeyings, and by means of which he was enabled to perform some wonderful cures, he attained not a mean share of his reputation. He has also been accused of boasting of being in possession of the philosopher's stone, the *elixir vitæ*, etc. Be this as it may, there can be no doubt that Paracelsus did good work, even if he had done nothing more than effect the junction of chemistry and medicine, a service which it is freely acknowledged he rendered to science.

Contemporary with Paracelsus was George Agricola, who was considered, and I think justly so, the most celebrated metallurgist of his time.

He certainly must have worked to some purpose in the particular branch of the science to which he devoted himself, as some of the processes with which he was acquainted are in use even in the present day. To technical chemistry he, without doubt, lent a valuable helping hand.

Andrew Libavius, who died about sixty years after Agricola, made a praiseworthy attempt to free chemistry from the absurdities of alchemy, and yet, curiously enough, he himself firmly believed to the end in the transmutation of metals. Libavius rendered signal service to the science by the publication of his "Alchemia." In this book, which was published about twenty years before his death, he sets forth in plain and forcible language all the then known leading chemical facts. He was a patient worker, and was rewarded by his labours resulting in discovery. The useful and most important salt, stannic chloride, which to this day is known as the fuming liquid of Libavius, was due to one of his researches. The object which he had principally in view in the course of his labours was the preparation of medicines, but he was also well known for his power of making artificial gems. He seemed to be able to imitate almost any precious stone with considerable fidelity; this he did by a process which no doubt was not very generally known in his day, but which is now common enough.

About thirty years after the death of Paracelsus, there was born in Brussels the celebrated John Baptist Von Helmont, who is said to have made such rapid progress in his studies, that he delivered public lectures at the age of seventeen. Notwithstanding some curious errors into which he fell, or rather from which he did not succeed in extricating himself, Helmont assisted materially the progress of chemical science. Previous to his time the almost universal belief seems to have been that when a metal is dissolved in acid, it is destroyed; he showed, however, that this supposed destruction did not take place, but that the metal during this action passed into a state of solution, from which it could by proper processes be recovered. Helmont also was the first who formally attacked the old theory of the four elements. He asserted that earth could not properly be considered an element, as it was possible to convert it into water; and fire, he maintained was not an element, because it had no material existence. He certainly was correct in his enunciations, that neither earth nor fire are elements, but the reason he gives why earth should not be considered an element is a remarkably poor one, and not worthy of a man of Helmont's powers. The other two elements of Aristotle, viz., air and water, he admitted were elementary in their nature. Water being a single and true chemical compound, we cannot wonder that—in those dark days when chemistry was still in its early infancy, being indeed as yet hardly born—it should be regarded as being composed of one kind of matter only; but it does seem surprising that Helmont, who was so far in advance, and who in fact was the first to demonstrate that there are different kinds of air, should have been contented to consider air as an element. Among the many valuable discoveries made by Von Helmont, one of the most important was the discovery of the gas which we in the present day call carbonic acid, but which he named gas silvestre. This substance, he tells us, is formed during the processes of combustion and fermentation, and is found in the Grotto of the Dog near Naples. By Helmont's labours a very great deal was done in the way of overthrowing old erroneous ideas, and although he did not accomplish exactly all which we—looking from a coign of vantage—think he might have done, we must acknowledge that he prepared the way for a decided forward movement being advantageously undertaken. Unfortunately, however, his discoveries were not fully utilised, and in point of fact many of the most valuable of them were neglected and forgotten.

Contemporary with Helmont was the well-known medical chemist, Glauber. Glauber had a happy knack of picking up and examining things which other people threw away, which peculiarity led, among other things, to the discovery of the salt which has for long borne his name. This salt is now rightly known as sodium sulphate, but it will be long before the old-fashioned familiar title, Glauber salt, is forgotten. Like a great many other philosophers of his age, Glauber unfortunately wasted a deal of time in a determined search for the philosopher's stone, and though he undoubtedly discovered some useful medicines, it does not appear that he promoted in any very signal manner the progress of chemical science.

About the time of Glauber's death, Nicholas Lemery, a French chemist, published a work which became exceedingly popular, and which influenced greatly the progress of the science. In this work there appeared for the first time a statement of the distinction between substances of animal origin and those of vegetable origin; and so we may say that as early as 1675 was the division which we still in a sense retain between organic and inorganic chemistry instituted. Lemery regarded earth and water as elements, and it was not until the distinguished philosopher Robert Boyle, who was born in Lismore, Ireland, in the year 1627, began his researches, that the absurd theories of Aristotle concerning the four elements, and of Paracelsus concerning the three kinds of matter, were proved to be absolutely false. Boyle was perhaps as much, or even more, a physicist than a chemist, but he certainly rendered very great service to chemistry. In fact, had he done nothing more than point out, as he did forcibly, that the true aim of chemistry was neither to discover the philosopher's stone nor the *elixir vitæ*, but was, by means of pure scientific research, to increase the store of human knowledge, he would be entitled to be honourably remembered by scientific men. Boyle, however, as is well known, did far more than this—his whole life indeed was devoted, and profitably devoted, to scientific research. It is to him we owe our first correct ideas regarding true elementary substances; and his teachings on this subject were really so important as to justify us in dating the commencement of a new era in the history of chemical science from his time. Hitherto men had either inclined to the Aristotelian or Paracelsian doctrine of the elements, and had regarded chemistry merely as a servant of the physician or as something worse of the alchemist. Boyle, however, completely overthrew both of these ideas, and by so doing forwarded greatly the progress of chemical science. By the world in general Boyle's name is best known in connection with the discovery of the well-known law—that the volume of a gas varies inversely as the pressure—which rightly bears his name, although a strong attempt was made, and is still made, I presume, to claim the honour of the discovery of this important law for a French philosopher, Mariotte. About the year 1672, or about a hundred years before the discovery of hydrogen was made by Cavendish, Boyle actually prepared this gas. He did so by dissolving metallic iron in acid, and he experimented so far with the new gas as to prove its combustible nature. He does not seem, however, to have carried his investigations much further than this point, and the honour of the discovery of hydrogen is always ascribed to Cavendish. Boyle, like many other great men, had a weak point, and in his case this consisted in allowing his mind to be unduly influenced by what perhaps I may be allowed to call a pet theory. He held most tenaciously certain erroneous opinions regarding flame, which action on his part, when we remember that these ideas must have been adopted without any proof of their accuracy, seems to us certainly a very extraordinary one, especially in the case of a man gifted with such mental powers as he possessed. Like other learned men of his day, Boyle was well aware that certain metals, when they are heated in contact with the air, produce compounds, or calces as they were then called, which invariably weigh more than the original metal from which they are formed. He made many experiments with the view of determining the cause of this increase of weight, but his mind was so much influenced by the opinions he held regarding the ponderable nature of flame, that he unfortunately, as many other philosophers have done, attempted to bend the facts to suit his theory, and came to the conclusion, as the result of his investigation, that fire or flame was of a material nature, and was capable of conferring weight. This certainly was a most unfortunate conclusion, and was the means, quite possibly, of preventing Boyle from anticipating some of the brilliant achievements of men who lived nearly a hundred years after his death. Boyle, so far as we can ascertain, was the first to promulgate correct ideas regarding elements and compounds. He said boldly that it was not possible to state—as it had hitherto been supposed it was—the exact number of elements, but that such substances as could not be resolved into simpler forms, and which had been obtained from a compound body, and from which the compound could be again prepared, were to be so regarded. This certainly comes very near to our modern definition. Boyle has been called the first scientific chemist, and he certainly merits the honourable appellation, for although not purely, or even perhaps principally, a chemist, his scientific work, and the clear statements he made regarding the value of true scientific investigation, well entitle him to the distinction.

In the year 1665 was published Robert Hooke's "Micrographia," which contained an account of his remarkable theory of combustion. In this, which was perhaps the first chemical theory worthy of the name, he declared that the air is the universal dissolvent of all sulphurous, or, as we should say, of all combustible bodies. The air, however, could not effect this action until the sulphurous or combustible substance was sufficiently heated; and he further explained that the dissolving operation produces great heat. He also taught that this peculiar dissolving action is caused by a substance belonging to or mixed with the air, which is like, if it is not the very same as, that which is fixed in nitre, and that, while the dissolving parts of the air are but few, saltpetre, when red hot and melted, abounds with them. All this, of course, seems to us nothing more than very crudely stated truisms. When we reflect, however, that this theory was propounded more than a hundred years before the discovery of oxygen, and when phlogiston was just beginning to be heard of, we cannot but admire the genius of the author, the great success of his experimental research, and the wonderfully correct conclusions he deduced therefrom. By stating that air was the universal dissolvent of sulphurous bodies, he simply meant to say that combustibles exposed to the air, under certain conditions, were dissolved by it. We say, for example, that a piece of charcoal in a red hot condition, exposed to the air, disappears and becomes converted into carbonic acid; while Hooke, writing more than two centuries ago, says that it is dissolved by the air—a statement which, it must be admitted, is wonderfully correct. Again, he says that the air will not dissolve the body until that has been sufficiently heated, which is just what we express by saying that different substances ignite at different temperatures; and further, he tells us that fire is the result of this action, or this dissolving process. More wonderful still, he tells us most distinctly that this dissolving power of the air is owing to a substance inherent in itself, which is like, if it is not the same as, that which is fixed in common saltpetre. We know now, after Priestley's famous discovery has been made, that Hooke, writing more than a hundred years before the result of that was known, was in these statements quite correct. The oxygen, which is the principal constituent of saltpetre, is the same element as that which confers upon air its "dissolvent power." On another occasion Hooke makes the remark, that it is reasonable to think that there is no such thing as an element of fire, but that what we call flame is nothing more than air mixed with the volatile sulphurous parts of combustible substances. Although these explanations of natural phenomena given by Hooke are quaintly and imperfectly, and even in some cases erroneously, given, still we cannot fail to be struck with the clear indications which they afford, that he was certainly on the right road, and also by the amount of real information which he had acquired, as the result of his valuable and remarkable investigations. Hooke expressed his intention, if opportunity and life were given him, of prosecuting, improving, and publishing his theory. This intention, however, he did not fulfil; but an Oxford physician, named John Mayow, who was born about ten years after Hooke, eagerly took up the work, and by means of many well-contrived experiments, elaborated and supported Hooke's theory. Mayow was among the first who made experiments with gases over water; and his book, in which he treats of what he calls *spiritus nitro œreus*, contains the description of many experiments in what is now called pneumatic chemistry. The date of the discovery of oxygen gas, which discovery is justly reckoned one of the most brilliant ever made in chemical science, is engraven on all our minds; in fact, August 1, 1774, has been called the birthday of chemistry. The more, however, which I read of and ponder on John Mayow's experiments, and the conclusions which he deduced therefrom, I am the more inclined to think that oxygen was almost discovered a hundred years before Priestley's famous *chef-d'œuvre;* and any one who reads carefully what Mayow has done in connection with this subject will, I imagine, be much of the same opinion.

The "dissolving part," as he terms it, of the air and of nitre, he calls nitre-air or fire-air. The air, he says, is not composed solely of nitre-air, for when a combustible substance, such as a candle, is burned in a confined space, only a portion of the air is consumed. Further, he says, this nitre-air or fire-air is contained in nitre, so that substances will burn even under water, or in a vacuum, if supplied with a sufficiency of nitre. Although it was thus known that this fire-air was a powerful supporter of combustion, Mayow was quite well aware of the fact that it itself would not burn. All acids, he goes on to say, contain nitre-air; sulphuric acid, for example, he tells us, consists of a union of nitre-air and sulphur. Several changes, such as fermentation, putrefaction, and souring of wines, are, he explains, owing to the action of this nitre-air. More wonderful still, he, in the face of the at-that-time-much-lauded phlogiston theory, distinctly taught that, during calcination, metals increase in weight, not because they lose phlogiston, but *because they absorb nitre-air*, or, as we say now in language hardly more correct, because they oxidise. In fact, so much in accordance with our modern theories are Mayow's statements, that if we made a few trifling alterations in the names of some of the substances he makes use of—such, for instance, as substituting the word oxygen for nitre-air—we could almost imagine, as we peruse his writings, that we had before us a book twenty years old instead of two hundred. A most important item in Mayow's work was his recognition of the part played by his nitre-air in respiration. He noticed that, and he also pointed out the compound nature of the air. Mayow was, in fact, far ahead of all his predecessors, and he did a great deal to extend the then scanty stock of chemical knowledge; indeed there is little doubt, I think, that if the works of this wonderful man had only been a little more faithfully studied at the time, the world would not have heard so much about phlogiston, and subsequent great chemical discoveries would have been made much earlier.

Another theory than that of Hooke, and one of a very different nature, was advanced about the same time as that in which Mayow had been making his famous experiments. The celebrated phlogiston theory, which shed such a powerful influence on the science of chemistry, first saw the light about the year 1669. This theory, which was first promulgated by John Joachim Becher, and afterwards supported, and in great part altered, by George Ernest Stahl, was proposed for the purpose of explaining various chemical phenomena, but principally that of combustion. There can be no doubt whatever that the advancement of this theory of phlogiston created in its day a profound impression, and attracted a vast deal of attention; but I think that, in our own time, it is very generally conceded that its usefulness has, to say the least, been very greatly overrated; and I imagine I am tolerably safe in saying, that about the only real service it ever rendered, was that of enabling a certain amount of method to be introduced into what had been hitherto, no doubt, exceedingly unsystematic. It has been said, and firmly maintained, by the supporters of this theory, that its rapid general adoption showed that it supplied a real want, as in point of fact it did. A want, however, may be supplied in a wrong way, as was the case in this instance. A void certainly did exist, but it is a marvel to me how it could have been filled by the absurd phlogiston theory, especially in the face of the masterly researches of Hooke and Mayow, which, as I have already indicated, were being conducted just about the time this theory was first brought forward. The phlogiston theory, as most people are aware, assumed the existence of a combustible principle, which was called phlogiston, and which, I think, I cannot better describe than by calling it the opposite of oxygen. When a substance is burned, the supporters of this theory taught that it lost phlogiston; and when it was, so to speak, unburned, they asserted that it gained phlogiston. Thus mercury, if it is heated in contact with the air for a certain time, loses its liquid form, and becomes a powdery solid. This change, we are told by the phlogiston advocates, is owing to the metal having lost phlogiston. If, again, the reddish powder, obtained in the way just described, be heated a little more strongly, another change takes place—the metal reappears, owing, so says Stahl and his followers, to its having absorbed phlogiston. That is to say, the metals, such as mercury or lead, were regarded by Stahl as compounds, whose constituents were phlogiston and the calx, or, as we should say, the oxide of the metal. In other words, the loss of phlogiston was identical with what we call absorption of oxygen, and *vice versâ.* Here, however, a difficulty arose. It was noticed that substances, by losing phlogiston, became heavier, and that by gaining it they became lighter. The phlogistians, however, got over this. They had proposed a ridiculous theory, and they were quite ready to support it by equally ridiculous assertions. Phlogiston, they explained, was a principle of levity, and conferred the property of lightness upon substances with which it was combined, much, indeed, in the same way as bladders lighten the swimmer to whom they are attached. Although this theory found many supporters even among men of genius, as witness the great Henry Cavendish, it must not be supposed that it was allowed to pass unchallenged. On the contrary, it was assailed from many different quarters, and notwithstanding its numerous friends, it ere long began to wane. Phlogiston was a substance so purely hypothetical, that it now became necessary, in order to support the tottering theory, to produce it in a tangible form, and as a last resource, hydrogen gas, with which Cavendish had recently been experimenting, was declared to be phlogiston. This was, however, an unfortunate step. So long as the phlogistians confined themselves to generalities, they were tolerably safe; but when they particularised in this decided manner, they stepped on dangerous ground. The phlogiston, as described by Stahl, was found to be so different from the hydrogen of Cavendish, that the theory by this false stroke received its death-blow. Lavoisier, about a hundred years afterwards, in a way to be shortly pointed out, showed the utterly untenable nature of Stahl's doctrine.

The time which elapsed between the date of the enunciation of the phlogistic theory, and that of its final *quietus*, was one of great progress. We are now at a point in our history when we, just emerging from a period of deep gloom, dispelled only occasionally by the results of the labours of such men as Paracelsus, Helmont, Boyle, Hooke, and Mayow, are about to enter one of dazzling brilliancy. The latter half of last century was the period in which the foundations of modern chemistry were fully laid; and prominent among the workers in this field during this fruitful time was Joseph Black, who was born of Scottish parents at Bordeaux in 1728. Black's great work, and the one which has made his name immortal, was the discovery of latent heat, the principles of which he expounded to his students in Edinburgh and Glasgow. The discovery of latent heat was certainly Black's greatest work; but that which has, perhaps, most interest for chemists, was his researches on the fixed alkalies, the results of which were published in 1755, and which rendered signal service in contributing in no small degree to the final overthrow of the phlogistic theory. Black brought a great power to bear on scientific research when he introduced the use of the balance so extensively in his investigations, and, indeed, it was by the skilful use of this invaluable instrument that he was enabled to complete satisfactorily some of his most famous researches. Thus, before Black's time, the carbonated or mild alkali, as it was then called, had always been regarded as a substance of a simpler composition than the caustic alkali. The latter, instead of being looked upon as something less than the former, was regarded as a compound of the former—that is, the carbonated alkali—with what was designated, somewhat vaguely it must be admitted, the principle of combustibility. So that when ordinary limestone, or what we call carbonate of lime, was exposed to the heat of a furnace, it was supposed to unite with the principle of combustibility, and thereby to become more complex in its nature than was the original limestone. And further, if this quicklime, resulting from the heating operation, was boiled with a solution of carbonate of potash, the change which took place was explained by saying that the carbonate of potash became caustic by taking from the quicklime the principle of combustibility which the latter had obtained from the fire. Black showed, however, by means of the balance, that the heating of magnesia alba, which rendered it no longer capable of effervescing with acids, was accompanied by a loss in weight, which certainly would not have been the case had it taken up any principle of combustibility from the fire. Black gave us, indeed, the correct information we now possess regarding the carbonating and decarbonating of alkalies. He showed most distinctly that carbonic acid, or, as he called it, fixed air, is given off from carbonated alkalies by certain modes of treatment, and that the change in their properties which these substances suffer when thus treated, and so rendered caustic, is owing to this loss, and not to the absorption of anything from without. This fixed air of Black, it is right to mention, was really first discovered by Helmont, who called it gas silvestre. Helmont's work, however, had been long forgotten by Black's time, so that that philosopher really made the discovery anew. The composition of this gas—which Black called fixed air, because it exists in a fixed or solid form in the alkaline carbonates—was first properly demonstrated by Lavoisier, who showed it to consist of carbon and oxygen.

Somewhat less than twenty years after Black published the results of his researches on quicklime and other alkaline substances, Joseph Priestley was busily engaged in investigating the changes produced on air by the breathing of animals, and by the burning of combustible substances in it. He found and proved conclusively that both respiration and combustion altered the character of the air, and also lessened its bulk. He also investigated the effects which living plants produce on air, and among other things he found, to his astonishment, that living plants had the power of undoing, so to speak, what the respiration of animals or the burning of combustibles had done. He found, for example, that a candle after having burned a certain time in a fixed quantity of air became extinguished, and that the residual air—which would no longer support combustion, nor enable an animal to breathe—was restored to its original condition by the action of a living plant. These experiments, which were made about the year 1772 or 1773, were preparing the way for his great discovery, which was made in 1774. On the first day of August in this year, Joseph Priestley discovered oxygen—a discovery deemed so important as to cause this memorable day to be called the birthday of modern chemistry. The mode in which the great discovery was made is well known. Some oxide of mercury, or red precipitate as it was then called, was heated in a closed glass vessel by means of the sun's rays, concentrated with a lens. The oxide was decomposed, and oxygen was given off. The name oxygen, by which the gas is now universally known, emanated from Lavoisier; Priestley called it dephlogisticated air. By his numerous admirers Priestley has been called the father of pneumatic chemistry; and no doubt his most valuable discoveries, especially in this department, entitle him to all praise, and yet he was not exactly the kind of man we would select as being eminently fitted for scientific investigation. He had an idea, I conceive, that discoveries are made by chance, and although he made a great many most important discoveries, he seems to have passed over without grasping, or, at all events, without rightly explaining, results which he obtained, and which might, if they had been properly utilised, have proved most valuable by paving the way for obtaining others. Thus, for example, although he had noticed the formation of water by the burning of a mixture of hydrogen and oxygen, he seems to have passed it over—wonderful as it must have appeared to him—without giving any real explanation of the phenomenon. This discovery, that is, the discovery of the composition of water, which might have belonged to Priestley, is ascribed, and rightly so, to Sir Henry Cavendish. Priestley not only produced the water by causing the hydrogen and oxygen to combine, but he observed and noted it, leaving the explanation of what he had done to be given by others. Curious as it may seem, Priestley was a firm believer in the phlogistic theory, and continued so till the last, although he, by his great life's work, had done more than any one else to bring about its overthrow.

Contemporary with Priestley, and like him in being the author of some valuable discoveries, and yet very unlike him in the mode of doing his work, was the celebrated Sir Henry Cavendish. Cavendish was born in the year 1731, and being of independent means, he devoted himself exclusively to scientific pursuits. He worked zealously and faithfully, and though he did not make so many brilliant discoveries as Priestley, or perhaps do so much work, yet what he did was done more thoroughly and completely. His work was greatly quantitative, and as proof of the accurate nature of his mode of carrying on his investigations, we find him in his experiments with gases making corrections for changes caused by the alterations of temperature and pressure, a refinement somewhat unusually observed, I am inclined to think, in these early days. The great work with which the name of Cavendish is inseparably connected is, of course, his discovery of the composition of water. His researches, however, upon hydrogen, or inflammable air as he called it, were very important and interesting. This inflammable air of his he obtained by the action of dilute acid upon certain metals, such as iron, zinc, and tin; and as showing the perfect way in which he carried on his experiments, I should mention that he clearly determined that the air given off from each metal was the same both in quantity and quality, no matter in what proportion he added the acid so long as the same amount of metal was employed. Cavendish also made a series of experiments by acting on the metals just named with acids of different degrees of concentration. Thus he found that with strong nitric acid the effect, to a certain extent, was the same as with, say, dilute sulphuric acid, viz., that gas was generated. He found, however, that the result was so far different, that while in the case of dilute acid the gas which was given off was inflammable, in the case of the strong nitric acid the gas which was evolved was not inflammable. He also made experiments in which he treated different metals with strong sulphuric acid, the result of which was that what he called sulphurous air was evolved. All of which are the same results as we obtain in the present day, and are described in language almost identical with ours. From this we have good proof that Cavendish was an accurate experimenter and observer. Unfortunately in his explanations of these different effects, he dragged in the phlogistic theory, in which, strange as it may seem, the great Sir Henry Cavendish was a firm believer. The gas which was given off when the metals were dissolved in dilute sulphuric acid he regarded as phlogiston. The metals, it will be remembered, were regarded by phlogistians as compounds consisting of the calx of the metal united with phlogiston. This phlogiston, therefore, as Cavendish remarks, is given off alone by metals when they are treated with dilute acid, but is evolved in combination with the acid when the metals are treated with that in a concentrated state. If this absurd phlogistic theory had never been heard of, and therefore not instilled into every one who gave any attention to chemical matters, as it seems to have been at one time, it is quite possible, indeed I think it is highly probable, that Cavendish, not being able to account in the way he did for metals giving off gas when subjected to the treatment referred to, might have made some experiments to ascertain whether the gas did not arise from the other ingredients he was using, and thus have anticipated Lavoisier's great achievement. As the result of all his training, however, his mind was evidently thoroughly imbued with the idea that metals are compounds containing phlogiston, and in the circumstances, what was more natural than to conclude when he saw the metal, during his experiment, disappearing, and gas being given off, that the former was being decomposed, and that the gas which was generated was the phlogiston arising from that decomposition. In the year 1781 Cavendish made his great discovery—that one with which his name is inseparably connected. Water, as we all know, had for long been regarded as an element; by a series of masterly experiments, however, which he carried out at this time, Cavendish clearly proved its compound nature. He was led to his famous discovery by noticing that in making some experiments in which he exploded a mixture of inflammable air, or hydrogen as we now call it, and common air, there was invariably a certain amount of moisture or dew produced. This matter he at once set to investigate, and in his own thorough and accurate fashion—being careful to work quantitatively, as indeed he did in almost all of his investigations. He took an accurately measured quantity of inflammable air and burned it with about two and a half times as much common air, and, in order to be able better to examine the products of the combustion, he caused the results of the burning to pass through a long glass cylinder. By this means he got a deposit of dew amounting in all to 135 grains, which, as it had no taste or smell, and did not yield any residue or pungent odour on evaporation, he rightly concluded must be water. In this way, then, but by using many precautions, and making a long series of calculations which it is quite unnecessary to enumerate here, did Cavendish fairly prove the composition of water. It has been suggested, and I believe with good reason, that although Cavendish thus showed how water could be produced, he had really no very clear ideas on the subject of water being a chemical compound of hydrogen and oxygen, and that in point of fact his own opinion of the matter was that the water existed ready formed in the hydrogen or inflammable air as he called it. Cavendish to the last was a firm believer in phlogiston, and it seems to me that his strong faith in that most ridiculous of theories must have tended to warp his mind, and frequently to lead him off the path of truth. Thus he says, speaking of the results of his researches on water: "From what has been said, there seems the utmost reason to think that dephlogisticated air is only water deprived of its phlogiston, and that inflammable air is either phlogisticated water or else pure phlogiston, but in all probability the former." Had his mind not been imbued with this theory of phlogiston, would it not be very natural to suppose that Cavendish, having put two gases together, and after having fired them, finding the gases disappear and water produced in their place, would come to the conclusion that the water had been formed from them, and was therefore composed of them. Unfortunately, however, the phlogiston was dragged in, and the obvious and simple explanation of the result of his experiment was ignored.

We have now reached what must be considered one of the brightest periods in the history of chemical science. Oxygen has been discovered by Priestley, Black has experimented with fixed air, and Cavendish has made his masterly researches on inflammable air. Nitric oxide, hydrochloric acid, ammonia, sulphurous acid, and a number of other gases are known.

The famous discovery of Cavendish leads us to consider the valuable results which were being obtained at this time by the world-renowned Scheele, then a poor Swedish apothecary. Scheele, like some of the other great chemists of his day, was a firm believer in phlogiston, and, as might be expected, he in consequence, like them, fell into a great many errors in explaining the results of some of his experiments. Scheele, however, will long be honourably remembered as the discoverer of chlorine, and also for his valuable researches on Prussian blue, which led, among other things, to the isolation of Prussic acid. Scheele, it should be noticed, also discovered oxygen. His discovery of this gas was made, it appears, subsequent to that of Priestley, but it was made quite independently. In consequence, however, of priority, the honour of this discovery is always accorded to the English chemist. Scheele did not content himself with investigations in inorganic chemistry alone; he turned his attention to the organic department, and as the result of his labours in this branch, he discovered, or, at least, first properly identified, the following among other acids: tartaric, oxalic, citric, lactic, etc., and in doing so fairly broke ground on this fertile field of organic chemistry, which has since been cultivated with most marvellous results. Scheele also in a manner may be said to have laid the foundation of quantitative analysis, as he was the first to make use of these distinctive properties of substances, in order to effect their detection and separation, which are now employed for the same purpose so extensively by students of chemical science in our own day.

From what has been said, it can easily be understood that the science of chemistry in the time of Scheele was much further advanced than it was before the onward movement given to it by Boyle, Hooke, Black, Priestley, and Cavendish. But, notwithstanding the valuable labours of all these chemical giants, the science was still under a dense cloud. Priestley, Cavendish, and Scheele, men of great genius as they certainly were, all believed in the phlogistic theory—they regarded the metals as being more complex substances than the oxides or calces as they called them, and until this great and fatal delusion was dispelled, it seems to me chemical science must always have remained in a most incomplete state. In this condition, however, the science was not doomed to remain. In the year 1743 Anthony Lavoisier was born, and ere he died he gave the phlogistic theory its death-blow. Lavoisier began life under very different circumstances than did poor Scheele. He was liberally and carefully educated, and being possessed also of a considerable fortune, he was unusually well equipped for his future brilliant career. His attention having been directed to the discoveries of Black, Priestley, and Cavendish, he entered this new field of inquiry with all his characteristic ardour and zeal, and obtained many most valuable results, which at once set chemical science on a true basis, and made his own name immortal. One of Lavoisier's earliest experiments was connected with a subject in which Scheele also made some investigations. The question which had been pretty keenly discussed for some time, viz., whether water on being heated was converted into earth, was set at rest by the result of this first important experiment. In carrying out this experiment he enclosed a certain amount of water in a glass vessel, and subjected it to heat for 101 days. At the end of that time he weighed the vessel and its contents, but could detect no change in weight. He then opened the vessel, poured out the water and evaporated it, and found that with a slight discrepancy, which he ascribed to experimental error, the water left no solid residue beyond that which it had taken from the glass, and therefore he concluded that water on being heated is not converted into earth. One of Lavoisier's most noteworthy contributions to science was his enunciation of the fact of the indestructibility of matter. He clearly showed that when a chemical change takes place, of whatever nature it may be, there is never any loss of matter. Matter may change its condition, or it may be transferred from one state of combination to another, but still in every case the weight of the sum of the ingredients remains exactly the same.

In the year 1772, that is before he had attained his thirtieth year, Lavoisier commenced his famous investigation on combustion, which was destined to yield results of the greatest value to chemical science. As I have already stated, it was the prevailing opinion previous to Lavoisier's time that when such things as phosphorus and sulphur are burned, they are decomposed, and that some mysterious, undefined, and undefinable substance which was called phlogiston was supposed to escape. Lavoisier, however, clearly demonstrated that when such things as these are burned, instead of losing they increase in weight; and he further showed that this increase arose from their having absorbed and fixed something from without, which something he explained was air; and he concluded that this absorption takes place when other substances besides sulphur and phosphorus increase in weight during the process of combustion.

In order fully to prove the truth of his speculations in this matter, he performed an experiment, the converse of these in which sulphur and phosphorus were burned. In this experiment he heated some lead oxide with carbon, the result of which was quite satisfactory, as showing that the oxide contained air, which was in union with the lead, and which was given off during the heating operation, leaving the pure lead behind. The phlogistians would, of course, have explained this action by saying that the calx of lead, as they called lead oxide, was changed into the metallic state in consequence of having absorbed phlogiston from the charcoal. These experiments of Lavoisier, and the conclusions he drew from them, although not quite correct, were certainly a most decided step in advance. Lavoisier's next work had reference to respiration, combustion, and fermentation, and he showed, as Black had done some twenty years before, the production of fixed air, as carbonic acid was then called. Following these researches, he made some very important experiments, in which he heated different metals in closed glass globes, and thereby was enabled to prove that the heated metal not only absorbed air from without, but that it only absorbed a certain part of the air, and that the part which was left had properties quite different from those possessed either by common or fixed air. Lavoisier, therefore, it is clear, held the opinion at this time (1774) that the air was composed of at least two substances. He had not, however, yet heard of Priestley's discovery of oxygen, and he does not seem at that time to have possessed nearly so much information on this point as he showed himself to be possessed of some time afterwards, by reading a paper in the following year, and after he had heard of Priestley's great discovery. In this paper, which was on the nature of the principle which combines with metals during their calcination, he shows that at last the theory of combustion is fully understood. In this paper he calls oxygen vital air, and three years afterwards he called it oxygen, the name it has since borne. This name is certainly a little unfortunate, as whatever Lavoisier's opinion on the point may have been, acids exist which do not contain any oxygen.

We are now pretty well advanced on our journey, and phlogiston, that enemy to progress, has well-nigh received its death-blow. It was not, however, until the year 1783, when Cavendish had made his discovery, that Lavoisier, in conjunction with Laplace, by producing water by the direct union of hydrogen and oxygen, and so confirming the results obtained by Cavendish, silenced for ever the phlogistians.

As my object in reading this paper has been simply to give an outline of the early progress of chemical science, I may, perhaps, be excused for passing over rather summarily the description of the great dispute which took place as to whom the honour was due of having first discovered oxygen—a dispute so celebrated, that it seems almost a necessity with some historians to treat of it at considerable length. There cannot be the slightest doubt, I think, that Priestley was the first discoverer of oxygen. Lavoisier, unfortunately in this, as in at least one other case, acted a little, or, perhaps, to speak more correctly, not a little dishonestly. But this, when we remember what this truly great philosopher has done for our science, is, to say the least, not a pleasant theme to dwell upon; and I think it will suffice if I go on simply noting as I pass, that certainly Joseph Black studied the properties of fixed air, and Joseph Priestley discovered oxygen, before Lavoisier knew of the existence of either one or other of these substances.

My pleasant task, gentlemen, of reading these few notes to you is now almost closed. In the year 1794, the great Lavoisier was led to the guillotine, but he had done his work, and in doing so he erected for himself a noble and lasting monument, which shall hand down his justly honoured name to many succeeding generations. Although I should hardly care to regard Lavoisier as "the immortal father of modern chemistry," as he has been styled by some of his admiring and enthusiastic countrymen, I would at once agree in ascribing to him the honour of making such good use of the discoveries and results of experiments made by other men as to lay the foundation of modern chemistry. I do not wish for a single moment to attempt to detract in the slightest degree from the just fame of Lavoisier, and I do not think I do so in saying that I cannot help thinking that, if Hooke and Mayow could have had the results of the work of Black, Priestley, and Cavendish to guide them as the French chemist had, they might in great measure, if not entirely, have anticipated his brilliant achievements. However, they lived before the discovery of oxygen or the discovery of the composition of water had been made, and they left Lavoisier's work undone, so that, leaving supposition out of consideration, and dealing alone with what actually happened, we must ascribe full honour to the French philosopher for having finally and completely upset Stahl's phlogiston theory, and for having placed chemistry on the firm and sure base it now occupies.

It may be objected, I know, and I admit, with some show of reason, that a sketch, superficial though it be, such as I have endeavoured to present to the Society tonight, which professes to give an outline, however meagre, of the early history of chemistry, is by no means complete without at least a mention of the names and chief works of such men as Proust, John Dalton, Thomas Thomson, Wollaston, Berzelius, Davy, Gay-Lussac, Dulong and Petit, Mitscherlich, etc. The history of the labours of these chemists, however, I think belongs to an era further on than that with which I have thought it wise to attempt to deal, and therefore I have determined to make the close of last century my halting-place, the more so as I feel that I have trespassed already sufficiently on your patience, and also that the mere mention of what these men have done for our science in this paper would prolong it far beyond its legitimate limits.

It has been said by an able writer on this subject, referring to the origin and rise of chemistry, that the basis of the chemical edifice is sunk deep in Eastern soil; that the walls raised slowly and laboriously during the Middle Ages were completed by Black, Priestley, and Lavoisier, and that the men of our own day are working at the roof. I therefore stop at the completion of the walls of our noble mansion, and leave the task of describing the making and fitting of the prodigious roof to some future and more able chemical occupant of the honourable position from which I now retire.

I. *Ornithological Notes.* By JOHN ALEXANDER SMITH, M.D., F.R.S.E., etc. (Specimens exhibited.)

(Read 20th November 1878.)

1. *Otis tarda*, the Great Bustard.—This fine specimen of a female of the great bustard was shot on the island of Stronsay, Orkney, in the autumn of 1877. It is the property of Colonel Balfour of Balfour, who writes that a male bird of the same species was killed in Kent a week after this one was shot, and he supposes they may have probably been a pair of stragglers which had got separated—driven out of their course on the Continent, I suppose, by adverse winds. The female is a much smaller bird than the male. It is now one of our rarest stragglers, or visitors, to any part of Scotland, very few instances of its occurrence being recorded, although in old times it was apparently a permanent resident. It occurred more abundantly in England. Mr Keddie, Mr Sanderson's assistant, has called my attention to the curious fact that the down at the roots of many of the feathers (as well as of their accessory plumes) of the great bustard (some of which I exhibit) are of a beautiful pink, changing above into pale buff colour. This peculiarity is present in the feathers in different parts of the body, whether they are coloured or pure white above; it is less so, or absent, on head. He also tells me he has noticed a similar peculiarity in the little bustard (*Otis tetrax*).

2. Hybrid between Capercailzie and Blackcock.—A beautiful male specimen of this peculiar bird, which at one time had applied to it the specific name *Tetrao medius*. The bird was shot at Ardkinglas, Argyleshire, on the 14th of October.

3. *Totanus glareola*, the Wood Sandpiper.—This beautiful bird was shot on the 3d October by Sir George Leith Buchanan, Bart., on Lochlomond. It is one of our rare or little noticed sandpipers. In 1856 I exhibited to the Society a young bird which was killed on the 14th August near Heriot, Midlothian.

4. *Anas boschas*.—A pure white variety of this bird, a female, the property of David Carnegie, Esq., who writes to Mr Sanderson, birdstuffer, that it was recently shot on

the river Balvaig, which issues from Loch Voil, about a mile from the loch. It was in company with other mallards, and was seen occasionally about the loch and river for some weeks previously. It has been suggested that the bird might have been simply a "decoy duck;" but Mr Carnegie states that George Morison, foreman on his farm of Tulloch, on Loch Voil, says that in the spring of 1877 he saw on several occasions a brood of six wild ducks when still small and unable to fly, two of which were quite white. The one exhibited is the only one seen this year. I may mention that the bill is of the usual greenish colour, and the size of the duck exactly corresponds to that of the wild duck, and the eyes being of the natural colour, it cannot be called an albino, but is simply a white variety of the wild duck.

5. *Puffinus cinereus,* Greater Shearwater.—This bird, a young male of the greater shearwater, was shot on the 29th of August, off North Berwick, by Robert Chambers, Esq., publisher, Edinburgh. Only a few examples of its occurrence in Ireland and England have been noticed, and I am not aware of its having been previously recorded in Scotland. Mr Gray, however, informed us last session he had seen it with flocks of the *P. anglorum* near the Bass Rock.

6. *Puffinus anglorum,* Manx Shearwater.—Is a better known bird, as it occurs occasionally in Orkney and Shetland, and especially in the Hebrides. On the east coast of Scotland it is rare. Five specimens, two males and three females, were also shot at North Berwick by different individuals about the 19th or 20th of August. It, like the other, generally keeps out to sea, and so may be less frequently noticed. Mr Gray considers it is now a regular autumn visitor to the Firth of Forth.

I am indebted to Mr Small, bird-stuffer, George Street, for sending me these birds, as well as many others, for exhibition to the Society.

7. *Alca alle,* the Little Auk.—A specimen of this bird, an occasional visitor, was driven ashore by stress of weather, and taken alive about two miles inland, near Coldingham, on the 3d of October. Another exhibited was killed yesterday at Portobello.

II. *Note of Large Skull of* Halichærus gryphus. By John Alexander Smith, M.D., F.R.S.E., etc. (Skull exhibited.)

(Read 20th November 1878.)

A very large seal, apparently recently dead, was cast ashore on the west coast of North Uist, in October 1878. It was much injured about the body, as if from fighting with other seals, and probably also from being dashed against the rocky shore. Captain Orde preserved the skull which I now exhibit. It is nearly quite perfect, and belongs to a very large specimen, probably an old male, of the grey seal (*Phoca gryphus*, Fab., or *Halichærus gryphus*, Nilsson). It is the haaf-fish of Orkney, and the *tapvaist* of the Hebrides, where it seems to be not uncommon. It is rare on our east coasts. The skull measures 1 foot in length along its base from the occipital condyles to the front of the projecting edge of the intermaxillary bone, and 7½ inches across the malar bones or the zygomatic arches. The teeth of this seal are very strong; large in the lower parts fixed in the alveolar sockets, and rather small and conical above; differing in this respect from the lobed or serrated teeth of the genus *Phoca*, etc. The seals require to have firm, strong teeth, as, besides feeding on fish, they eat up crabs and lobsters, etc.; and Mr Keddie tells me he has often found remains of the large strong feet or claws of these crustaceans in their stomachs.

III. *Notes on the Natural History of Islay.* By Robert Scot-Skirving, Esq.

(Read 18th December 1878.)

The following cursory notes on some of the features presented by the natural history of Islay refer almost exclusively to its ornithology during the summer and autumn of the present year.

I propose to note the appearance of some of our migrants, somewhat after the fashion of our late friend Mr M'Nab, of the Botanical Society, who used to chronicle the foliation and the flowering of the various trees and shrubs in the garden over which he presided.

Before saying anything of what I may call "the birds of the season," I shall, in a very few sentences, notice one or two features presented by the trees and plants of Islay.

Forest trees in Islay, when properly cared for, reach fair dimensions, and appear healthy and vigorous, yet I think there must be a weakness of constitution somewhere, as they lose their leaves a month sooner than they do here. Two very different trees seemed to retain their leafy vitality longer than the rest. These were the hard-grained oak and the soft-fibred lime.

Though I know I repeat what I once before said here, I cannot leave the vegetable kingdom without again noting the extraordinary growth of three of the natural plants of the island. These are the honeysuckle, the brier, and the whin. I wish some botanist would tell me why the long sinuous branches of these briers are fanged with such murderous thorns. If a divine were to say it was part of the original curse pronounced upon the earth, I should be inclined to ask if Islay sinned in any special degree, as these terrible briers would seem to indicate. I have repeatedly found sheep strangled by getting entangled in their serpent-like embrace. But the most striking botanical feature of Islay is undoubtedly its gigantic whins, the stems of which are tree-like in size, whilst their rich and profuse blossoms far exceed in splendour the flowering of any gorse I have elsewhere seen. It is in the middle of October that these Islay whins burst into bloom, and by the first week of November they are all one blaze of glowing golden yellow. Each bush seems as if on fire, till the whole bright array is generally destroyed in a night by the first sharp frost of winter.

To turn to the birds, I may remark, in the first place, that the last breeding season has proved a remarkably favourable one for all kinds of game and wild ducks. There is no doubt that the numbers of all these were doubled, and in some cases quadrupled, comparing 1878 with the previous year. It is in some of the western islands that, alone in Great Britain, the pheasant is an entirely self-sustaining bird, the mildness of the winters enabling it to procure insect and other food at every season of the year. Numerous as pheasants are in many parts of the island, they would be much more so did they not persist in choosing marshy places for their nests, which are frequently flooded during the breeding season.

Whilst the ornithologist has so frequently to deplore the extinction of breeding-stations, it is pleasant to have to record any instance where some innocent and beautiful bird is found in increased numbers. This I am able to do in reference to the common tern (*Sterna hirundo*). In the centre of a large loch on the property where I live in summer there is a tiny islet, not more than twice the size of this room, in the centre of which grows a bush of tall sedges. The rest of the ground is flat and bare. About three couple of terns have been in the habit of nesting there. This summer, on approaching the place on the 29th of June, I was surprised to see the islet assume the appearance of a beehive. Hundreds of terns were hovering and screaming round it. Almost every foot of ground was occupied by a tern's nest with eggs, no young ones having then appeared. Among them were the nests of a few black-headed gulls, whilst in the midst of the sedge bush, the apex of the islet, sat a red-breasted merganser on her nest, containing eight eggs. On the 12th July about half of the terns' eggs were hatched, and I found many of the young sickly and many dead, which I attributed, perhaps erroneously, to over-crowding.

Another island in the lake, not more than a quarter of a mile distant, contained the nests of many of the lesser black-backed gull and a few of the larger black-backs, and I was rather surprised that I never saw these fine but voracious birds visit the islet to relieve it of the supernumerary eggs and young of the terns. A much larger breeding-station of the same species of tern is situated on the sea-coast, a couple of miles distant from the fresh-water loch. From this station a person told me he had taken this season, on one day, sixteen dozen of eggs. Numerous though this species is, the beautiful little tern (*Sterna minuta*) is, so far as my observation goes, a stranger to Islay. It has indeed, I fear, disappeared from many places in the south of Scotland, and I have not observed a single specimen for years, though I remember it breeding in numbers in Aberlady Bay. Wild ducks breed in considerable numbers on two islands in the above-named loch, and I may mention that a teal succeeded this season in hatching there no less than sixteen eggs. The most remarkable influx of birds which came under my observation last summer occurred on the 5th of September, the species being the razor-bill (*Alca torda*). The island of Islay is almost cut in two by an arm of the sea called Loch-in-daal, which opens to the Atlantic. Its shore is almost without rocks. No sea fowl breed on it, and in early summer it is almost destitute of birds, though in winter it becomes a great resort of migrants. On Sunday, the 4th of September, not a diver of any kind was to be seen on the loch, but on the following day there was a remarkable change. That morning every man, and woman too, that I met told me the loch must be full of herrings, because "the herring birds had come"—so they expressed it. On going to the shore I saw a fair and interesting sight. Loch-in-daal is some four miles broad, and about twelve miles long. On that 5th of September its waters were as smooth and as clear as crystal, and its glittering surface was literally covered with birds, whilst the air was filled with plunging terns. I did not doubt at first that the majority of these birds would prove to be guillemots, a bird which I consider much more abundant than the razor-bill. On rowing out among them, however, I was surprised to find that the whole multitude was exclusively composed of razor-bills. During a week that these birds remained with us, I only saw half-a-dozen of their congeners, the guillemots and puffins. More than this, I was equally surprised to find that a vast majority of these razor-bills were young birds. I could make no exact computation, but I imagine that not more than one in twenty were old birds. When we remember that the razor-bill, like other auks (with one exception), lays but a single egg, this vast assemblage of almost exclusively young birds struck me as being very singular.

If the guillemot is called "foolish," these young razor-bills were not very wise. They were so fearless as to allow boys to hunt them in boats and kill them with sticks, and seemed to have no fear of man whatever. It was interesting to observe the few old ones among them utter from time to time a weird, plaintive, not unmusical call of warning to the young generation, which, however, gave little heed to the prudent caution and example of their elders. I have said that at this period the sea was absolutely calm and translucent. Looking down into its depths one saw myriads of minute fishes—most of them, I was told, the young of the herring. On these countless birds were feeding, whilst larger fishes, including vast shoals of mackerel, were devouring an infinitely greater number. I could not but think, when I gazed on this scene, of much of the evidence given to the Government commissions on the herring fisheries, and I regret to say their report too. In that document the poor gannets are specially singled out as sinners above all other fish destroyers; but if Mr Frank Buckland, who has written on this question, had visited Loch-in-daal last September, he might have seen that Nature may very well be left to take care of herself. He might have seen that, though not a gannet was near, countless thousands of other birds fed on fish, and that nevertheless the work of the birds was to be counted as nothing compared to havoc done on fish by other fish. Had a flock of gannets been present they would have killed some thousands of mackerel, and in so doing they would have diminished by that number far deadlier enemies of the herring than they themselves are.

Wherever there is much animal life, *there* also death is busy. Still I was surprised to see so many dead razor-bills float ashore. The beach during their short stay was almost fringed with their dead.

I think, but I quote from memory, that Mr Gray noticed in a paper a remarkable mortality which took place among the auk tribe some years ago in the Firth of Clyde, and I think he attributed it to a deficiency of food. This could not be the case in Loch-in-daal, which swarmed with minute fishes. I hardly care to mention a circumstance with regard to the dead razor-bills, as I can offer no explanation of it, but it was observed by many persons, and was certainly a fact.

It was this: some five out of six of the dead birds had one, and in some cases both, of their legs mangled, as if crushed or gnawed by some animal. Could it be by small crabs after the birds were dead? In a week or ten days the great majority of the razor-bills disappeared, though a sprinkling remained in the loch. I may note, while speaking of this description of bird, that in fine seasons I have never seen a single black guillemot (*Uria grylle*) on the Atlantic side of the island, yet I found them numerous (in their winter garb) on the other side in Jura Sound, on the 5th of November last.

Previous to this season I had noted that I had never seen a single skua gull of any species in Islay; but this year, for a short time, Richardson's skua (*Lestris Richardsonii*) appeared in considerable numbers during very stormy weather in the middle of September. Some of them left the sea and betook themselves to the fresh-water loch already mentioned. They were in the course of their southern migration.

Of hawks I have little to report. I have seen no osprey, as I did last year, when the strange sight of a hawk plunging into the sea attracted the attention of several persons as well as myself.

Gamekeepers have exterminated every hawk breeding in the island, except the peregrine, the sparrow-hawk, and the mouse-devouring kestrel.

Our most common migrants are the merlin and the hen harrier. The males of the latter arrive early in August, and are followed some ten days later by their dark feathered dames. One or other may generally be seen in any country walk. I have often seen two females hunting in couples, but I never saw a male and female, or two males, at one time. I have also to note, that formerly the males seemed to be in the majority. This season the females were, on the contrary, as six to one. But this might, to a great extent, be accidental as regarded my personal observation. In former years both long and short eared owls were occasionally met with. This season I have seen neither. Turning to the largest of our migrants, as I this year left the island at the beginning of November, I saw no swans; but they are regular visitants, and arrive towards the end of November in considerable numbers. About seventy swans generally frequent the loch. I have mentioned Loch Gurom, which being translated means the *Blue* Loch, and it well deserves its name.

The wild geese come earlier. All the species of *really* British wild geese visit Islay, but from personal observation I can only speak of three. The bean-goose, so numerous in East Lothian; the pink-footed goose, and the grey-lag (which I am told is the common goose of the northern Hebrides), I have never met with in Islay. The other three species of geese—the brent, the bernicle, and the white-fronted—are very common; but so far as both my observation and my information goes, they are *strictly*, and very *singularly*, as it seems to me, confined to certain special localities. Perhaps this may not be absolutely true as regards the brent goose (*Anser brenta*). This is much more a sea-bird than any of the others. It very seldom comes inland, and feeds almost exclusively on marine vegetation. It arrives early in Loch-in-daal, and remains there all the winter. The beautiful bernicle goose, so far as I know it, arrives in a flock of about five hundred (I am told that twenty years ago fifteen hundred was nearer the mark). This flock appropriates to itself a small island to the north of Islay, close to the shore, and it is only when the season is advanced that it ventures to take up its abode on the adjacent coast of Islay itself.

One of the songs of Islay (and they have many songs there) enumerates the distinguishing features of the island. One of these is—"Strings of wild geese long and grey." Islay, however, is not visited by one grey goose for a hundred that come to feed on the broad stubble of East Lothian. My information does not serve me as to whether portions of Islay which I do not know, are, or are not, visited by wild geese; but a flock of eighty or a hundred come as regularly as clock work to the locality which I know best, arriving early in October. These are the white-fronted goose (*Anser albifrons*), and unlike bean-geese. They really are rather stupid geese, because they persist in frequenting the small fields of small crofters, where there are great opportunities of stalking them, whilst every day they fly over several very large fields of oat stubble, where they would be comparatively safe from the gun of the fowler.

I never saw this species of wild goose till I went to Islay. I find that the first year's bird has none of the distinguishing marks of the white-fronted goose. There is no white on the head, and there are no black feathers on the breast. The breast is in fact *white.* Year by year the black feathers seem to multiply, forming first in bars, and these widening till the breast becomes wholly black.

Mr Charles St John, a well-known field naturalist, writing from personal observation on the habits of wild geese generally, states in one of his works that, having managed to approach a flock of geese unperceived, he always gave a low whistle or made some slight noise, which caused the birds to run together, and so offer him a better shot. Now, my experience is, that no species of wild goose ever stirs a foot when rendered anxious or alarmed. They all strike up their heads, and stand motionless, listening and gazing intently, and, no doubt, exercising their strong powers of scent as well. Then, when they are certain of danger, they spring at once, nearly perpendicularly, into the air, with considerable exertion of wing no doubt, but still far from slowly.

Just as I have each year reluctantly to leave Islay (at the beginning of November), the woodcocks begin to arrive in numbers. Some are very plump and fat, and do not seem tired. Others are thin, and are at first so weak as to be capable of short flights only. They, no doubt, come from very various distances. But whether they come chiefly from the south, the north, or the centre of Europe, or from all of these regions, they must fly across the whole of Great Britain before reaching the west coast of Scotland, or, I may add, any part of Ireland. It is impossible that they can rest their weary wings even for an hour on any part of the east coast of Great Britain, as the arrival of the flights would be eagerly watched for, and quickly ascertained by hundreds of ardent sportsmen. It seems to follow, then, that the great bulk of the woodcocks which visit us from other countries, disdain to rest till they have reached the districts their instinct tells them to select for their winter abode.

It is pleasant to note that the lively, dapper, and glossy chough is as frequent among the sea-cliffs as in recent years, and its merry, and not unmusical cry, is often heard at a considerable distance from the shore.

I shall now conclude with a notice of two birds, each of a species sufficiently common, but whose plumage was abnormal.

The first was a rock pigeon, a bird which is abundant in many parts of the island. Their feathering is singularly uniform, considering how apt the domestic pigeon is to vary in its plumage. I observed one rock pigeon, however, which was of a uniform sooty black.

The other bird I had a full opportunity of observing. Its form showed it to be a barn owl, a bird with which I was very familiar in my youth, but which I scarcely ever now meet with. This individual was absolutely *white* all over, not even a single tawny feather was to be seen. It is the only instance of the barn owl I have observed in Islay.

IV. *Notes on some Examples of Torrent Action near Blairgowrie and Edinburgh.* By ANDREW TAYLOR, Esq.

(Read 15th January 1879.)

I. In a former paper, I showed how such floods as those of Dollar in 1877, the result of a set change of meteorologic conditions, may even in modern times be powerful agents in making or deforming the geology of the surface. I desire, in continuation of the subject, to show how such agencies may have accompanied glacial ones, as they do at present in the Alps. Much confusion has arisen from attributing all the details of our superficial deposits entirely to ice action. The eager advocacy of popular exponents of the power of the glacier has caused Alpine observers to ask the question, Could glaciers deposit boulder clays? Here, as mostly always, the truth seems to lie in a middle course. Observers of glaciers have mostly confined themselves to measuring the moraines of such places as the "Mer-de-Glace," to the dilatation or regelation of the ice, or other minute physical experiments requiring such accuracy of observation as to preoccupy the mind from a broad view of surrounding phenomena. In M. Violet Le Duc's "Mont Blanc" we have a comprehensive survey of the work of the glacier, with its accessories. And there it is laid down that torrents, not glaciers, are the immediate cause of the dreaded avalanche of the Alpine villagers, as well as the distribution of great beds of boulders, sand, gravel, or clay. The glaciers, indeed, are only reservoirs of potential water, rendered so when loosened from their icy covering by melting spring or autumn suns. The glacier does comparatively little in altering the surface-contour of the mountains. Its course is marked by a long gently-smoothed plain. The side moraines will be there, so, too, a thickish deposit of mud; but the rocks will retain their sculpturing they had before being covered by its icy sheet. Change, indeed, is only effected when the water from its hard sides is melted and flows into the joints and fissures, when mountain masses are reft in obedience to hydraulic laws. At the same time, the ancient glaciers of the Alps, in their recession from a level which was probably at least 6000 feet below the present ice limit, have left moraines, which serve as dams to the descending torrents, till they gain such an impetus, when bursting them, to carry the huge boulders down to the plains below. The deposits consequent on such action are funnel-shaped. The stream drops first the large boulders; next, gravel, great and small; afterwards, clay and sand, as its carrying-power decreases. But it may happen that a torrent, instead of bursting an old moraine, may only have sufficient energy to cast up the sand and gravel it has hitherto carried around its sides, so forming a mountain lake. This will become a permanent scenic feature all the more, if fed by natural springs. That it has an outlet in nowise denies its original mode of forming. We have thus to take, as concomitants of torrent action, the more ancient extension of the glaciers, and surely, also, accompanied with a more powerful torrent energy: the breaking through and carrying away of ancient moraines, a power evidenced by the existence of mountain lakes where it is only half effected;

and that glacier muds and moraines really are only feeders to the distributing power of torrents, which readily carry away previously-formed boulder deposits on steeply-sloping ground. Further, M. Le Duc shows that snows remaining unmelted on high mountain summits till July or September cause even more destructive torrents than those proceeding from melting glaciers.

II. I would refer the Scottish student of these Alpine principles of geology in the first place to the course of the Ericht above Blairgowrie, not forgetting a general survey of the scenic aspects of that favourite entrance to the Aberdeenshire Highlands.

A survey from the high hill above the town gives perhaps the best panorama of all the varied scenic aspects of central Scotland. To the east, the Sidlaw Hills, flanking the beautiful vale of Strathmore; northward, the great Grampian outliers; and, in a semicircular sweep westwards, the curiously-contorted schistose peaks of the Perthshire and Argyleshire Highlands, form their noble setting to the picture. The eye, again reverting eastwards, is struck by the characteristic single mountain summits round the Trossachs, standing up above that great central plain, stretching in almost painful uniformity from Perth to near Dunblane. Fife is diversified by the peculiar trap-weathered features of the Ochils and the Lomonds; with the windings through fertile carses of the noble Tay, and bounded by the rough North Sea. No one agency could have sculptured this landscape. The great sea-wave mentioned by Hector Boece as having destroyed a town near the sands of Barry in the reign of Alexander III. may also have come on this side of the Sidlaws. Then the popular tradition that once the Tay found access to the German Ocean may not be solid historic evidence, still it accords with some geologic hypotheses as to the incursion of other rivers also on the present area of the North Sea. A large chloritic boulder of several tons weight on the hill of Caputh, above Blairgowrie, is perhaps the best local monument of the glaciers. Standing alone in a barren moor, it seems the wreck of a large moraine, destroyed by subsequent torrent agency. If the long central plateaux along which the whilom

Scottish Central Railway runs marks the line of retreating glaciers into central Perthshire, no less do the series of barren moorland plateaux which stretch in terraces from our coign of observation to the Grampians. The series of small shallow lochs, of which the six at the Stormonth district are the termination, may be the memorials of successive torrents. This appears probable, rather than that they are dammed up channels of the Tay, from other mountain lochs of apparently the same set, being at altitudes of 1000 feet or more. The soil round Blairgowrie is a light gravel, much akin to the underlying conglomerate rock, more adapted for arboriculture than for modern husbandry—very sterile, indeed, in this respect, except for the special strawberry crops, to which much of it is now devoted. The same characteristics apply to the ground flanking the high conglomerate escarpment bounding the north-west side of the valley. It is the product, indeed, of these mountain torrent streams—the Ericht, the Alyth, and the Isla. When joined into the latter in the centre of Strathmore, the current has lost boulder-carrying power, and only spreads sand and clay, hence the high agriculture round Cupar-Angus. The manner in which the Ericht now rapidly cuts out its conglomerate bed may be studied in its channel immediately above Blairgowrie.

The Lornty joins the Ericht about half a mile out from Blairgowrie, after a course of about the same length, and presents many of the peculiar aspects of a mountain stream in miniature. On either of its shelving sides, which owe much of their peculiar physiography to the series of trap dykes running east and west through this district, and which also greatly aid in shaping both the western mural escarpment of Strathmore, as well as the Sidlaws, on the opposite side of the valley, are marks of combs, caused by sudden transverse currents, only active in very stormy seasons. The side valley on which stands the old ruins of Glascune Castle is a very marked example of a comb on a constant feeder; and at its junction with the Lornty will be found a long gravel funnel. Nearly opposite, at the head of a grass park, the surface soil has slipped down nearly a foot and a half from a dry-stone dyke. The inclinature of a field is such that a stone hurled from the top speedily finds its way into the Lornty, which flows here in great force. The winter snows may thus press the soil into the rapid flowing waters, and this ultimately goes to form the haughs at its junction with the Ericht, near Mr Grimond's flax mill.

The name Ericht, the Gaelic for rough or rapid, sufficiently suggests torrent action. The tourist ascending from Blairgowrie to Glenshee follows its course in an almost south-east direction across a series of high table lands to its source in a Grampian summit. The normal contour line of that great stretch of moors through which, too, the Isla and Alyth run in a parallel direction, is 1000 feet. This may have been due to a receding glacier; but the banks of the Ericht show earth sculpturing long after the icy sheet was confined to the higher ranges of the Grampians, probably at a much loftier elevation than now. To this may have been superadded torrents from melting snows on the higher mountain peaks in summer. The Ericht proper begins near the Bridge of Cally, above which the Ardle and Blackwater join; but this last main stream has had a previous course of nearly twenty miles, beginning at Cairnbeg. The traveller by coach road to Braemar, after passing through Rattray, and gaining the summit of the waterfall above Craigmill, finds the route to Invercauld Arms to run along the top of a wide valley in which the Ericht runs more than 300 feet below. The bold escarpment of conglomerate on which stands Craighall House, the Tully Veolan of Sir Walter Scott, shows the last remnants of a washed-out conglomerate from the road level. The numerous cross feeders having their source on the flat moorlands on either side are also powerful denuders, except when protected by skilful arboriculture, as in Mr Alexander Grimond's lovely paradise of Glen Ericht. Along the upper course of the Ericht are scenes very like those depicted in Le Duc, illustrative of the sculpturing work of Alpine torrents, especially near the Mains of Drimmie, and at the junction of the slate and conglomerate, near Invercauld Arms Inn. The contouring of the valley downwards has an interesting connection in this point of view. In the valley of the Ericht the lines fall rapidly from 1000 to 500 feet; its total breadth is two miles. At the inn itself, where the conglomerate rests on the harder slates, 400 feet is lost in little over half a mile. The general slope from the high country above the inn down to the junction of the Ericht and Lornty, below Craighall, a distance of over three miles, is fully 100 feet.

III. The observers of the superficial deposits around Edinburgh have noted that their local character dominates over their other more general relations to other districts. Beds showing turbulent action, and quiet lacustrine deposits, have distinctly marked areas round the city. The presence of great boulders on Arthur Seat and the Pentlands, which must have come from a site several hundred feet above their present localities, are amongst our most noted geological puzzles. In view of the general remarks on Alpine torrents at the beginning of this paper, might not our local deposits be again surveyed? True notions of the amount of local denudation of the rock strata must form the bases of our conclusions. From several papers recently published, we see that the assertion of many thousand feet covering Arthur Seat does not meet with its once universal credence. And, if it is granted, it is doubted whether the covering beds were those of the upper carboniferous beds following the regular stratigraphic sequence so dear to text-book geologists. Extensive evidences of lateral pressure and shift prevail throughout the district. Can it be denied that the contortions, faultings, and downthrusts of the surrounding shale and coal fields, affected also the incumbent superficial deposits? Of course the geologist, according to his text-book, holds that either all the successive strata up to the Mesozoic, the wrecks of which constitute the Western Islands, were successively laid on Arthur Seat to be afterwards swept away; or, that a great quiet prevailed through all the time from the Permian to the Glacine period. But is this seeking out the true succession shown in field observations? The belief in the plug at the summit of Arthur Seat is now questioned. If it be not there, may not the old lakes round the hill and the large boulders be the relics of torrents from ice-sheets at a higher locality now washed away? Professor Fleming noted that the boulder clay takes its colour from the character of the rocks it caps. The shales of the Midlothian coal measures give it a dark brown colour; but on passing Cupar it changes to a light reddish grey, in accordance with the prevailing tint of the subjacent sandstones. Fleming thence argued that probably our eastern boulder clays were deposited in two or three great lakes, extending from Edinburgh to near Aberdeen; all the great rivers now cutting through it, finding access in that direction to the German Ocean. Perhaps a series of smaller lakes in connection with high glacier or snow gathering grounds, now either washed away or warped down by those forces evidenced by the cleavage planes of our Scottish hills, may come nearer the truth. This system of lakes and torrents prevailed long after this, even probably to prehistoric times. It is said that branches and stems found in the clays of Boroughmuirhead are identical as to the character of the wood with that found in the old timber fronts of the High Street. Old residenters still remember the sheet of water at Norton Park; and of many smaller sheets in the vicinity of Scotland Street, the inciting cause of that aristocratic fever once the cause of great mortality in the New Town. Mr Milne Home, at page 29 of his "Estuary of the Forth," gives the following section of a cutting at the North British Railway workshops of St Margaret's, at Parson's Green, 150 feet above the sea-level: (4.) Sand horizontally stratified, about 20 feet thick; (3.) Finely laminated brown clay, apparently derived from Nos. 4 and 2; (2.) Brown clay, partially stratified, containing angular fragments of rock and coarse gravel; (1.) Boulder clay resting on the trap-rocks of Arthur Seat—very tough.

Again in the "Lithology of Edinburgh," p. 59, Professor Fleming says: "We have already noticed the proof of a motion from the west by the boulder clay squeezing eastwards portions of the shivers which it overspreads. At the junction above of the clay with the sand, angular fragments of sandstone frequently occur in considerable quantity, as in the recent excavation on the south side of the Canongate and north side of St Leonard's valley. Those comparatively flat or tabular masses, were *generally* arranged as we find similar flat stones in the channel of a river, dipping in one direction.

From the pressure exerted on their surfaces, they cannot rest unless either lying horizontally or dipping in the direction where the current flowed, or towards the source. In this case the current which assorted the boulders in the sand, had an easterly direction. It is difficult to find, in the boulder clay itself, satisfactory examples sufficiently numerous, among the generally rounded blocks, from which to draw any inference."

The destruction caused to property round Canonmills, in the autumn of 1877, by the floods of the Water of Leith, was evidence of the carrying and carving power of that rather insignificant stream in an ordinary season. Geologists had previously noted sections of its bed showing rapid action. Thus in digging for the foundations on the north side of Charlotte Place, to the west of St George's Church, Fleming records the finding of a bed of from 2 to 3 feet of angular fragments or shivers of bituminous shale, resting on the fixed strata of the same material. "The boulder clay rested on the shivers, and seemed to have had a motion from west to east." In one place it had caused pipes of the shivers, below and above the regular bed. In some places again a sand-bed interposes betwixt the two layers. Mr John Henderson has since described a somewhat similar section in the upper course of the stream above Colinton. But at the site of the gasometers, beside the once celebrated Tanfield Hall, on the road to Newhaven, several of such sections have been noted.

Both of the companies supplying Edinburgh have depots at this locality.

The following quotation, from Fleming's "Lithology of Edinburgh," p. 52, refers to the first and westermost gasometer erected by the Edinburgh and Leith Gas Company, on the Brandon Street side of the river: "When the foundation for the gasometer on the south side of the Water of Leith, at Tanfield, was being dug, a similar display of the junction of the shivers with the boulder clay presented itself. In this case, and the former, the shivers sometimes reached the length of 3 or 4 inches. Here they consisted of a light-coloured somewhat indurated slate-clay, occasionally arenaceous. This mass of fragments, forming a bed from 2 to 3 feet in thickness, rested on the edges of strata of apparently similar materials, and were covered by the boulder clay. There was no transition between the one and the other, the line of junction being abrupt. At one place a tongue or spit of shivers ascended into the till, of nearly 6 feet in length, rising at about 20°, and pointing eastward."

In the figure given with this description, a trap-dyke (*d*) cuts through the almost vertical rocks, and is marked as abraded to allow the shivers to lie on it. In cutting the foundations for the most easterly of this company's gasometers nine years ago, to a depth of 25 feet, this dyke was found standing right up in the boulder clay. It had to be levelled by blasting.

The Edinburgh Gas Company occupy the area on the north side of the stream by five gasometers, the two westerly ones having only been erected last summer. Through the kindness of Mr Peter Henderson I give a section of the foundations, which were dug to a depth of 20 feet. They formed 4 feet humus and soil, 9 feet sand and gravel, and 13 feet boulder clay. In this latter bed were found long trunks of beeches, 20 feet by 2 feet broad. While digging the foundations for the gasometer on the opposite bank of the stream just referred to in the preceding paragraph, half-a-dozen stems of beech and hazel were dug out. Here, too, the total thickness of the boulder clay was pierced, which was not done in the foundation digging of last summer, and beneath it was found, not a layer of shale shivers as in Fleming's section, but one of trap-boulders, which were broken up to macadamise the yard. These finds apparently connect with the peat-bed between Leith and Golden Acre, described by Mr Milne Home many years ago. Below a bed of sand, some 10 feet thick, this peat-bed, 1 foot thick, rested on 10 feet of laminated blue clay, again superinjacent on the boulder clay. In this peat-bed were roots of trees, apparently hazels, which evidently had grown in the clay. The bark was alone undecayed; there were stems of marsh plants, and small seeds not unlike those of the whin which the late Mr M'Nab attempted to germinate without success; there were also some elytra of beetles. Professor Fleming conclusively showed this to be drift peat—and it indicates a continuous set of conditions for at least a mile. Perhaps a smaller find, reported to have been discovered near Colinton, also may be due to torrent action of very recent times.

At the Botanic Garden and Golden Acre geologists have recognised filled-in lakes of silt or sand in the superincumbent boulder clay. As previously stated, such a series of lochs would form part of a scheme of the surface deposits being laid down by intermittent torrent action.

In connection with the paper there was shown an iron horse shoe of recent make, covered by a ferruginous conglomerate cement, and found 13 feet from the surface, in the sand and gravel capping the boulder clay, at the New Leith Docks, beside Seafield Baths. The shoe is in the possession of Mr Johnstone of the Leith office of the Edinburgh Gas Light Company.

V. *List of the Birds which have been observed in the Parish of Callander, Perthshire.* By J. Hamilton Buchanan, Esq.

(Read 19th March 1879.)

The following list is the result of observations made from time to time by my father during the last thirty-two years, with some additions from my own notes for the past four years; and although it may be still necessary to supplement it, it is, I think, as nearly complete as possible. Before proceeding to give the list in detail, it may be well to describe the physical characteristics of the district.

The parish of Callander is situated in the south-west of Perthshire. It is about eighteen miles long by ten broad, and exhibits the usual variety of Highland scenery, except at the eastern extremity, where it bounds with the Lowlands.

There are several lakes in the parish, the chief of which are, Loch Katrine, Loch Vennachar, and Loch Lubnaig. The shores of the first two are sandy, while those of the last named consist mainly of gravel, there being also a marshy portion, which forms the breeding haunts of many coots, and several pairs of little grebes. Around the shores are to be observed in summer many common sandpipers, and occasionally a few pairs of oyster-catchers. The lesser black-backed gull also frequents the loch at the same season, but I have never been fortunate enough to discover its nest. In winter, when the water is not frozen, certain species of wild fowl are also found there.

The mountains are mostly in the northern and western parts of the district, the chief of which are Ben Ledi and Ben Voirlich, the former 2875 feet above sea-level, and the latter 3224 feet. These were formerly the retreats of some of our nobler birds of prey, but owing to the short-sighted policy of gamekeepers and vermin-killers, few, if any, are now found there.

Probably two-thirds of the area of the parish are mountainous, and one-third wooded or in tillage. The woods are chiefly natural copse, but there is also a considerable extent of pine plantation, which varies in age from three to sixty years. In these woods are found several interesting birds, such as the woodcock, jay, ringdove, and capercailzie. On the lower grounds the partridge and several of our smaller birds are to be found; and on the moorland are innumerable grouse, blackgame, plover, and curlew.

From the chain of lakes comprising Loch Katrine, Loch Achray, and Loch Vennachar, flows one branch of the Teith; and from Loch Lubnaig there falls another branch down through the Pass of Leny. These unite immediately above Callander, and being joined by the Kelty at the eastern border of the parish, fall eventually into the Forth a few miles above Stirling. The natural flow of all the water of the parish is into the basin of the Forth, but of late years an artificial flow for a large portion has been constructed to supply the basins and punch-bowls of Glasgow in the valley of the Clyde.

With reference to geology, the rocks of the district consist chiefly of slate of the Silurian period, with occasional sections of conglomerate and grey sandstone of the Lower Devonian strata. There is also a vein of fine mountain limestone or marble, running from south-west to north-east in the hills to the north of Callander. This contains 96 per cent. carbonate of lime, and is probably a cause of the fertility of the meadow land in the valley of the Teith. The dip of the strata is from north-east to south-west. The soil is naturally rather light, but has been much improved by draining and tilling, and other agricultural operations.

One or two botanical notes may be of use, as the distribution of birds in a district largely depends upon the food and shelter afforded by the plants which it contains, especially the trees. I have already observed that there are considerable pine plantations. In the glens are numerous coppices of hazel, oak, birch, alder, and many other native woods; while the banks of several of the streams are edged with willows. In the natural woodlands there is an abundance of the various berry-producing plants; while in many places the commoner ferns grow in such luxuriance, as to make it difficult to force one's way through them. Formerly there were several of the rarer sorts of ferns, which were so eagerly sought after, as to have apparently become extinct. On the higher grounds there is an abundance of broom, juniper, gorse or whin, and bog myrtle. Heather grows luxuriantly on the hill sides, and higher up such plants as cranberries are found, while on many of the mountain tops, amidst their rocks and peat hags, are the mosses that red-deer delight in.

The average yearly rainfall for the last ten years is from 56 to 86 inches in various parts of the parish; and the temperature for the same period in the summer six months is 57°, and in the winter 36°.

I have given in this paper the Latin, the English, and, where practicable, the original and literal translations of the local Gaelic names, as given to me by a shepherd resident in the district.

Buteo vulgaris (Leach); Common Buzzard; *Clamhan* ("loosely feathered").—A few are usually seen about November, but none breed in the neighbourhood.

Aquila chrysaëtos (L.); Golden Eagle; *Iolair* ("leader, shower of the way").—Almost, if not quite, extinct. The former eyries were Ben Ledi, Glenartney, and Balquhidder.

In my father's note-book for January 31, 1862, he says that he had a shot at an eagle, but failed to secure it. In the "New Statistical Account of Scotland," in the chapter referring to the parish of Callander, eagles, probably golden eagles, are spoken of as being sometimes seen in the Trossachs.

PANDION HALIAËTUS (L.); Osprey; *Iolair-uisge* ("water eagle, eagle fisher").—Quite extinct. There used to be a pair on Loch Menteith, but these were destroyed, probably about thirty or forty years ago.

FALCO PEREGRINUS (L.); Peregrine Falcon; *Seabhag-seilge* ("hunting hawk").—Rare. A pair nested on Ben Ledi in 1874, but not subsequently.

TINNUNCULUS ALAUDARIUS (Gmelin); Kestrel.—Abundant; especially in early spring.

MILVUS ICTINUS (Savigny); Kite; *Clamhan gobhlach* ("forked-tailed gled").—Extinct; said to be formerly common in the Trossachs. I have seen one or two remnants of tails, of the parts that are used for salmon flies from that locality, and have been told that early in the present century rewards were offered there for the destruction of this and other birds and beasts of prey.

ACCIPITER NISUS (L.); Sparrow-hawk; *Speireag-bheag* ("little savage").—Common, but not nearly so plentiful as the kestrel.

CIRCUS CYANEUS (L.); Hen Harrier.—Very rare; one shot in 1875.

SYRNIUM ALUCO (L.); Tawny Owl.—Tolerably common.

OTUS VULGARIS (Flem.); Long-eared Owl.—Pretty common in early spring.

OTUS BRACHYOTOS (Forster); Short-eared Owl.—Comparatively rare; one shot in 1874.

STRIX FLAMMEA (L.); Barn Owl.—Common, but mostly so in autumn.

The local Gaelic name for all owls is *Cailleach oiche*, "night wife," or "old woman of the night."

CAPRIMULGUS EUROPŒUS (L.); Night Jar.—Very rare; one shot in 1866.

CYPSELUS APUS (L.); Swift.—Tolerably common. A few pairs generally nest about the village of Callander.

Cotyle riparia (L.); Sand Martin.—Common. There is a small colony of about thirty nests $2\frac{1}{2}$ miles west of Callander. Their usual date of arrival is about the 6th of May.

Hirundo rustica (L.); Swallow; *Gobhlan-gaoithe* ("forked wind").—Abundant. They usually arrive from the 13th of April to the 8th of May, and depart about the 2d of October.

Chelidon urbica (L.); House Martin.—Still common, but on the decrease.

Alcedo ispida (L.); Kingfisher; *Cruitean* ("cymbal").—Very rare; two seen in December 1873, another in March 1877.

Certhia familiaris (L.); Creeper; *Shag* ("quick tap").—Common, especially in winter, which, I think, is partly due to the fact of the leaves being off the trees, and consequently the birds are much more easily seen.

Troglodytes parvulus (Koch); Wren; *Dreadhan* (from its voice).—Common.

Sylvia cinerea (Lath.); White Throat.—Common.

Phyllopneuste trochilus (L.); Willow Warbler.—Common, especially in certain localities along the river sides.

Regulus cristatus (Koch); Golden-crested Wren.—Very common in winter; generally in flocks of considerable size.

Ruticilla phœnicura (L.); Redstart; *Ean-dhearg* ("red stern").—Pretty common in June and July.

Erythaca rubecula (L.); Robin; *Broinn* ("red belly").—Extremely abundant throughout the year.

Saxicola œnanthe (L.); Wheat-ear.—Almost rare; only seen in early spring. I do not think that this bird breeds in this neighbourhood, as I have rarely, if ever, seen it after the middle of April, and have never found its nest.

Pratincola rubetra (L.); Whinchat; *Cloichuin* ("cairn frequenter").—Bred in 1875, and possibly since.

Pratincola rubicola (L.); Stonechat.—Rare; one shot in 1877.

Accentor modularis (L.); Hedge Accentor.—Extremely common.

Parus major (L.); Great Titmouse.—Very common.

Parus cæruleus (L.); Blue Titmouse; *Coichan.*—Common.

Parus britannicus (Sh. and Dr.); Cole Titmouse.—Common, especially in autumn, at which season it assembles in tolerably large flocks.

Parus palustris (L.); Marsh Titmouse.—Not common by any means, though I shot one on Loch Lubnaig side in May 1877.

Acredula rosea (Blythe); Long-tailed Titmouse.—Tolerably common.

Motacilla yarrelli (Gould); Pied Wagtail; *Breac 'n sil* ("speckled one of the seed").—Common; breeds.

Budytes boarula (Penn.); Grey Wagtail.—Common; more so, indeed, I think, than the preceding.

Anthus pratensis (L.); Meadow Pipit.—Very common.

Anthus arboreus (Bechst.); Tree Pipit.—Rare; one shot in 1876.

Turdus viscivorus (L.); Missel Thrush; *Liath-truisg* ("grey bird").—Very common throughout the year.

Turdus pilaris (L.); Fieldfare.—Common from the end of October to the beginning of April, sometimes not leaving us until the middle of that month.

Turdus musicus (L.); Song Thrush; *Smeorach.*—Very abundant. The literal translation is the end of an arrow next the bow-string—perhaps from the shape of the tail, or from the feathers being used for arrows.

Turdus iliacus (L.); Redwing.—Tolerably common, but not nearly so much so as the fieldfare.

Turdus merula (L.); Blackbird; *Lon-dubh* ("black impudent thing").—Extremely common. Rarely pied specimens occur.

Turdus torquatus (L.); Ring Ouzel.—Rare; one last found in 1874.

Cinclus aquaticus (Bechst.); Dipper; *Gobh-uisge* ("water smith").—Common, though much persecuted by gamekeepers and others, who imagine that they are great enemies of fish spawn.

Muscicapa grisola (L.); Spotted Flycatcher.—Not common.

Ampelis garrula (L.); Waxwing.—Very rare. Some seen about 1840; another observed by myself on December 29, 1878.

Garrulus glandarius (L.); Jay; *Scriachag choille* ("wood screamer").—Not common. There are generally, however, one or two nests found every year.

Pica caudata (Flem.); Magpie; *Pioghaid* ("parti-coloured"). —Rare, owing to continued persecution.

Corvus corax (L.); Raven; *Fitheach* ("deer-eater").—Rare. One pair still breeds on Ben Ledi, and another on a rock in the immediate vicinity.

Corvus corone and cornix (L.); Carrion and Hooded Crows; *Fionnag.*—In the last edition of Yarrell these birds are described as being one and the same species. With us both are common, and breed, but I have never heard of a single instance of their inter-breeding.

Corvus frugilegus (L.); Rook; *Rocas.*—Tolerably common in spite of a great portion of the only rookery having been "partly blown or partly cut" down within the last two years, which has caused the mass of the birds to migrate to another parish. Prior to this disaster, the extent of the rookery was about 2½ acres, and the number of nests from two to three hundred. They first appeared in the parish about sixty or seventy years ago.

Corvus monedula (L.); Jackdaw; *Cathag* ("little quarrelsome one").—Extremely common.

Sturnus vulgaris (L.); Starling; *Druid.*—Very common, but last year hardly so plentiful as in the preceding one. I have been told that thirty or forty years ago this bird was rarely, if ever, seen.

Fringilla cœlebs (L.); Chaffinch; *Breican-beithe* ("speckled birch frequenter").—Plentiful, and on the increase.

Fringilla montifringilla (L.); Brambling.—Rare.

Fringilla carduelis (L.); Goldfinch.—Very rare, owing to it being continually persecuted by birdcatchers.

Passer domesticus (L.); House Sparrow; *Gealbhan.*—Abundant.

Chlorospria chloris (L.); Greenfinch; *Geal-haine.*—Pretty common.

Pyrrhula rubicilla (Pall.); Bullfinch; *Lasair-choille* ("woodflame").—Common in all suitable localities, and on the increase.

LOXIA CANNABINA (L.); Crossbill.—Very rare, but, I believe, forty or fifty years ago a regular winter visitor.

ÆGIOTHUS RUFESCENS (Vieill); Lesser Redpole; *Gealan-lin.* —Comparatively rare.

LINOTA CANNABINA (L.); Linnet; *Gealan.*—Very common.

EMBERIZA MILIARIA (L.); Common Bunting.—Not common, and becoming much rarer every year.

EMBERIZA CITRINELLA (L.); Yellow Bunting, Yellow Broom Bird; *Buidheag-bhealuidh.*—Abundant.

EMBERIZA SCHŒNICLA (L.); Reed Bunting.—Very rare; one shot in 1876.

PLECTROPHANES NIVALIS (L.); Snow Bunting.—Rare as a rule. A great many occurred during the winter of 1874-75.

ALAUDA ARVENSIS (L.); Skylark; *Uiseag* ("exalted, dignified, high-born").—Still common, though very much on the decrease.

CUCULUS CANORUS (L.); Cuckoo.—Common, especially in warm, dry years. They usually arrive about 28th April, and depart in the beginning of July.

COLUMBA PALUMBA (L.); Ring Dove; *Colman-coille.*—Common, but chiefly in spring and summer.

PHASIANUS COLCHICUS (L.); Pheasant; *Eascag.*—Abundant, but only so within the last forty years.

PERDIX CINEREA (Briss.); Partridge; *Cearc-thomain* ("hen of the knolls").—Not common, which is probably due to the fact of the absence of crop.

TETRAO UROGALLUS (L.); Capercailzie; *Cabar-coille* ("wood horse").—It may be interesting, as Perthshire is still the stronghold of this species, to give a few particulars of its restoration to the Callander district: "In 1845 Mr Carnegie of Stronvar obtained three female and two male birds, and kept them alive for two years, when both the females died. This led him to turn out the males, which were shortly afterwards found dead. In 1856 they began to appear in the pine woods of Laurick, at the south-east of the parish, but it was not until 1860 that they became fairly established there." A female was noticed for the first time in Leny woods, just above Callander, in 1872, and in 1876 I have good reason to believe that they bred there. "There is sufficient evidence to show that they came to the woods around Callander from the Braes of Doune, but owing to the isolated and not very extensive nature of the woods on Lord Moray's property, they probably arrived at Laurick and Blair Drummond direct from Ardoch and Drummond Castle, as our statistics show an earlier date of arrival at Laurick and Blair Drummond than at the Braes of Doune."

TETRAO TETRIX (L.); Black Grouse; *Corliach-dubh* (male), *Liath-chean* (female).—Common, but decreasing.

TETRAO LAGOPUS (L.); Ptarmigan; *Tarmachan* ("high mounting bird").—Very rare. In my father's notes he states that he shot some on Ben Ledi in 1849; and in the latter part of December 1874, I flushed three on Leny Moor. There are still said to be a few on Ben Voirlich.

TETRAO SCOTICUS (Lath.); Red Grouse; *Corliach fraoich* ("red bird").—Still abundant, though in decreased numbers since the appearance of the disease in 1846.

VANELLUS CRISTATUS (M. and W.); Lapwing; *Adharcan-luachrach* ("sprightly changeling").—Extremely abundant in suitable localities during spring and summer.

CHARADRIUS PLUVIALIS (L.); Golden Plover; *Fead-ag* ("little whistler").—Tolerably common on the moors in spring.

HÆMATOPUS OSTRALEGUS (L.); Oyster-catcher; *Pioghaid cuain* ("ocean magpie").—Pretty common, especially of late years. A few pairs breed on the Kelty, and possibly on the shores of Lochs Vennachar and Lubnaig.

ARDEA CINEREA (L.); Heron; *Cor-ghlass* ("watchful bird").—Pretty common. There is, however, no heronry nearer than the Lake of Monteith, which is several miles from the borders of the parish.

NUMENIUS ARQUATA (L.); Curlew; *Guil bneach.*—Common from February to August.

TOTANUS CALADRIS (L.); Redshank.—Tolerably common. Two or three pairs breed in the parish.

ACTITIS HYPOLEUCUS (L.); Common Sandpiper.—Very abundant along the loch shores in summer.

GALLINAGO MESIA (Leach); Common Snipe; *Gobhn-adhair* ("sky goat").—Abundant throughout the year.

Gallinago gallinula (L.); Jack Snipe.—Common in winter. Said to breed in Glenartney. I have received eggs from keepers from that locality, and have been assured that they were of this bird, but from its known breeding-range this is extremely improbable.

Scolopax rusticola (L.); Woodcock; *Crom-nan-duilloeag* ("the wounded," from oblique manner of flying).—Common throughout the year. It was first noticed to breed in 1848.

Rallus aquaticus (L.); Water Rail.—Not common. It is generally in the months of February or March that it occurs.

Ortygometra porzana (Bechst.); Land Rail; *Trean-ri-trean* ("bird of the clearance" made for growing any crop).—Common, but not nearly so much so as it was fifty years ago. They usually arrive from the middle to the end of May.

Gallinula chloropus (L.); Moorhen.—Very common in all suitable localities. I found a nest in the beginning of last June in the centre of a tuft of rushes, in an open moor, about a mile from the nearest water.

Fulica atra (L.); Coot.—Common, arriving in April and leaving in autumn.

Mareca penelope (L.); Wigeon.—Rare. Sometimes shot on Loch Vennachar.

Anas acuta (L.); Pintail.—Mr Colquhoun informs me that he saw a small flock of this species on Loch Vennachar about 1840.

Anas boschas (L.); Wild Duck; *Tonnag* ("wavelet").—Plentiful throughout the year.

Querquedula crecca (L.); Teal; *Crann-lach* ("dwarf-duck").—Tolerably common.

Fuligula cristata (Ray); Tufted Duck.—Rare. Females are sometimes shot on Loch Vennachar.

Mergus castor (L.); Goosander.—Rare, though it has bred on the banks of the Teith. To assure myself of this fact, I wrote to the owner of the property where the nest was, and I give his reply verbatim: "The goosanders nested in the park here, the year before last (1877), but not again last year. Their nest was on the grass among the roots of an old ash-tree, about twenty yards from the river. The drake did not remain at the time of the nesting, but four young birds were to be seen about all the summer." This I can confirm, as I saw the old female and the four young birds in the end of July or beginning of August of that same year.

MERGUS SERRATOR (L.); Red-breast Merganser.—Much rarer than the preceding. Sometimes seen on Loch Vennachar.

PODICEPS MINOR (L.); Little Grebe; *Spagair toin* ("ungainly walker").—Tolerably common. A few pairs generally breed on Loch Lubnaig.

LARUS CANUS (L.); Common Gull.—Not common.

LARUS FUSCUS (L.); Lesser Black-backed Gull.—Common in spring, at which season it is frequently caught along with the curlew, in traps that are set for hooded crows.

LARUS ARGENTATUS (Brünn.); Herring Gull.—Tolerably common in spring.

CHROICOCEPHALUS RIDIBUNDUS (L.); Black-headed Gull.—Very common. Large flocks of adult birds assemble for the evening, in wet seasons, from May to August, in the meadow land. They usually arrive about six o'clock, and disappear towards midnight. Their nearest breeding-station is about eight miles distant.

I am indebted to Mr Harvie-Brown for much help in the Capercailzie note; and to Mr D. Campbell, Callander, for the local Gaelic names and translations.

VI. *The Influence of the Recent Storm on Bird Life.*

By Professor DUNS, D.D.

(Read 19th March 1879.)

In this communication I wish to submit to the Society some facts to illustrate the effects of the recent very severe weather on a considerable number of our resident and also of our migratory birds. The period embraced in the following notes is chiefly so much of December 1878 and of January 1879 as was marked by exceptional severity.

With the view of obtaining information, I drew up a set of queries, varying according to the physical conditions of the districts to which they were sent. The gentlemen from whom I obtained returns are all trustworthy observers. By their painstaking kindness, and as the fruit of my own observation, I am in circumstances to lay before the Society a good deal of accurate information on the subject of this paper, gathered from Aberdeenshire, Argyleshire, Banffshire, Berwickshire, Inverness-shire, Linlithgowshire, Midlothian, Perthshire, Stirlingshire, and Wigtownshire. The topics to which the attention of correspondents were directed related mainly to the supply of bird-supporting berries last autumn, the number of birds found dead from starvation, the species which had suffered most, the condition of our winter birds of passage, and the occurrence of stragglers.

Aberdeenshire.—Mr Ferguson of Kinmundy has put at my disposal some interesting notes made by him in answer to my queries. He says (10th March 1879): "(1.) The supply of bird-supporting berries, such as haws, rowans, service berries (*Pyrus torminalis*), was not only below the average last autumn, but at Kinmundy, Pitfour, and the district of Buchan, Aberdeenshire, it was almost *nil.* (2.) Many birds have died from starvation during the recent storm. Even the robin has succumbed in many instances, and since the snow disappeared great numbers of the skeletons of partridges have been seen. (3.) Woodcocks this winter have been exceptionally few. When at Kinmundy, where, however, there is not a great deal of cover, we only saw three or four. At Pitfour, where there are thousands of acres of wood, they were very scarce. Those obtained were not less fit for the table than usual. (4.) The migratory birds have been later than usual. Up to this date only an occasional lapwing has been seen, and as there are always a few which remain with us over the winter, these exceptional individuals may have wintered here. The starlings are making their appearance again, but I am not satisfied that they leave us at all, though they are not seen in the dead of winter. (5.) In December and January, when the ground was completely, to a great depth, covered with snow, the wood-pigeon migrated in immense flocks to the coast, where the snow covering was more partial. They were seen in immense numbers, for instance, in the parish of St Fergus, which lies along the coast to the north of Peterhead. The Highland piet, or fieldfare, seemed to become unusually tame, and numbers of them took refuge in the small gardens of the town of Fraserburgh, and were fed by the people along with the robins. I saw a considerable flock of them this month in the garden of the Free manse at New Deer. As soon as the soil began to be visible in this neighbourhood, the wood-pigeons returned in innumerable quantity, and have caused great destruction among turnips. (6.) The only further remark which occurs to me is, that I am struck with the absence of common birds in their usual numbers, such as blackbirds, thrushes, linnets, and even sparrows. During the severity of the storm partridges and even grouse fed quite tamely among the ricks in the farm-yards, and the former frequented cottage gardens quite familiarly." A newspaper correspondent writing from Aberdeen on the night of Tuesday, the 31st December, said: "As showing the severity of the weather, it may be stated that a number of partridges have found their way to the city, where several were caught during the day."

Argyleshire.—Under date December 18, 1878, Mr John Campbell, Ledaig, near Loch Etive, writes: "Yesterday I found a number of little birds dead and dying—redwings, common thrushes, a pair of a kind, one of which I send you, chaffinches, etc., etc." "LEDAIG, *December* 25.—I received your note this morning, and send you a few more birds which I found dead in the garden to-day—a thrush the same as the last to make a pair, two redwings, a little bird I don't know by its English name; our Gaelic name for it means the heather chatterer. The redwings are dying in dozens. To-day I got some blackbirds, chaffinches, hedge sparrows, and common thrushes." "LEDAIG, *December* 26.—The contents of the box I forward to-night I found frozen to death in different parts of the garden. The woodcock illustrates the great severity of the weather. The weasel was one of the prettiest I have ever seen." "LEDAIG, *January* 16, 1879.—I send you a little bird I got at the roadside, near my house. I have never seen such a small snipe here before. I have been inquiring after what you wish to know. The game-keeper says the grouse stood the last storm well, as there was plenty of heather, swept bare over large areas by the high winds. As to number, I shall give you what I have seen myself within the range of a common gunshot—18 redwings, 9 thrushes, 6 blackbirds, 2 woodcocks, 2 curlews, 1 black-headed bush-chatterer, 1 hedge sparrow, 1 chaffinch, 1 snipe, a weasel and a mole; they were all about or near the garden. I account for so many in such a small space by their seeking shelter from the north and east winds under the southern face of the high overhanging rock behind my house." In a note of date 4th current, Mr Campbell says that, since he last wrote, he has picked up in the neighbourhood 9 curlews (*Numenius arquata*), 2 golden plovers (*Pluvialis aurea*), and many more of the kinds referred to previously. With reference to these notes, I may point out that the so-called heather-chatterer is the black-headed bush-chat, or stone-chat as it is sometimes called (*Silvia rubicola*); it is occasionally found in Scotland during the winter, though it is not frequent. The pair of thrushes referred to are fieldfares (*Turdus pilaris*), about whose identity Mr Campbell hesitates. One hardly wonders at this hesitation, their forms, which I now show to the Society, are so much more beautiful than usual. The plumage of the woodcock is also very fine, though the bird was in very poor condition. It seemed literally to have lost all its flesh. The keel of the sternum was almost sharp as a knife, and the body of the sternum felt as if its only covering was a hard thin skin, the plump padding of muscle having been lost. The weasel (*Mustela erminea*) noticed above merits a word. As described, it was very pretty when it reached me, more so than now, though it is even yet attractive. The fur is only partially whitened. I refer to it chiefly with the view of asking, Is it a young form, and does complete albinism take place only when its second winter sets in? If so, what becomes of the disguise theory? I have another specimen similarly marked, which was killed in the dead of a severe winter, and have seen others. But this by the way.

Banffshire.—Both Mr Ferguson and my Ledaig correspondent refer to grouse. On the 30th December 1878 the following note appeared in the *Scotsman*:

"SIR,—During the height of the present severe storm grouse were observed to take wing from the high rocky coast between Helmsdale and Berriedale, and proceed right out to sea. Fishermen tell me that they had seen them fly in packs over their heads when about three miles from shore, and by the direction they took would strike land somewhere on the Banffshire coast, after a flight of about forty miles. It would be interesting to know if ever they reached, but which I very much doubt, as these birds are not adapted for making such long journeys without rest.—I am, etc., A. B."

Being curious to learn if the arrival of these very venturesome birds had been noticed, at my request an acquaintance of Mr Thomas Edward wrote to "the Banffshire Naturalist," and received the following reply:

"LOW SHORE, BANFF, *January* 17, 1879.

"DEAR SIR,—There have been grouse seen, and shot, too, on our coast during this stormy weather, but whether they came from Sutherland, or only down from our own hills, I am not aware. That they, as well as other birds and beasts, have suffered dreadfully, there is no doubt.—Yours sincerely,

"THOMAS EDWARD."

Berwickshire.—From John Wilson, Esq. of Wellnage, Dunse, I have the following: "I have been so little out of doors for a month past, that I could not give you the information you asked about the wild birds, of my own observation. I have now had the opportunity of questioning several of my farmer friends, and shall give you the results. I know from my own observation that the crop of haws and berries was this year a very poor one. Dog hips were plentiful, but nothing else. There were a few berries on some of my hollies, but they disappeared with the very first days of snow. A few dead fieldfares have been noticed lying about, but not many, and I hear of nothing else. When the snow was at the deepest, the wood-pigeons were desperate. A regular shooting went on daily in most of the gardens about Dunse. Above a dozen were killed in my own. They were in a fair condition, but I hear of both them and rabbits being very lean. For a time the pigeons were seen in such incredible numbers, that I have no doubt there had been an arrival from Scandinavia." (Perhaps these were the Linlithgowshire birds noticed by Colonel Gillon below as having deserted that district.) "One friend has seen a flock of snow buntings, after an interval of thirty years since he had seen them before. At Bogend a lot of partridges, with some water-hens, wood-pigeons, and smaller birds, came close in front of the farmhouse, attracted by crumbs thrown out to them. The front door being purposely left open, several of the partridges actually came into the lobby."

Inverness-shire.—I am indebted to Arthur Forbes, Esq. of Culloden, for the following valuable note as to his locality: "*January* 1, 1879.—In reply to your esteemed favour, I may state that the last severe and protracted frost told severely on birds in this district, although not so much so as in some previous winters. Rooks, wood-pigeons, partridges, and some kinds of smaller birds were found dead, and woodcocks became so poor as to be quite unfit for the table. Wild swans were seen on the coast, and great numbers of wild duck. Grouse forsook their accustomed moorland haunts; some were seen and shot close to the sea-shore. There were unusually few berries on holly, hawthorn, shrubs, etc., this season, and even turnip-tops—very much the winter food of wood-pigeons—were covered with snow, which lay on the ground to about a foot in depth. I consider it was want of food rather than the severe frost that killed the various birds. The lowest temperature in the air was 13° 8′, and 6° on the grass. For twenty-three nights the thermometer was below the freezing-point, and the average temperature for the whole month was only 33° 38′, being 3° 63′ below that of 1860.—Yours sincerely, ARTHUR FORBES."

Linlithgowshire.—Colonel Gillon of Wallhouse, Bathgate, writing on January 9, says: "I may begin by stating that, having delayed covert shooting a little too long, the snow came on in such earnest, that I had to abandon that sport and take to wild fowl and snipe shooting along the rivers and burns, chiefly however on Couston and its tributaries. A good many birds have died of starvation. Since the storm began I have only seen one woodcock, and when we shot it we immediately remarked, 'How thin!' As to pheasants, the near feeders, which have grain put down for them, have kept their condition well; but those in outlying coverts have suffered much, and two have been picked up starved. Some ducks and snipes were in poor condition. Regarding the latter, I may mention that when the rivers were all but frozen up, I went into Ballbardie Park, where there are two warmish streams, one from the distillery, the other from the pits, and in an hour and a half I bagged six couple. Examining their crops or throats, I found they had been living on slugs of a grey colour. Is this usual? Before the storm there were numbers of wood-pigeons roosting in the Desert and Nethermuir, which tried to subsist for a time on the shaws of the turnips, but a fortnight ago they disappeared. Where have they gone? Two autumns ago I noticed large flocks of wild pigeons coming in to roost, as well as covering some fields during the day. I shot two and found they were foreigners —smaller than the cushat, of a slaty blue, and without the ring. I never saw fewer berries. Our old hollies last year had a splendid crop. On December 16th I shot a kingfisher —a rare bird here; five years ago a greenshank (*Totanus glottis*), and in 1870 a quail (*Coturnix vulgaris*)."

Midlothian. — The autumnal supply of bird-supporting berries was much below the average, the fruit in some cases, as in the hawthorn, falling far short of the promise in the form of bloom. When the December storm began to moderate, many birds, chiefly blackbirds and common thrushes, were found dead in the gardens and by the highroads in country districts. In one garden at Portobello six thrushes were picked up. By notes in the newspapers, public attention was called to the matter and many instances given. The weakness of the birds through cold and hunger was taken advantage of by youngsters to whom the handling of a gun has ever a charm. One could not but sympathise with the vigorous protest of "Avis" in the *Scotsman*. He says: "Any one may hear all day long, and in all directions, what might almost be termed a 'rattle of musketry,' which is simply nothing else but men shooting at, and I presume killing, blackbirds, thrushes, starlings, and even sparrows. . . . Where is the glory or even the sport of killing small birds. I too have seen poor birds under the hedgerows scarcely able to fly. Where is the glory or sport in killing a half-dead bird ?"

Perhaps nowhere so well as in the neighbourhood of a city can the effects of a severe winter on bird-life be estimated. If the instances of death from starvation be many in a locality where most things favour the chances of picking up a livelihood, what must the state of matters be in districts where everything is unfavourable ? A great amount of feeding is practised in the outskirts of a city especially; and to the points where crumbs, etc., are regularly laid down, many different species congregate, some of them, to judge from the state of their plumage, from the country. I have for many years, not during the winter only, but, though to a less extent, in summer also when at home, been in the habit regularly at eight in the morning, of laying down food of different sorts in one spot. In severe weather the company that flocks together is both numerous and various. Some I know have paid a morning visit for several years. There is, for example, a sparrow lame of foot and with a strong tendency to *albinism,* which I first noticed four years ago, with one unusually light coloured primary quill, which is now prettily mottled all over with white. Perhaps, I should say, *was* thus marked, because it has not appeared for several days. One morning I counted an assemblage of eight rooks, three jackdaws, seventeen starlings, five blackbirds, three thrushes, more than two dozen of sparrows, one chaffinch (male), two large tits (*Parus major*), two blue tits (*P. cæruleus*), two hedge-sparrows, and one redbreast. When ten days ago blinks of more genial weather deceived us into the belief that winter had passed, the flock, with the exception of about a third of the sparrows, two blackbirds, a pair of starlings, and the hedge-sparrows, all disappeared till Tuesday of last week, when they again reported themselves in large numbers. On Sabbath last all were again present in even greater force than before. This near approach to so many species has had one great advantage. Aspects of habit, bearing on their association with one another, on modes of feeding and the like, with which one can become acquainted only in such circumstances, are brought strongly out. All of them are worth noting, while some are very interesting. But it would delay us too long to refer to these more fully. An unusual number of kingfishers have recently appeared in our neighbourhood and elsewhere. Mr Hope, birdstuffer, George Street, alone preserved nine between December 7, 1878, and January 11, 1879. These may be tabulated thus:

Sex.	Locality.	Date.
Male, . . .	Liberton, . . .	Dec. 7, 1878.
Female, . . .	Liberton, . . .	Dec. 14, 1878.
Female, . . .	Liberton, . . .	Dec. 14, 1878.
Male, . . .	Ratho, . . .	Dec. 18, 1878.
Female, . . .	Dolphinton, . .	Dec. 25, 1878.
Female, . . .	Burntisland, . .	Jan. 1, 1879.
Male, . . .	Ormiston, . . .	Jan. 4, 1879.
Male, . . .	Yetholm, . . .	Jan. 7, 1879.
Male, . . .	Jedburgh, . . .	Jan. 11, 1879.

The Dolphinton specimen was shot at a cottage door at some distance from the water. Some of the birds were in extremely low condition.

Perthshire.—In answer to queries, Mr Hew Miller, Westerton, Ochtertyre, near Crieff, says, 13th March: "The supply of bird-feeding berries last autumn was far below the average. Many birds have died, particularly the mavis, blackbird, chaffinch, etc. Only five woodcocks have been shot here this season. At the same time last year forty had been shot. This year they all made off when the severe weather set in. Grouse stood out pretty well. They appear to be quite strong and healthy in the Grampians. Partridges are also strong and healthy."

Stirlingshire.—A fellow of the Society, Mr Robert Kidston, has shown me a communication, dated 11th March, from David Bruce, Esq., Stirling, in which the following remarks occur: "Few birds were visible long before the end of the severe weather. It is, however, difficult to know whether their absence is occasioned by death, or departure farther south." Referring to the town of Stirling, he says: "The few birds visible were chiefly sparrows and blackbirds. In the early period of the storm there were many redwings to be seen in the Back Walk—say a flock of about sixty or seventy. I watched them for about a week or ten days, and noticed that they got gradually weaker and fewer. Boys had little difficulty in catching them with the aid of their caps. They seemed too weak to get away, and I have no doubt every one of them perished. Strange, I have seen only one fieldfare this winter, and it seemed always to keep about fifty yards away from the redwings. The paucity of the feathered tribe about us is now marked."

Wigtownshire.—The Rev. George Wilson, writing on the 22d of January 1879, says: "I have heard of a few small birds being seen dead below hedges, and one man reports he had seen a good many dead blackbirds." On the 18th of February Mr Wilson informed me that the mortality had been much greater than he was aware of previously. Many linnets, green and grey, had been found dead. The gulls at Luce Bay had suffered much in consequence of the freezing of the shore between tide marks, and, as he believes, because the surface-swimming fishes had gone out of the reach of the gulls because of the intense cold. Gulls alighted and fed along with the barn-door fowls.

These notes supply a good deal of material for speculative questions of great interest. For example, the common impression indicated in the lines—

"Sae lang as it snaws
The birds will hae haws,"

not only shows that there is some ground for the belief that the supply of food for birds generally answers to their necessities, but it raises a question which lies further out of view. May there not be purpose when the provision is not equal to the wants? Then there is a deeper question still, which would lead us to expect the existence of an analogy between such seasons of wide-spread havoc among groups of animals, say birds, and periods of great mortality among men. Both questions seem to me susceptible of a thoroughly satisfactory discussion from the point of view of creative interference. But this would lead us into a field which properly lies outside of the work of our Society. I merely hint at the existence of this field. It is one of immense interest to the philosophic naturalist. Leaving such topics, however, I conclude from the foregoing notes:

1. That the supply of bird-supporting berries was much below the average last autumn.

2. That the number of our winter birds of passage has been smaller this season than usual.

3. That the present winter has been one of very exceptional mortality among birds.

4. That the forms which have suffered most are those (1.) which depend on berries, and those (2.) which depend on worms and slugs—the mixed feeders having an advantage.

5. That certain species are enabled to some extent to neutralise the exceptional severity of the weather by having recourse to partial migrations.

VII. *Note on the Migration of the Pied Wagtail* (Motacilla Yarrellii). By A. B. Herbert, Esq.

(Read 15th January 1879.)

Walking along Inverleith Row one evening, just before sunset, in the middle of last September, I heard repeatedly the well-known call-note of the pied wagtail, and, looking up, saw on two of the houses a large assemblage of these birds, sixty or seventy at the least; and there may have been double this number, as I could see only one side of the roofs. Many others kept continually arriving, and I noticed that all came from one direction, namely, from the north-east, exactly from the same quarter whence I observed a large flock of fieldfares (*Turdus pilaris*) in the first week in November. I have no doubt the wagtails were migrating, for they seemed tired and glad to rest, and I need scarcely remark that they are not as a rule gregarious in their habits. Mr Gray informs me he has observed similar migrations in the west of Scotland, and Mr Scot-Skirving says he once saw some two hundred of these birds resting on the roof of the General

Post Office in Edinburgh. The question naturally arises, whence come these birds and whither do they go? As far as my observation extends, we have no perceptible increase or decrease in their numbers in the winter either here or in the middle of England, nor am I aware that this is the case in the south of the island; and it has occurred to me, though of course this is merely a conjecture, that these migrations may be from Scandinavia to the Continent, or even farther south to Africa. Of the winter habitat of the hirundines, thanks to Canon Tristram and other observers, we are now pretty well informed, but of that of these migratory wagtails we seem to know little. I am aware that both Gould and Yarrell, and our friend Mr Gray, draw a distinction between the Continental species, *Motacilla alba*, and our own, and I would suggest that it is *possible* these migrants may be the Continental species, but I could discover nothing in their call-notes, mode of flight, etc., to induce me to think those I saw were any other than our common species; but this point could be easily solved by shooting one of the migrants; and I have ventured to make these few remarks in the hope of eliciting from some of our members information on the subject. I know no tribe of birds more interesting than the three common species of *Motacilla* of these islands; beautiful in colour, elegant in form, sprightly, joyous, and agile in habits, they at once attract our attention, and they are perhaps the quickest runners for their size of any birds we possess, not proceeding by a series of small jumps like the chaffinch and so many others, but running in the ordinary mode, and with such rapidity that the eye can scarcely follow their movements. I consider the yellow species (*M. Rayi*), which is truly migratory and a summer visitant, the most beautiful and graceful of the three; it is more attenuated in form, and the fine shadings of yellow and greenish brown render it an attractive and extremely pretty bird. Often, as a boy, have I sat on a common in summer to watch a pair of these birds feeding close to a cow, with whom they seem to establish a sort of friendship, as they fearlessly and with great adroitness capture flies within a few inches of her mouth or legs, for all the tribe are expert fly-catchers, no doubt to the mutual gratification of both bird and quadruped. Any one wishing to observe the habits of the grey wagtail (*Motacilla boarula*) can do so without difficulty on the Water of Leith, for it is almost impossible at any time, winter or summer, to walk from Stockbridge to Dean Bridge without seeing several, and they are also frequently to be seen on the same stream at Bonnington. A favourite place for the nest of the pied wagtail is the ivy against our dwellings, and a well-kept lawn a favourite feeding ground. They are met with at a distance from streams more frequently than the grey wagtail, and the yellow species seems to me to be as much a frequenter of pastures and commons as streams. The grey-headed wagtail (*Motacilla flava*) is unknown to me, though Mr Gray records its having been seen at the Water of Leith.

VIII. *On an Abnormal Specimen of Euplectella aspergillum (Owen).* By George Leslie, Esq., Demonstrator of Zoology, University of Edinburgh.

(Read 16th April 1879.)

The specimen which I now exhibit to the Society is one which attracted my attention while lately examining the zoological collection in the museum of the Albert Institute of Dundee. It was sent from Manilla in the Philippine Islands, together with a fine *Meyerina* and examples of the normal form of *Euplectella,* and was very kindly entrusted to me for description by Mr John Maclauchlan, the curator of the museum, to whom I would now tender my best thanks. Before describing the specimen, a few observations on the history of our knowledge of *Euplectella,* and on its general structure and contour, may be profitable.

This beautiful sponge was first described by Professor Owen, who in 1841 communicated a paper on the structure of an example received from the Philippines to the Zoological Society of London. This was subsequently printed, accompanied with an excellent figure in the *Transactions* of the

Society.* Professor Owen supposed that the narrower extremity of the sponge, with its prolongation of siliceous fibres, was the upper free end, and that the wide extremity was embedded in the mud or sand of the sea-bottom. It is now known that the narrower end is basal, its fibrous terminal appendages serving as an anchor to the organism. A similar misconception was long current in regard to *Hyalonema*, the glass-rope sponge of Japan, which was described and figured as if the cup-like sponge was the embedded part, while the siliceous rope, with its encrusting *palythoa*, was free. It is thus necessary, in reading Professor Owen's description, to reverse his terms of upper and lower, apical and basal, etc.

In 1857 Professor Owen described † a second species of the same genus, *Euplectella cucumer*, differing from *E. aspergillum* by its ventricose shape, the absence of the lateral wavy ridges, and in other characters. This specimen was received from the Seychelles. Up to this period no second example of *E. aspergillum* seems to have reached this country, as the author still terms it unique. In the same paper an account is given of the capture of the type specimen of *Euplectella aspergillum*. It was said to have been got by a fisherman off the island of Bohol on a rocky bottom, at a depth of ten fathoms. Considering the extreme reluctance of the Philippine islanders to show the fishing-grounds of *Euplectella*, and the facts that they have been obtained by Europeans at depths of not less than ninety fathoms, and on a soft muddy bottom, it is probable that the ingenious mariner's account of its capture in ten fathoms on a rocky bottom displayed a greater share of sagacity than of candour.

Within recent years the skeletons of *Euplectella aspergillum* have been brought to this country in large numbers, so that from being one of the rarest of zoological treasures, it has now become a very familiar object in our museums. Its beauty and symmetry have procured for it the popular name of "Venus's flower-basket." More lately it has been obtained with the sarcode or sponge-flesh adhering to it, and Sir

* Vol. iii., p. 203. † Trans. Linn. Soc., vol. xxii.

Wyville Thomson has kindly permitted me to exhibit a specimen in this condition.

In 1868 Drs Herklots and Marshall described * a new form, to which they gave the name of *Euplectella Owenii.* Five examples of this species were brought from Japan by Major von Siebold, and these are now in the Leyden Museum. Unfortunately no indication of the depth from which these were obtained is given. *Euplectella Owenii* is oval instead of round in transverse section, and wants the apical frill. This species and a number of other hexactinellids are described at length by Dr William Marshall in his admirable "Untersuchungen über Hexactinelliden." † This author regards *Euplectella aspergillum* and *cucumer* (Owen) as being specifically identical—an opinion now very generally accepted. It is worthy of notice in this connection, that Dr Marshall contemplates the possibility of the existence of ramose or colonial forms of *Euplectella,* as he writes, ‡ "Es würde mich wenig wundern, wenn z. B. Formen gefunden würden, die nicht mehr aus einer Person beständen sondern einen Cormus bildeten." The contour of the abnormal specimen now exhibited seems to favour this hypothesis.

Sir Wyville Thomson has recently described § and figured a third species, *Euplectella suberea,* obtained during the voyage of the "Challenger," at a depth of 1090 fathoms, ninety miles south-east of Cape St Vincent. This is the only Atlantic form of the genus at present known; but Sir Wyville believes in the existence of others from fragments obtained during dredging, too imperfect indeed for description, but evidently belonging to distinct species. *Euplectella aspergillum* was obtained in the living state in considerable numbers by the naturalists of the "Challenger" off the island of Zebu, one of the Philippines, at depths of 95 to 100 fathoms. All the "Challenger" specimens possess the normal form.

Captain Chimmo, R.N., has recently published an interest-

* Archives néerlandaises, Bd. iii.

† Zeitschrift für Wiss. Zool., xx. Bd. Suppl.-Heft.

‡ *Loc. cit.*, p. 209.

§ "Voyage of the 'Challenger'—The Atlantic," vol. i., p. 133.

ing account of *Euplectella*,* in which he describes the means employed by the natives for its capture, and their manner of preparing its skeleton. He states that it is to be found only within a very limited area, and at a depth of 120 to 140 fathoms. It is known, however, that it has a rather greater bathymetrical range than this, as shown by the "Challenger" specimens. Captain Chimmo figures two abnormal forms, neither of which resembles that now exhibited, in which one tube is a diverticulum of the other, both of his specimens being double tubes, with equivalent longitudinal axes.

Euplectella belongs to the family *Hexactinellida*, which is characterised by its members always possessing six-rayed siliceous spicules. The skeleton consists of a cylindrical tube closed at its upper and lower extremities. The internal cavity is simple, and is often inhabited by commensal crustaceans. The average length of specimens, exclusive of the basal fibres, is from eight to twelve inches, but some which have attained the length of two feet are recorded. The normal form which I now exhibit, and on which I shall base my description, is 24 centimetres = $9\frac{1}{2}$ inches, in length. Its transverse diameter at the apex is three centimetres, and this remains almost uniform throughout the upper half of the sponge, but it rapidly diminishes in the lower half, so that the transverse diameter of the basal extremity is rather less than two centimetres. The lower third of the cylinder is sharply bent, and this curvature also affects, but to a much less degree, the upper part. A concave and a convex side are thus determined. In some specimens a secondary curve is seen near the upper end, so that the side which is strongly convex below, becomes slightly concave above.

The parietes of the sponge are formed by white glistening siliceous fibres, which are arranged in a very definite manner, there being a transverse, a longitudinal, and an oblique set. The transverse fibres are internal, and form annuli, which are very marked when we examine the internal cavity. Each annulus is composed of a considerable number of parallel siliceous fibrils. They form a very regular series for the

* "Natural History of *Euplectella aspergillum*." London, 1878.

whole length of the sponge, and are placed at a distance of about three millimetres apart, but of course this varies with growth.

The longitudinal fibres, which are external to the transverse, are also compound. In the apical portion of the sponge they are arranged at intervals of about three millimetres. They enter largely into the formation of the coronal plate, and sometimes bifurcate, so that a band which is simple throughout the greater part of its length, is continuous with two peripheral trabeculæ of the plate. Towards the lower extremity each band is resolved into its constituent fibrillæ, the basal prolongations of which form the root of the sponge. These terminal fibres are barbed along their margins and at their extremities.

The transverse and longitudinal bands are bound together by oblique fibres. These are not arranged in bundles, but consist of a delicate network of primitive fibrillæ, which project into the large quadrangular spaces left between the two former sets, reducing them to small rounded or irregular openings. From the sides of the cylinder some of the fibrils are produced outwards,forming the lateral ridges characteristic of this species. The ridges are arranged in a number of interrupted spirals. They are most marked towards the upper extremity.

The upper opening of the cylinder is provided with a coronal plate formed by a number of stout anastomosing fibres, which leave very irregular interspaces. The fibrillæ entering into its composition are very intimately united, and the coronal fibres have a dull, opaque, fused appearance, very different from those of the parietes. This plate is convex outwardly. At its periphery the parietal fibres are produced upwards into a delicate frill, about four millimetres in height. In this process the transverse and longitudinal bands are not present. It consists entirely of very delicate reticular fibrils.

From the consideration of the normal form of *Euplectella aspergillum* we shall now turn to that of the abnormal specimen which forms the subject of this paper, and we shall find that its peculiarities relate entirely to the contour of the sponge, not to its general structure or the arrangement of its spicules. It presents a primary axis, consisting of a hollow curved tube, closed below by the siliceous coil, and above by a coronal plate, just as in the typical form. When the longitudinal fibres are traced upwards from the base to the apex, on one of the lateral surfaces, they are seen to be perfectly continuous throughout, and regular in their arrangement. The primary tube differs from ordinary specimens, in that the arcuation is stronger in the lower half, and in the upper half the direction of the longitudinal axis is changed, producing an oblique lateral curvature. The greatest transverse diameter is at the junction of the lower and upper halves of the tube, where it measures four centimetres, while the widest diameter of normal specimens is at or near the apex. Its length, measured along the curvature of the convex side, is twenty-four centimetres, so that it must be regarded as a dwarfed specimen, being more robust and wider than the normal form we have exhibited, but not exceeding it in length.

The most remarkable feature of this sponge, however, and that on which the irregularities of the primary tube depends, is a diverticulum, which leaves its convex side near the junction of its middle with its upper third. This forms a shortened elliptical tube, of which the greater transverse axis is oblique to the longitudinal axis of the parent sponge. It thus presents an infero- and a supero-lateral surface. The cavities of the two tubes are continuous with each other. The infero-lateral wall is three centimetres in length; the supero-lateral measures from one to two centimetres. The structure of the walls of the diverticulum is fundamentally the same as we have previously described, consisting of transverse, longitudinal, and oblique fibres, but these are disposed with less regularity. It is closed above by a convex reticular coronal plate of the ordinary structure, above the periphery of which the parietes are produced into a delicate frill.

That part of the upper wall of the parent sponge continuous with the supero-lateral angle of the diverticulum is much distorted. It is twisted downwards, and the longitudinal bands which enter into its composition meet those of the lower part at a considerable angle, instead of having the same direction. The structure of the opposite wall is perfectly normal. It should also be observed that the diameter of the tube decreases towards the apex, which measures only three centimetres across. In the ordinary form we found that the greatest transverse diameter was at the upper extremity.

I was at first inclined to consider this specimen a ramose varietal type of *E. aspergillum*, but, after an examination of it, have come to the conclusion that it is to be regarded as an abnormality. The sponge, while yet in a very young condition, had received an injury, by which a small portion of its wall had been torn away. The process of reparation of this lesion consisted not of a mere bridging across of the aperture, but of a slight and irregular lateral outgrowth of its margin, and of the partial occlusion of the tube so produced by a coronal plate. This increased in size with the growth of the sponge, and has been the cause of the irregularity of the upper part of the primitive cylinder, which has been already noticed.

The perfect regularity of the lower part of the tube, the asymmetry of the diverticulum, and the distortion of that part of the parent sponge implicated in its growth, are facts which disprove the hypothesis that this is to be regarded as a normal variety of *Euplectella*. I have not seen any record of a similar malformation in the literature of the subject, but believe that there is a specimen exhibiting it in the Elgin Museum. My friend, Mr F. Jeffrey Bell, of the British Museum, informs me that there are no branched specimens in the national collection.

IX. *The Old Red Sandstone of Shetland.* By B. N. Peach, Esq., A.R.S.M., F.G.S., and John Horne, Esq., F.G.S. (Plate I.)

(Read 19th February 1879.)

The Old Red Sandstone of Shetland, though inferior in development to that of Caithness or Orkney, claims special attention on account of the interesting proofs which it affords of the previous extension of that formation, as well as the remarkable history of the volcanic phenomena which characterised that period. Though the areas now occupied by the sedimentary rocks are limited in extent, there can be little doubt that they convey but a faint impression of the original extension of this formation in the Shetland Isles. The fine mural precipices of Old Red Sandstone which are visible in some of the islands, notably in Bressay and Foula, furnish a striking proof of the importance of the relics which have escaped denudation.

As far back as the year 1811, Dr Fleming pointed out the occurrence of vegetable impressions in the sandstones of Bressay, in a paper published in the Memoirs of the Wernerian Society, vol. i., entitled, "A Mineralogical Account of Papa Stour." Since that time numerous plant remains have been found in the members of this formation at different localities in Shetland.

In 1853 Dr Hooker referred some plant remains collected from the Lerwick sandstones, by the Right Hon. Henry Tuffnell, to calamites; while, in 1858, Sir Roderick Murchison intimated the discovery of *Estheria* in the Lerwick beds, which linked these strata with those of Caithness and Orkney.

Dr Hibbert, in his admirable work on the Shetland Isles, laid down approximately the limits of the different Old Red Sandstone areas. In 1877 Dr George Gibson published a thesis descriptive of these rocks; and in 1878 Professor Geikie, in his exhaustive monograph on the Old Red Sandstone of the North of Scotland, described the relations of the Shetland representatives to the other members of this formation in Orkney and Caithness. He refers specially to the proofs of volcanic activity in Papa Stour, the geological structure of which is given in detail.

During the summer of 1878 we made some traverses in the islands for the purposes of determining the disputed question of their glaciation, and in the course of these traverses we felt it to be necessary to map out with as much minuteness as time would permit the boundaries of the various Old Red Sandstone areas, on account of the important evidence which they furnish regarding the movements of the ice in the glacial period. We were induced to work out the order of succession on the eastern side of the Mainland as well as the relations of the associated contemporaneous and intrusive igneous rocks in the western districts.

While pursuing this object we were fortunate enough in discovering in the Walls district a rich series of plant remains in rocks which have been hitherto considered as forming part of the metamorphic series. Mr C. W. Peach has kindly named the plant remains for us, and from his description it is evident that they are identical with the plants found in the Old Red Sandstone formation of Caithness and Orkney. The rocks in which they are embedded must therefore be relegated to that period, though they seem to have undergone a considerable amount of metamorphism.

In this paper we propose to give a brief sketch of the different areas occupied by these rocks in Shetland, indicating as far as possible the succession of events and the relations of the contemporaneous and intrusive igneous rocks. We shall endeavour to show that during the early phases of that period, the Mainland, which is the largest of the Shetland group, must have formed an island somewhat smaller in size than now, round whose coast-line the basement breccias accumulated; but eventually as the land slowly sank beneath the sea-level, the higher deposits overlapped on to the gneissose rocks, and ultimately buried them. The long process of denudation to which the Shetland archipelago has been subjected has removed in a great measure the greater portion of these deposits; those which now remain being protected in part by the hard gneissose rocks against which they have been brought by dislocations of the strata.

The order of succession on the east side of the Mainland is as follows:

e. Flaggy group of Bressay and Noss.
d. Lerwick sandstones.
c. Rovey Head conglomerates.
b. Brenista flags.
a. Basement breccia, resting unconformably on the underlying schists.

Owing to a series of faults which form the boundary line over a great part of Lerwick, Quarff, Conningsburgh, and Dunrossness, it so happens that different zones in the foregoing vertical section are brought into conjunction with the gneissose rocks. The true base of the series, however, is exposed in the neighbourhood of East Quarff on the north side of the bay, and again on the south side towards Fladabister, while still another locality in which the basement breccias occur, is to be seen near Loch Spiggie in Dunrossness. In each of these localities the breccia varies in character according to the nature of the underlying rock. Perhaps the finest exposures of this breccia are to be seen on the hills to the north of East Quarff, and round the shore towards Brenista Ness. Here it forms well marked cliffs, the beds being inclined to the east at an angle of 25°, and resting on a highly eroded platform of the metamorphic schists. The prominent ingredient in this deposit round the bay of East Quarff is the underlying rock, which consists mainly of grey schists. Blocks of this material sometimes measure three feet across, retaining their angular edges and showing little trace of aqueous action.

Near Loch Spiggie, in Dunrossness, the fragments mainly consist of pink syenite and serpentine derived from the underlying rocks which form the floor on which the breccia rests in that neighbourhood. The occurrence of fragments of these rocks in the basement breccia is of great moment, as it helps us to fix the age of the pink syenite and serpentine between Quendale Bay and Loch Spiggie.

In the bay west of Brenista, the overlying series of the Brenista flags is thrown against the breccias and underlying schists by a fault which is traceable inland in a N.N.W. direction. Between East Quarff and Fladabister, however, the relation between the two is seen in several fine exposures which show the gradual passage from the breccia into the overlying chocolate flags. But farther, about half-way between these two localities, the basement breccia, which is upwards of 200 feet thick on the shore, thins out inland to a few feet, and in some places disappears altogether, so that the Brenista flags rest directly on the underlying rocks. This interesting phenomenon evidently points to a gradual sinking of the area during the deposition of the successive members of this formation.

Returning to the shore section north of East Quarff, we find a gradually ascending series from the Brenista flags to certain coarse conglomerates seen in a small stream at the head of the bay of Gulberwick, which are totally different in character from the breccias already described. The included pebbles are well rounded and are to a large extent composed of different materials from the basement beds. These beds are traceable up the slope of the Gulberwick hollow to the road between Lerwick and Scalloway, where they form crags on the hill face. They are also traceable across the hills northwards to Rovey Head, about two miles north of Lerwick, where they are thrown against the metamorphic rocks by a fault which is well seen on the shore. From Rovey Head southwards to the ridge overlooking the head of Fitch Dale, this fault forms the boundary line between the metamorphic rocks and the conglomerates. It follows, therefore, that the underlying Brenista flags and the basement breccia have been thrown out along this line.

Again, on the shore south of Rovey Head, and to the east of Gulberwick, the Rovey Head conglomerates are succeeded by a thick series of coarse sandstones, passing into pebbly grits, with occasional conglomeratic layers. These have been termed by us the Lerwick sandstones, because they are most strikingly exhibited in the neighbourhood of the capital of Shetland.

The patches of Old Red Sandstone rocks which occur between Ocraquay and Aith's Voe, and between Sandlodge and Hoswick, are faulted against the metamorphic rocks, as described by Professor Geikie and Dr Gibson. The strata in these isolated areas, as well as in the island of Mousa, belong to the series of the Brenista flags. Near the fault they are highly inclined, but at some distance from it they dip towards the south-east, at angles varying from 15° to 20°. The well-known veins of copper and iron ore at Sandlodge, which we had ample opportunities of examining through the kindness of Mr Walker, occur in these rocks.

Again, at Levenwick, the fault is seen on the shore, which brings this flaggy series into conjunction with the metamorphic rocks. It may be followed southwards along the base of the hills towards the Dunrossness Manse, where it probably dies out, as the flags succeed the basal breccias of Loch Spiggie without any apparent dislocation. Round Boddam, and southwards towards Lambhoga Head, the characteristic features of the Lerwick grits and sandstones are displayed, the underlying Rovey Head conglomerates being represented on the shore west of Sumburgh Head, and west of Boddam.

On the eastern side of the Mainland, therefore, the highest beds are represented by the Lerwick sandstones, and it is only when we pass to the east side of Bressay that the overlying series is to be met with. Along the eastern shores of Bressay, and in the island of Noss, the beds consist of grey, blue, and red flags, with occasional bands of breccia and reddish grey sandstones, which remind one forcibly of the flaggy series in Caithness and Orkney. The appearance of these beds encourages the hope that ichthyolites will yet be found in them, though a careful search failed to bring any to light. At the base of Noss Head we discovered a zone of dark shale, with limestone nodules, which strongly resembles the well-known fish-bed on both sides of the Moray Firth.

The flaggy strata of Bressay and Noss are pierced by a remarkable series of volcanic pipes, which we shall refer to presently when we come to discuss the igneous rocks associated with this formation.

In the peninsular tract of country which lies between Weesdale and the western shores of Walls and Sandness there is a great series of rocks, which have hitherto been considered as forming part of the metamorphic series. At the north-west corner of this area a small strip of ground, bordering the coast at Melby House, about a mile and a half in length, is occupied by Old Red Sandstone rocks, which have been referred to by previous observers. The strata in this small patch consist of reddish sandstones, with dark blue flags and shales, which are faulted against the quartzites and shales of Sandness Hill.

With this exception, however, the strata in the tract now referred to consist of red and grey quartzites, with red and pale shales. The quartzites are traversed by joints in all directions, which are abundantly coated with peroxide of iron, and in many places they have a marked schistose character. We were fortunate enough in discovering an abundant series of plant remains in these altered rocks, some of which are tolerably well preserved. Mr C. W. Peach has referred the plants to *Psilophyton* and *Lepidodendron nothum,* and regards them as identical with the plants occurring in the Old Red Sandstone rocks of Caithness and Orkney. It follows, therefore, that the rocks in which they are embedded, altered though they be, must be relegated to this formation.

Contemporaneous Igneous Rocks of Old Red Sandstone Age. —In the western district of North Mavine, between Stennis and Ockren Head, there is an important development of lavas and ashes, associated at certain localities with ashy sandstones and red flags, which belong to this period. These porphyrites and tuffs resemble in every respect the volcanic rocks of the same age in the Ochils. Excellent sections of these rocks are exposed in the coast-line from Braewick to Stennis, and thence to Ockren Head, where they have been tunnelled in a wonderful manner by the action of the sea. The structure of the area is comparatively simple, as the beds lie in a synclinal fold, the dip near Braewick being to the north of west, while along the western shore the porphyrites and tuffs dip to the south of east. On the west bank of Roeness Voe, about a mile from the mouth of the sea loch, the porphyrites are thrown against the intrusive quartz-felsite by a fault, and in Braewick Bay it is highly probable that the same relation exists between the two, though the evidence is obscured by the sandy beach.

In the Holm of Melby a bed of slaggy porphyrite occurs, dipping to the west; and again in Papa Stour Professor Geikie * has described a similar series of volcanic rocks, exposed here and there along the base of the cliffs underneath the sheet of pink porphyry. These are likewise associated with beds of sandstone and conglomerates, and are doubtless on the same horizon as the volcanic rocks of North Mavine.

* See "The Old Red Sandstone of Western Europe," vol. xxxviii. Edin. Roy. Soc. Trans., p. 345.

On the eastern shore of Bressay, opposite the north end of the island of Noss, we discovered a bed of tuff, interbedded with the flags, which is probably connected with the volcanic pipes in that neighbourhood.

Intrusive Igneous Rocks of Old Red Sandstone Age.—In North Mavine, as well as in the districts of Delting, Sandness, and Sandsting, on the Mainland, there is a series of intrusive masses, which doubtless belong to this period. These intrusive rocks vary considerably in lithological character, but they all agree in possessing a large proportion of silica, while the felspar is almost invariably orthoclase. The dome-shaped mass of Roeness Hill is formed of this material, while northwards it extends to the shores of the Mainland, opposite the island of Uya. It likewise crosses the peninsular tract west of Hillswick to the Heads of Grocken, reappearing in the Drongs, and on the west side of Meikle Rooe. From the marked columnar structure which characterises these rocks on the banks of Roeness Voe, and between the Heads of Grocken and Braewick Bay, as well as from the manner in which the Roeness mass spreads over the edges of the metamorphic rocks, we are inclined to believe that the granite and quartz-felsite in that district is an intrusive sheet, which was injected between the underlying metamorphic rocks and the overlying Old Red Sandstone strata, which have been long since removed by denudation. The quartz porphyry of Papa Stour, which covers nearly the whole of the island, is an intrusive sheet injected along the lines of bedding of the Old Red Sandstone rocks, as numerous sections clearly show. Indeed, a small patch of red sandstone is still to be met with resting on the pink porphyry at the Horn of Papa. Though no trace of the once superincumbent strata is now visible on the Roeness mass, this is not to be wondered at, when we consider the great denudation which has taken place since Old Red Sandstone times.

In the district of Sandsting there is satisfactory evidence to prove that the granitic mass between Gruting and Skelda Voes has been injected along the lines of bedding of the altered Old Red Sandstone rocks. While the inclination of the granite mass is nearly the same as that of the quartzites and shales, it may frequently be observed cutting across the sedimentary rocks, and sending veins of pink felsite across the lines of bedding of the quartzites. We are inclined to believe that the metamorphism which the Old Red Sandstone rocks have undergone between Weesdale and Sandness may be due to the existence of masses of granite not far from the surface, for it is highly probable that the isolated masses of highly siliceous intrusive rocks in the west and north of the Mainland are connected underneath, though this cannot be proved to be the case on the surface.

On both sides of Noss Sound, in Bressay and Noss, we discovered a series of volcanic pipes filled with a coarse agglomerate made up of fragments of the stratified rocks pierced by these vents. There is a singular absence of blocks of porphyrite in the agglomerate, but a thin vein of this rock is traceable for a short distance along the side of the old orifice.

Farther on the shores of Roeness Voe, as well as in Meikle Rooe, the quartz-felsites are traversed by a series of porphyrite dykes running in a north and south direction, which probably represent the last indications of volcanic activity during the Old Red Sandstone period in Shetland.

X. *On the Classification and Affinities of the "Tabulate Corals."* By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E., Professor of Natural History in the University of St Andrews.

(*Read* 29*th May* 1879.)

In the present communication I purpose giving a very brief general sketch of the structure and relationships of the so-called "Tabulate Corals," a group of Cœlenterates which I have been long engaged in investigating by means of modern methods of research, and which I shall treat of in considerable detail in a work now passing through the press. In the following remarks I shall confine myself to giving merely a short account of the results which have been arrived at by the combined observation of living and extinct forms, indicating the groups into which the so-called "Tabulate Corals" may be divided, with the structure and zoological affinities of these groups, so far as at present known.

The "Tabulata," as originally understood, constitute one of the four primary divisions of the Zoantharian *Actinozoa*, as laid down and defined by Milne-Edwards and Haime in their great works on the fossil corals (Brit. Foss. Cor., Intro., 1850, and Pol. Foss. des Terr. Pal., 1851). The distinguished authorities just mentioned included under the name "Tabulata" a large number of corals, ranging from the Silurian period to the present day, and often of very different structure, but characterised by the possession of well-developed "walls," by the fact that the visceral chambers of the corallites are traversed by horizontal partitions or "tabulæ," and by the rudimentary condition of the septa. Of these characters the essential one is the division of the cavities of the corallites into successive storeys by means of "tabulæ" or transverse plates, since the walls are often more or less largely perforate, and the condition of the septa is quite a secondary matter. Milne-Edwards and Haime divide the "Tabulata" as follows:

Family I. MILLEPORIDÆ.—Corallum principally composed of a very abundant cœnenchyma, distinct from the walls of the corallites, and of a tubular or cellular structure. Septa not numerous; tabulæ numerous and well formed. Genera —*Millepora*, Lam.; *Heliopora*, De Blainv.; *Heliolites*, Dana; *Plasmopora*, E. and H.; *Fistulipora*, M'Coy; *Propora*, E. and H.; *Axopora*, E. and H.; and *Lobopora*, E. and H.

Family II. FAVOSITIDÆ.—Corallum essentially formed by lamellar walls, with little or no cœnenchyma. Visceral chambers divided by numerous and well-developed complete tabulæ.

Tribe 1. *Favositinæ.*—Corallum massive; walls perforated; septa rudimentary; no cœnenchyma. Genera—*Favosites*, Lam.; *Michelinia*, De Kon.; *Koninckia*, E. and H.; and *Alveolites*, Lam.

Tribe 2. *Chætetinæ.*—Corallum massive; walls not perforated; neither septa nor cœnenchyma. Genera—

Chœtetes, Fischer; *Dania*, Edw. and H.; *Stenopora*, Lonsd.; and *Constellaria*, Dana.

Tribe 3. *Halysitinæ*. Corallum composed of corallites constituting vertical laminæ or fasciculi, but more or less free laterally, and united by means of connecting tubes or mural expansions; walls well developed and not porous; septa distinct, but small. Genera—*Halysites*, Fischer; *Harmodites*, Fischer (subsequently abandoned for *Syringopora*, Goldf.); and *Thecostegites*, E. and H.

Tribe 4. *Pocilloporinæ*.—Corallum massive, gibbous, or subdendroid, with thick imperforated walls, forming towards the surface an abundant compact cœnenchyma; septa quite rudimentary, Genus—*Pocillopora*, Lam.

Family III. SERIATOPORIDÆ.—Corallum arborescent or bushy, with an abundant compact cœnenchyma; visceral chambers filling up by the growth of the columella and the walls, and showing but few traces of tabulæ. Genera—*Seriatopora*, Lam.; *Dendropora*, Mich.; *Rhabdopora*, E. and H.

Family IV. THECIDÆ.—Corallum massive, with an abundant, compact, spurious cœnenchyma, produced by the septa becoming cemented together laterally; tabulæ numerous. Genus—*Thecia*, E. and H.

Various additions, modifications, and improvements in the above classification of the "Tabulata" were made by Milne-Edwards and Haime during the progress of their classical monograph on the fossil corals of Britain; many new genera were added, and the tribe of the *Stylophyllinæ* (to include the Cretaceous *Stylophyllum*, Reuss) was inserted in the family of the *Favositidæ*. Most of the changes here indicated will be found by those interested in the subject in the systematic account of the "Tabulata" given by Milne-Edwards in his masterly "Histoire Naturelle des Coralliaires" (vol. iii., 1860).

The first serious attack upon the classification of Milne-Edwards and Haime, and upon the position of the "Tabulata," was made by Professor Louis Agassiz, who in 1857 examined the living animal of *Millepora*, and arrived at the conviction that this well-known genus was truly *Hydrozoal* (Amer.

Journ. Sci. and Arts, ser. 2, vol. xxvi., p. 140, 1858, and Proc. Bost. Soc. Nat. Hist., vol. vi., p. 373, 1859). This conclusion has since been fully confirmed by the researches of Moseley, as I shall subsequently show, but it by no means affords a sufficient basis for the generalisation put forth by Agassiz—namely, that in view of the hydrozoal nature of *Millepora*, all the "Tabulate" corals (as well as the *Rugosa*) should be removed from the *Actinozoa* to the *Hydrozoa*.

Another very important discovery was made at a later date by Professor Verrill, who showed, from an examination of the living animal, that the genus *Pocillopora*, Lam., is truly a *Zoantharian*, and referable to the large and widely-distributed group of the Aporose corals, in the neighbourhood of the family *Oculinidæ* (Trans. Conn. Acad., vol. i., pp. 2, 523, 1870). Moreover, in another important memoir, we find the same high authority strongly urging the identity of a great many of the "Tabulate Corals" with the ordinary *Zoantharia*, and, in particular, maintaining the view that the great group of the *Favositidæ* is truly referable to the *Porosa*, and probably to be actually placed in the existing family of the *Poritidæ* (Amer. Journ. Sci. and Arts, ser. 3, vol. iii., p. 187, 1872).

In the year 1872 was also published the well-known "Third Report on the British Corals," by Professor Martin Duncan (Rep. Brit. Ass., 1872). In this important memoir, Professor Duncan deals very largely with the structure and affinities of the "Tabulate Corals," his wide knowledge of both living and extinct *Actinozoa* rendering his views upon this subject peculiarly valuable and suggestive. Dr Duncan retains the "Tabulata" of Edwards and Haime as a great sub-division of the *Zoantharia*, and his principal conclusions will be readily seen by a glance at the following table of the families and genera of the "Tabulata" as adopted by him:

FAMILIES.

With cœnenchyma.	*Milleporidæ.*	Cœnenchyma cellular.
	Acroporidæ.	Cœnenchyma compact.
Without cœnenchyma.	*Favositidæ.*	Walls perforated.
	Halysitidæ.	Walls imperforate.
	Alveolitidæ.	Septa tridentate.

Genera.

Milleporidæ.	*Millepora.* *Heliolites, Heliopora, Polytremacis.* *Propora, Plasmopora, Thecia.* *Lyellia.* *Thecostegites.* *Axopora.*
Acroporidæ.	*Acropora, Seriatopora, Pocillopora, Dendropora, Rhabdopora.*
Favositidæ.	*Favosites, Koninckia, Favositipora, Michelinia, Roemeria, Emmonsia.* *Syringopora.* *Aulopora.*
Halysitidæ.	*Halysites.* *Stylophyllum.* *Chonostegites.* *Columnaria.* *Beaumontia.*
Alveolitidæ.	*Alveolites.* *Cœnites.*
Incertæ sedis.	*Fistulipora.* *Fletcheria.*

Alcyonaria.

Chætetes, Monticulipora, Dania, Stellipora, Labechia.

Another very important memoir upon the "Tabulate Corals" was published in 1873, by Dr Gustav Lindström (Öfversigt af Kongl. Vetensk. Akad. Förhandl. 1873; Trans. in Ann. and Mag. Nat. Hist., ser. 4, vol. xviii., p. 1, 1876). In this paper Dr Lindström entirely discards the "Tabulata" of Milne-Edwards and Haime, as a distinct division of corals; *Labechia*, E. and H., is placed among the *Hydrozoa; Monticulipora*, D'Orb., *Fistulipora*, M'Coy, and some other forms, are regarded as *Polyzoa;* the *Favositidæ* are placed in the *Poritidæ*, among the Perforate corals; the *Heliolitidæ* are considered as forming a special group of uncertain zoological position; *Columnaria*, Goldf., is placed in the Rugose corals, among the *Cyathophyllidæ; Fletcheria*, E. and H., and *Michelinia*, De Kon., are referred to the *Cystiphyllidæ;* and

Syringopora, Goldf., is regarded as a Rugose coral, allied to *Lithostrotion* or *Diphyphyllum*.

Passing over a paper by M. Dollfus (Comptes Rend., t. lxxx., 1875), we come next to the exceedingly important papers by Mr Moseley on the anatomy of the recent *Millepora* and *Heliopora* (Phil. Trans., 1876; Ann. and Mag. Nat. Hist., 1876; and Phil. Trans., 1878), which have thrown a flood of light upon the subject of the structure and affinities of the Palæozoic "Tabulata." Without entering into Mr Moseley's discoveries in any detail, it is well known that their general result was to complete the disintegration of the "Tabulata" of Edwards and Haime, and to fairly remove from the *Zoantharia* certain groups that had previously been referred to this order of the *Actinozoa*. Thus, *Millepora* and its allies, as formerly asserted by Agassiz, are now definitely proved to be true *Hydrozoa*, of which class they form, with the *Stylasteridæ*, the new order of the *Hydrocorallinæ; Heliolites* and its numerous allies, instead of being relations of *Millepora*, are shown conclusively to be *Actinozoa*, but to be at the same time referable to an unsuspected order of this class, namely, to the *Alcyonaria;* while various familiar types of the Palæozoic "Tabulata" are brought by these discoveries into more or less probable relationship with either the *Hydrozoa* or the *Actinozoa;* and light of the most important character is afforded as to certain structural peculiarities in the Palæozoic types, which have hitherto proved obscure or inexplicable.

The foregoing brief sketch will render it evident that recent researches, though still incomplete, are so far advanced as to render the abandonment of the "Tabulata" as a distinct group of the *Zoantharian* a hardly avoidable step, while the removal elsewhere of some of the principal forms previously included under this head is already a fact accomplished. It is indeed now quite clear that the principal character relied upon by Milne-Edwards and Haime in their definition of the "Tabulata"—namely, the presence of "tabulæ"—is one of very limited classificatory importance. Thus, "tabulæ" are now known to occur in *Pocillopora, Cyathophora, Cœlastræa, Clausastræa*, etc., among the *Zoantharia aporosa;* in *Alveopora* and the allied *Favositipora*, among the *Zoantharia per-*

forata; in *Heliopora* and its allies, among the *Alcyonaria;* in the great majority of the *Rugosa;* in *Millepora* and its allies, among the *Hydrozoa;* and, lastly, in a few extinct types of the *Polyzoa* (*e.g. Radiopora* and *Heterodictya*). The mere fact of the occurrence of "tabulæ" in so many forms of such diverse zoological affinities, is sufficient proof that these structures cannot be used in framing a classification of the corals; but it is at the same time conclusive that the "tabulæ" of these different types, though undistinguishable in appearance, and performing identical functions, cannot be precisely and in all cases homologous structures. As to the "tabulæ" in the true *Actinozoa,* Professor Verrill is doubtless right in believing that they are partitions formed after each discharge of the ova, the vacuity thus formed being useless, and being therefore cut off by a "tabula" from the visceral cavity above. Upon this view, the "tabulæ" of the *Actinozoa* are essentially of the same nature as the "dissepiments" of most of the *Zoantharia,* only they are formed after the simultaneous evacuation of *all* the ovaries at successive periods; whereas the latter are produced after the *successive* discharge of the different ovaries, in the different intermesenteric chambers, at different times. How far, however, there is really an identity in structure and origin between the "tabulæ" and the "interseptal dissepiments" is a question into which I cannot enter here. If, however, the "tabulæ" of the *Actinozoa* are periodic partitions formed after the discharge of the ova, then it is clear that they cannot be homologous with the apparently similar structures found in certain sections of the old group of the "Tabulata." Thus, Mr Moseley has shown that the *Milleporidæ* are undoubted *Hydrozoa,* and that their ova are therefore not produced within the visceral chamber at all. It is consequently clear that in this family the "tabulæ" cannot be partitions produced subsequent to the extrusion of the ova. It must also be admitted that any transverse partitions which may be found to intersect the cells of undoubted *Polyzoa* (such as *Heterodictya,* Nich.) must be fundamentally different in their nature from the "tabulæ" of either the "tabulate" *Actinozoa* or of the *Milleporidæ,* though they may not be distinguishable from these in appearance.

With the abandonment of the "tabulæ" as structures of classificatory significance, the "Tabulata" of Edwards and Haime must necessarily be broken up and redistributed. It remains for consideration, however, what groups are really included under the old name of "*Zoantharia Tabulata,*" and whether or not this name may be still retained, in a restricted sense, for any of the forms originally included under it. By the investigations of Agassiz, Verrill, Lindström, Duncan, Moseley, Rominger, and others, we have been made acquainted with the true structure and relationship of several of the groups which constituted the old division of the "Tabulata," and my own researches upon the varied and numerous Palæozoic types have enabled me to throw more light upon the nature and affinities of some of the others. Our present knowledge is admittedly imperfect, but it would appear that the division of the *Zoantharia tabulata,* as until very recently understood, comprised about twelve distinct groups of animals. What these groups are, and what is their ascertained or probable position in the zoological series, will appear from the following very brief synopsis:

I. Milleporidæ.—The corallum of *Millepora,* the type of this group, has long been well known. Its form is usually foliaceous or lobate, and it is composed of an extremely porous cœnenchyma, traversed in every direction by tubular canals, which freely communicate with one another and also with the visceral chambers of the polypites themselves. The surface exhibits two sets of openings, one large, the other small, the latter much the most numerous. The large openings (the true "calices") are the mouths of tubes which are crossed by well-developed transverse partitions or "tabulæ," the smaller tubes being similarly and more closely tabulate. From the researches of Mr Moseley, we now know that these two sets of tubes are occupied by two sets of zoöids of correspondingly different sizes. In the large tubes are contained large zoöids ("gastrozoöids"), which are short, with four tentacles, a distinct mouth, and a digestive cavity, and which carry on all the work of digestion and assimilation. The small tubes enclose smaller zoöids ("dactylozoöids"), which are long and slender, carry numerous clavate tentacles in successive whorls, and have no mouths. They surround the larger zoöids in definite systems, and perform all the functions of prehension, supplying the latter with food. The structure of the various zoöids of the colony is such as to leave no doubt as to the fact that *Millepora* is not an Actinozoan at all, but that the genus is referable to the *Hydrozoa*, in which class it constitutes the type of the new order *Hydrocorallinæ*. *Millepora* is a Tertiary and living genus, but the Cretaceous *Porosphæra*, Steinm., appears to be closely related to it, and therefore also to belong to the *Hydrocorallinæ*. The Tertiary *Axopora*, E. and H., with its fasciculate columella, may also belong here, but its affinities are not quite clear.

II. Pocilloporidæ.—The type of this group is the Recent *Pocillopora*, Lam., in which there is a dendroid or foliaceous corallum, composed of numerous tubular corallites, surrounded by an imperforate compact cœnenchyma, provided with twelve to twenty-four septa (sometimes obsolete), and intersected by complete tabulæ. Professor Verrill, as before stated, has shown that the polypes in *Pocillopora* are provided with twelve nearly equal tentacles, and are in all respects identical with the polypes of the ordinary *Zoantharia aporosa*. The genus must therefore be retained among the true "corals" in the neighbourhood of the *Oculinidæ*. From the close general resemblance between the corallum of the recent *Seriatopora* and that of *Pocillopora*, we may conclude that the former is also one of the *Zoantharia aporosa*, so that we may abolish the family of the *Seriatoporidæ*, as understood by Milne-Edwards and Haime.

The genus *Pocillopora* is Recent and Kainozoic, and it is questionable if any fossil forms of *Seriatopora* are known. It may, at any rate, be taken as certain that the alleged forms of *Seriatopora* in the Palæozoic deposits will be ultimately found to have different affinities. The Palæozoic genera, *Trachypora*, *Dendropora*, and *Rhabdopora*, usually associated with *Seriatopora*, Lam., are, again, truly *perforate* corals, destitute of a true cœnenchyma, and referable to the *Favositidæ*.

III. Favositidæ.—The corallum in this family is composed typically of polygonal, more or less closely contiguous, corallites, which possess well-developed walls. The walls are, however, perforated by a larger or smaller number of rounded apertures—the "mural pores"—which place the visceral chambers of neighbouring corallites in direct communication. There is no cœnenchyma; the septa are usually spiniform, sometimes obsolete, rarely lamellar; and the tabulæ are numerous and usually complete.

After an extended study of the minute structure of the *Favositidæ*, I cannot doubt that Professor Verrill and Dr Lindström are correct in referring the family to the *Zoantharia perforata.* I also recognise the numerous points of resemblance between the *Favositidæ* and the *Poritidæ,* but I cannot follow the above-mentioned high authorities in regarding the present group as a mere sub-family of the *Poritidæ.* On the contrary, I believe that the *Favositidæ,* as here understood, embraces a large number of types (mostly Palæozoic), all of which are more or less closely allied to the *Poritidæ,* and some of which are perhaps undistinguishable from the latter family, but which really represent a series of separate but allied groups.

The *Favositidæ* constitute by far the largest and the most important group of the so-called "Tabulata," and it is quite impossible that I should discuss here, even in the briefest manner, the different types which belong to the family. I can, therefore, only content myself by subjoining here a list of the genera which I believe to properly belong to this great family, and I have no doubt that future discoveries will show that this table must be enlarged:

Genus.	Geological Range.
Favosites, Lam.,	Silurian to Carboniferous.
Alveolites, Lam.,	Silurian to Devonian.
Vermipora, Hall,	Silurian to Devonian.
Michelinia, De Kon.,	Upper Silurian ?, Devonian, and Carboniferous (perhaps =*Pleurodictyum,* Goldf.).
Pleurodictyum, Goldf.,	Upper Silurian ? and Devonian.
Chonostegites, E. and H. (=*Haimeophyllum,* Bill.),	Devonian.
Pachypora, Lindström,	Upper Silurian and Devonian.

GENUS.	GEOLOGICAL RANGE.
Striatopora, Hall,	Upper Silurian and Devonian
Trachypora, E. and H. (with *Dendropora*, Mich., and *Rhabdopora*, M'Coy),	Devonian and Carboniferous.
Cœnites, Eichwald,	Silurian and Devonian.
Columnopora, Nich.,	Silurian.
Koninckia, E. and H.,	Cretaceous.
Favositipora, Sav. Kent (? *Poritidæ*),	Recent.
Aræopora, Nich. and Eth., jun. (? *Poritidæ*),	Devonian.
Rœmeria, E. and H. (? *Syringoporidæ*),	Devonian.
Syringolites, Hinde,	Upper Silurian.
Nyctopora, Nich.,	Lower Silurian.
Romingeria, Nich., (= *Quenstedtia*, Rominger),	Devonian.
Stenopora, Lonsd.,	Carboniferous.
Billingsia, De Kon.,	Devonian.
? *Laceripora*, Eichw.	Upper Silurian and Carboniferous.
Nodulipora, Lindstr.,	Upper Silurian.

IV. Columnariadæ.—Under this head I provisionally place a few Palæozoic corals, of which *Columnaria alveolata*, Goldf. (= *Favistella stellata*, Hall), is the type-form. In this type the corallum is massive, composed of polygonal, usually more or less closely contiguous, corallites, with well-developed imperforate walls, destitute of "mural pores," and with complete lamellar septa, some of which usually extend to the centre of the visceral chambers of the tubes. There is no columella and no cœnenchyma, and the tabulæ are remarkably well developed. We may provisionally place in this group the singular genus *Lyopora*, Nich. and Eth., jun., in which the septa are rudimentary, and the walls are remarkably thickened. Both genera are Lower Silurian.

As to the precise position of the typical *Columnariæ* in the zoological series, it does not seem possible to speak with any certainty. The typical forms of the group exhibit certain curious Rugose features in the disposition of the septa, and may really form an aberrant group of the *Rugosa*.

On the other hand, they present some conspicuous points of resemblance to the *Astræidæ* among the *Zoantharia aporosa.*

V. SYRINGOPORIDÆ.—The type of this group is the Palæozoic genus, *Syringopora,* Goldf., in which the corallum is fasciculate, and composed principally of long cylindrical corallites which grow up side by side, rarely absolutely touching one another, and are enclosed by strong and compact walls. The visceral chambers of contiguous corallites are placed in direct communication by means of hollow connecting-processes; and there are usually marginal and rudimentary septa. The tabulæ are well developed, more or less funnel-shaped, and sometimes giving rise to a central tube in the median line of the visceral cavity.

I cannot agree with the opinion of Dana, Hæckel, and Zittel, that *Syringopora* and its allies should be placed among the *Alcyonaria,* in the vicinity of the Recent *Tubipora.* Nor can I accept Dr Lindström's view that *Syringopora* is truly a Rugose coral with affinities to *Lithostrotion* and *Diphyphyllum.* On the contrary, I am at present disposed to believe that the real relationship of the *Syringoporidæ* is with the *Favositidæ,* and that they should therefore find a place—though a special one—in the division of the *Zoantharia perforata.* Upon this view, the hollow connecting-processes of *Syringopora* are the homologues of the "mural pores" of the *Favositidæ;* and the singular genus *Syringolites,* Hinde, is a direct connecting link between these two apparently dissimilar groups, since it possesses the mural pores of the latter, conjoined with the infundibuliform tabulæ of the former.

VI. AULOPORIDÆ.—Taking *Aulopora* as the type of this group, we find it to comprise singular parasitic corals which grow upon the exterior of shells and corals in deposits of Silurian, Devonian, and Carboniferous age. The corallum consists of a network of creeping prostrate tubes, which send up at intervals conical tubular corallites which have marginal and rudimentary septa, and which, in some instances at any rate, possess well-developed horizontal tabulæ. The visceral chambers of the corallites are not placed in communication by means of mural pores or hollow connecting-processes. I cannot enter here into the structure and affinities of this group, but I may say that I do not think there is sufficient evidence for the union of the *Auloporidæ* with the *Syringoporidæ*, as supposed by some palæontologists; and I think it not unlikely that the former will prove eventually to be referable to the Alcyonarian division of the *Actinozoa*. *Cladochonus*, M'Coy (= *Pyrgia*, Edw. and H.), seems to be inseparable from *Aulopora;* but the Carboniferous *C. crassus*, M'Coy, is a special generic type, destitute of all affinity with the group with which it has been hitherto associated.

VII. Halysitidæ.—This group is typified by the common chain-corals (*Halysites*) of the Silurian rocks. In this genus the corallum is composed of long cylindrical corallites, united to one another by their sides only, along their whole length, but otherwise free. Between each pair of corallites—typically, but not invariably—is situated a single much smaller tube, which is destitute of septa, and possesses numerous close-set tabulæ. The larger tubes have complete, comparatively remote "tabulæ," and often have minute spiniform septa. The walls of all the tubes are imperforate, and neither mural pores nor hollow connecting-processes are present.

The family of the *Halysitidæ* was made by Milne-Edwards and Haime to include *Syringopora* and its allies; but the fact that the visceral chambers of contiguous corallites communicate in the latter directly by means of hollow connecting-processes, whereas the tubes of *Halysites* are enclosed by imperforate walls, sufficiently proves the distinctness of these two types. Upon the whole, I am inclined to think that *Halysites* will find its nearest ally among the *Helioporidæ*, which it resembles in one important particular, namely, in the general possession of two sets of tubes, indicating the existence of two sets of zoöids. Moreover, the tubes of the one series are of large size, with remote tabulæ and with radiating septa; while those of the other series are small, have close-set or vesicular tabulæ, and are destitute of septa. If this conjecture be correct, then *Halysites* must be removed to the *Alcyonaria;* but it will in any case form the type of a distinct group.

VIII. Tetradiidæ.—This group includes only the singular

Silurian genus *Tetradium*, Dana, in which the corallum is massive, and is composed of polygonal corallites, of great length, and in close contiguity. There are no "mural pores;" the tabulæ are numerous and complete; and there are generally four septa, which look as if they were formed by inflections of the wall.

Tetradium resembles *Halysites* in its long imperforate corallites, and occasionally in its mode of growth, while its peculiar septa, except in number, remind one of the "pseudo-septa" of the *Helioporidæ*. Upon the whole, it seems probable that this curious genus should be referred to the *Alcyonaria*, though I know of no group in this order to which it could be definitely referred.

IX. Thecidæ.—This group comprises only the singular Silurian genus *Thecia*, E. and H., the corallum of which forms laminar expansions, covered below by an epitheca, and having the calices placed upon the upper surface. The tubular corallites cannot be said to be bounded by distinct proper walls, but they are embedded in and surrounded by a dense tissue composed of minute vertical tubuli. A few blunt septal ridges are present in each corallite; the tabulæ are well developed; and the visceral chambers of contiguous tubes communicate by horizontal canals.

This extraordinary genus forms in many respects a link between the Perforate corals and the Alcyonarian family of the *Helioporidæ*. It resembles the former in the fact that the visceral chambers of contiguous corallites communicate directly with one another; and it approaches the latter in the fact that the ordinary polypes are surrounded by what has usually been regarded as a tubular "cœnenchyma," though not really of this nature. Judging from the analogy of the recent *Heliopora*, the so-called "cœnenchymal tubuli" are really tenanted by special zoöids, and cannot, therefore, be properly cœnenchymal. In the possession, then, of a series of large polypes, surrounded by a much more numerous series of small specialised polypes, *Thecia* agrees with *Heliopora* and *Heliolites*; and the genus, therefore, is probably Alcyonarian. It differs from the *Helioporidæ*, however, in the presence of distinct and direct channels of communication between the larger polypes, in the nature of the septa, the absence of a differentiated wall to the larger tubes, and the apparent want of tabulæ in the interstitial tubuli.

X. HELIOPORIDÆ.—This family has been constituted by Mr Moseley (Phil. Trans., vol. clxvi., p. 92, 1876) for the reception of the extraordinary Recent *Heliopora* and the extinct *Heliolites* and its allies. The corallum in this family is composed of two sets of corallites, a larger and a smaller, the latter hitherto improperly spoken of as "cœnenchymal tubuli." The larger tubes are furnished with delicate septa (generally twelve in number), and are traversed by remote tabulæ. The smaller tubes everywhere surround the larger ones, have no septa, and are crossed by close-set tabulæ.

Mr Moseley has shown that the polypes of *Heliopora* are of the Alcyonarian type, with eight pinnately-fringed tentacles and eight mesenteries. The septa, thus, do not correspond with the mesenteries, and are, therefore, to be regarded as "pseudo-septa." The small interstitial tubes are occupied by rudimentary sexless zoöids, without mouths, but freely communicating with the body-cavities of the sexual zoöids by means of transverse canals. *Heliopora* itself is Recent, Tertiary, and Cretaceous; *Polytremacis* is Cretaceous; while *Heliolites, Plasmopora,* and *Propora* are Palæozoic.

XI. CHÆTETIDÆ.—This group is made up of very heterogeneous materials, and will undergo disintegration when subjected to a sufficiently searching investigation. As it is even, the lines along which this disintegration will take place are, to some extent, discernible. Taking the group as it stands at present, no other general definition of it seems possible than that it comprises very variously-formed corals, composed of contiguous, thin-walled, mostly prismatic corallites, which have imperforate walls, are intersected by well-developed tabulæ, and are destitute of septal laminæ or spines.

The typical members of the group, such as *Chætetes radians*, Fischer, and its few immediate allies, possess coralla in all essential respects similar to those of the *Favositidæ*, except that "mural pores" or other openings in the walls are wanting, while there are (in reality) no trace of septa. These two last-mentioned differences are, of course, sufficient to show that the place of *Chætetes* in the system must be very far removed from that of *Favosites*. I am, nevertheless, satisfied that *Chætetes radians*, Fischer, and the forms immediately related to it, are genuine *Actinozoa*, though I am not able to assign to them any certain place in this class. So far as one can judge, they seem to have more affinity with the *Alcyonaria* than with any other group.

The position of the numerous forms referred to, *Monticulipora*, *Fistulipora*, and other allied types, is, again, most uncertain. Strong evidence has been brought forward to prove that all these forms are really *Polyzoa;* but it certainly cannot be said that this conjecture has, as yet, been sufficiently proved. Some of these forms may very probably turn out to be true *Polyzoa;* but I am disposed to think that the majority will prove to be referable to the *Actinozoa*. This seems to be indicated as a *general* conclusion by their close resemblance, in many cases, to types of an undoubted Cœlenterate nature; by the fact that their coralla are often composed of two sets of corallites, pointing to a heteromorphic condition of the zoöids, such as is highly characteristic of many of the *Cœlenterata;* and lastly, by the fact that no forms possessing their characteristic features *in conjunction* have as yet been pointed out as existing either among recent or fossil *Polyzoa*. Their alliances with *Chætetes* proper are slight, and they should be regarded as constituting a special group, to which the name of *Monticuliporidæ* may be given.

XII. Labechiidæ.—This extraordinary group comprises only the anomalous genus *Labechia*, E. and H., at present only known as a Silurian fossil. The skeleton in this genus forms a laminar or expanded mass, the under surface of which is covered by an epitheca, while the upper surface shows an apparently imperforate expanse, rising above which are close-set tubercles. Microscopic sections show that these tubercles are the projecting summits of short calcareous and solid, but apparently primitively tubular, columns, separated from one another by a loose vesicular tissue, formed by the anastomoses of curved, calcareous lamellæ. Dr Lindström has strongly supported the view that *Labechia*—originally placed by Edwards and Haime among the *Chætetidæ*—is truly a

Hydrozoön allied to *Hydractinia.* The peculiarities in its structure are, however, so numerous, and the apparent total absence of any superficial openings of any kind is so puzzling, that I do not at present see how it can be placed among either the *Hydrozoa* or the *Actinozoa;* nor can I give any definite opinion as to its affinities beyond the negative one that it cannot at present be referred positively to any known group of corals, and that it certainly has no relationship to *Chætetes* proper.

XI. *Note on the Destruction of Fish in Linlithgow Loch during the Winter of* 1878-79. By R. Scot-Skirving, Esq.

(*Read* 29*th May* 1879.)

The fish of Linlithgow Loch consist of roach, perch, pike, and eels. There are no trout. The right of fishing is held by the Crown, and let to Mr Jameson, fishmonger, Edinburgh. Mr Jameson has been in the habit of taking annually a considerable quantity of fish, and in particular a very large number of eels, many of which were of the largest size. Last month one of Mr Jameson's shopmen happened to mention to me that they had this season no supply of eels, as the fish in Linlithgow Loch had been destroyed by the severity of the winter. I was quite convinced that mere cold, however intense, could not have destroyed the fish; as I had often read of fish being exposed to more intense frost than ever occurs in this country, and that even though actually *frozen* for a considerable period, they have ultimately survived.

On subsequently seeing Mr Jameson himself, he gave me the following information regarding the fish, and suggested what I have no doubt was the true cause of their destruction. He said that during the continuance of the frost, while the loch was thickly covered with ice, boys were constantly to be seen taking dead or dying eels from any small openings in the ice at the margin of the loch; and I may here mention that I had personally observed this, and I find that several of my friends did so also. These dying eels quickly attracted the attention of a number of local poachers, and these men, Mr Jameson informed me, despatched at least *seven tons* of diseased eels to the London market. When the ice finally broke up, it was found that the edges of the loch, chiefly at one extremity where the water flowed out, were literally lined with dead fish, which it was necessary to remove and bury. Mr Jameson had twelve cart-loads of these offensive dead fish buried. They consisted of about two-thirds eels and one-third roach and perch, but not a single pike was found dead. The cause of this destruction, in Mr Jameson's opinion, was that the very considerable amount of sewage which is always discharged from the town into the loch is rendered less noxious in ordinary seasons by evaporation. This year the gases could not escape, being bound down under thick-ribbed ice. This was very obvious, Mr Jameson said, as on holes being bored in the ice, very offensive effluvia was immediately felt. This fact I cannot corroborate, in so far that I happened to see a gentleman testing the depth of the loch through a hole he had made in the ice, and I did not observe any smell, though I have no doubt Mr Jameson did on other occasions. The fact that no pike were found among the dead fish is interesting, and seems to show that these tyrants of the lake possess stronger constitutions than their co-habitants, including eels, or else some habit in the pike had tended to its preservation.

XII. *Note on the Breeding of the Pochard* (Fuligula ferina) *in the South-west of Perthshire.* By J. Hamilton Buchanan, Esq.

(*Read 29th May* 1879.)

The accompanying series of eggs were collected by Mr Gibson and myself at a loch in the south-west of Perthshire, on the 22d of this month. It includes six pochards which we were fortunate enough to secure. The nest was placed among very tall reeds. It seemed to be somewhat similar to a coot's in structure, and was lined with a small quantity of down. When we approached within ten yards of it the female flew off, and both Mr Gibson and myself obtained an excellent view of her. The ground on which the nest was placed was so marshy that the keeper was enabled to reach the eggs almost from the boat. They were deeply incubated, and the embryo fully confirmed the species. They are six in number, though the gamekeeper had taken two from the nest on the previous Monday. They vary in measurement from $2\frac{1}{2}$ in. by $1\frac{9}{16}$ in. to $2\frac{7}{16}$ in. by $1\frac{3}{4}$ in.

As far as we are aware, this is the first Scotch nest, as Mr More states in his paper on "The Distribution of Birds in Great Britain in the nesting season,"* that it has never been taken north of Yorkshire, and rarely in Britain at all.

We also saw several wigeon, but we did not succeed in finding a nest, though the gamekeeper believes that they breed there, and that he has taken the eggs.

XIII. *On the Genus* Nemagraptus (*Nematolites*) *of Emmons.* By CHAS. LAPWORTH, Esq., F.G.S., etc. [Plate II.]

(*Read* 29*th May* 1879.)

Among the numerous Lower Palæozoic fossils described by Dr Emmons as characteristic of his disputed Taconic System, some of the most remarkable were the forms to which he gave the generic title of *Nemagraptus*.† They were originally discovered by himself in the comparatively barren and partially metamorphic shales and flagstones that floor the eastern slope of the valley of the Hudson River. He appears to have had no doubt of the propriety of classifying them with the true Graptolites, though he distinctly admitted his inability to detect upon them the characteristic marginal serratures of the *Graptolitidæ*, or indeed any appendages whatever available for nutrition. The genus is characterised by him as follows:

"NEMAGRAPTUS (new genus).

"Axis elongated and thread-like; simple or compound

* *Ibis*, 1865.

† Emmons: "American Geology," vol. i., p. 109.

branches, round at the base and flattened at the extremities; cells appear to be arranged on the flattened part of the axis instead of the margin."

Two species of *Nemagraptus* are described and figured in the "American Geology," * viz: *Nemagraptus elegans* and *Nemagraptus capillaris.*

The figure of *Nemagraptus elegans* shows a Graptolite-like fossil with a slender arcuate stem of about half an inch in length, giving off six simple, elegantly-curved, and very slender branches at sub-equal distances along its convex margin. According to Emmons's description, these branches expand somewhat towards their distal extremities, but show no trace whatever of marginal serrations. Under the microscope the surface of the fossil is seen to be "slightly dotted, so as to give the appearance of the mouth of cells."

The second species, *Nemagraptus capillaris,* is a remarkable thread-like form, with a main stem of about seven inches in length, and of almost equal diameter throughout. It appears to have been highly flexuous, and is irregularly coiled up into a space of little more than a square inch. This main stem throws off a few simple branches, apparently from both margins, at distant and irregular intervals. These are capillary and flexuous like the main stem, but do not exceed one-fourth of an inch in length.

In the first volume of the "Palæontology of New York," issued in 1847, and about eight years previous to the publication of Emmons's "American Geology," Professor James Hall had already described and figured numerous Graptolites from the slaty rocks of the valley of the Hudson River. Among these, one,† named by Hall *Graptolithus gracilis,* bears at first glance a striking general resemblance to Emmons's *Nemagraptus elegans,* as figured in the "American Geology." Accordingly, in 1865, we find Hall in his fine work on the "Graptolites of the Quebec Group," very naturally claiming Emmons's *Nemagraptus elegans* as "part of an individual of

* Emmons: "American Geology," Pl. i., figs. 6 and 7.

† Palæontology of New York, vol. i., Pl. lxxiv.

Graptolithus gracilis, or of some similar species." * Three years later the progress of our knowledge of the Graptolites in Britain compelled Hall to recognise the generic distinctness of this *Graptolithus gracilis;* and in the Twentieth Annual Report of the State Cabinet of New York, published in 1865, we find Hall placing *Graptolithus gracilis* and some allied forms in a new generic group designated *Cœnograptus,*† of which he implies that he regards *Graptolithus gracilis* as forming the type species. In this connection he again very properly calls attention to Emmons's species and genus (p. 236), and distinctly admits the possibility of the generic identity of *Nemagraptus* and *Cœnograptus;* but with the reservation that Emmons's remarks regarding the absence of cellules would, if eventually verified, exclude the typical species from that group. This is probably meant to glance at Emmons's second species, *Nemagraptus capillaris,* which Hall had already more than once referred to, but without attempting to identify it,‡ as he held that its relations could scarcely be determined from the figure given.

The generic distinctness of Hall's *Graptolithus gracilis* had already been pointed out by Dr H. A. Nicholson,§ who proposed for it the title of *Helicograptus,* which however he subsequently suppressed on becoming aware of what Hall had done.

In 1871 Mr Jno. Hopkinson, accepting Hall's suggestion of the probable identity of *Nemagraptus elegans,* Emm., and *Cœnograptus gracilis,* Hall, and carrying out the recognised rules with regard to priority of zoological nomenclature, applied Emmons's generic title of *Nemagraptus* to the whole of the forms previously included under *Cœnograptus,* Hall, *Cladograptus,* Carr., and *Pleurograptus,* Nich.|| In 1873 these special forms and their most intimate allies were classed by myself as forming a distinct family of the Graptolites; and I laid aside my proposed title of *Leptograptidæ* for this family

* Graptolites of the Quebec Group, p. 43.

† *Loc. cit.*, p. 236.

‡ Graptolites, Quebec Group, p. 43.

§ *Annals and Mag. Nat. Hist.*, 1868, p. 25.

|| *Geological Magazine*, vol. viii., p. 5.

in favour of the MS. term of *Nemagraptidæ*, proposed by Mr Hopkinson.* At the same time, however, I felt that if Hall was correct in his view of the identity of *Cœnograptus gracilis*, Hall, and *Nemagraptus elegans*, Emmons, it would be better to regard *Nemagraptus capillaris*, Emm., as the type of Emmons's genus, and thus both these generic terms would be preserved to science. I was confirmed in this opinion by the discovery of several peculiar forms of Graptolites in the Moffat shales of the south of Scotland. These occur in association with *Cœnograptus gracilis*, H., and are most intimately allied to that species; but they show most distinctly the capillary stem, the short, irregular, simple branching, and the flexuous character of Emmons's *Nemagraptus capillaris*. On the other hand, however, when tolerably well preserved, they are seen to be most indubitably celluliferous throughout the whole of their extent. Thus Emmons's name *Nemagraptus* was provisionally restricted to these new forms, and Hall's title of *Cœnograptus* confined to *Graptolithus gracilis*, H., and its allies.

In 1874 the numerous Graptolites collected by Dr Hicks and others from the Arenig and Llandeilo rocks of St David's were placed in the hands of Mr Hopkinson and myself for description. Among them was a most peculiar form which instantaneously reminded us of Emmons's problematical *Nemagraptus capillaris*. The fragments of the Arenig species were in precisely the same state of preservation as the accompanying Graptolites; and beyond the apparent absence of anything like marginal serrations, there was nothing to suggest their belonging to a different zoological group. The puzzling and abnormal nature of this fossil will be apparent from our description at the time.† One point, however, was tolerably clear. If this form were specifically, or even generically, identical with the *Nemagraptus capillaris* of Emmons, the Moffat Graptolites previously placed under *Nemagraptus* would have to be removed from it.

In 1875 numerous fossils, belonging, without question, to the same generic group as the *Nemagraptus capillaris* of

* *Geol. Mag.*, November 1873.

† *Quart. Journal Geol. Society*, vol. xxxi., p. 631.

St David's, were detected by myself in the Lower Palæozoic rocks of Girvan, Ayrshire. They occur here in extraordinary abundance, and apparently in a good state of preservation. The examples collected showed at once that in this genus we are no longer dealing with a compound symmetrical siculate Graptolite, like *Cœnograptus gracilis*, H., but with an extraordinary thread-like fossil, forming an irregular meshwork, and occurring in unbroken nets, probably several feet in diameter. The filiform branches appear not to be strictly confined to a single bed, but pass irregularly through a slight thickness of the rock. Even in the calcareous shales, where the other organisms are preserved with their full relief, few of these branches show any appreciable thickness. Where they are best preserved they appear to be cylindrical. As in the American and Welsh forms, there is nothing that can be interpreted as the remains of *hydrothecæ* or cellules beyond an irregular ill-defined crenulation of the margins of the branches. These fossils rarely occur in association with the true Graptolites, but when they are so associated, the distinctness of the two is placed beyond question, as these net-like forms, even when best defined, show nothing of that carbonaceous character so marked among the *Graptolitidæ*. The thread-like branches vary in colour, from dark grey or green to purple, according to the varying composition and texture of the matrix. They are generally bordered with a strong discolouration, about one-tenth of an inch in width. This feature, however, is not invariable, and in rare cases is altogether absent.

I have recognised similar fossils in the Bala rocks of North and South Wales, in the Skiddaw slates of the Lake District, and in many localities among the Silurian rocks of the south of Scotland. It may be regarded as certain that they are widely scattered through the Lower Palæozoic sediments; but that their unsatisfactory state of preservation and enigmatical character has hitherto caused them to be neglected by the palæontologist.

The Girvan species appears to be restricted in its range to a definite formation, and it may be expected that other species will eventually be found to possess a certain geological value.

Of the systematic position and the probable alliances of this strange group of fossils it is at present extremely hazardous to conjecture. I would suggest, however, that they are possibly the remains of the creeping stolons of some sertularid hydrozoon, or the like. It is clear that they are not *Rhabdophora* or true Graptolites. The absence of anything like carbon in the fossil is decisive upon this point. They occur also in incredible multitudes in beds from which Graptolites are altogether absent.

We cannot, it is true, be absolutely certain that our British forms belong to the same genus as Emmons's *Nemagraptus capillaris;* but if his figure and description of this species are reliable, its generic identity with the Arenig form from St David's is highly probable. In view, however, of the doubtful character of Emmons's type species, and of the undoubted distinctness of our British examples from the true Graptolites, it becomes a matter of necessity to avoid the use of Emmons's title of *Nemagraptus* for these forms. I propose to substitute the parallel title of *Nematolites,* by which I have usually designated them in the field.

NEMATOLITES (gen. nov.) (=? *Nemagraptus,* Emm.).

Polypary (?), compound, net-like, consisting of numerous filiform and apparently smooth branches, dividing dichotomously, or throwing off at irregular intervals similar secondary branches, which anastomise and form an irregular network.

The whole of the forms known to myself are very similar in their general aspects, and it is by no means easy to decide upon the characters which may serve to separate the different species. The main points of distinction appear to be the greater or less tenuity of the branches, their comparative remoteness, their greater or less flexibility, the varying angle of their divergence from each other, and the form and size of the resultant meshwork.

Three forms will here be noticed, which appear sufficiently distinct for specific titles. The first is characteristic of the Upper Caradoc rocks of Girvan, the second is peculiar to the Skiddaw slates, and the third is present in the Upper

Arenig rocks of St David's. They may very properly be dedicated to those scientific investigators who have made these respective formations the subject of special study.

Sp. 1. *Nematolites Grayi*, sp. nov.; Plate II., figs. 4, 5.—Branches of great tenuity, about one-hundredth of an inch in average diameter; slightly and irregularly undulating; bifurcating or giving origin to similar branches at distances varying from half an inch to two inches apart, and anastomising and forming an irregular network of large meshes, which are occasionally invaded by a secondary network of smaller and more closely arranged branchlets.

The characteristic peculiarities of this form are the extreme tenuity of its main branches, and their wrinkled or irregularly undulating character.

Locality — *Upper Ardmillan* or *Nematolites beds* (Upper Caradoc) of Girvan, Ayrshire; at Shalloch Mill, Penwhapple Glen, Quarrel Hill, etc., in great abundance.

This species is dedicated to Mr Robert Gray, F.R.S.E., to whom all palæontologists are under a heavy debt of obligation for his zeal in the discovery and publication of the Girvan fossils.

Sp. 2. *Nematolites Nicholsoni*, sp. nov.; Plate II., fig. 6.—Branches rigid, about one-fiftieth of an inch in average diameter; slightly undulating; bifurcating or throwing off similar branches from their convex margin, at right angles to its general direction, sometimes at intervals of half an inch, sometimes in dense groups.

This form is distinguished from the foregoing in several of its characters. Its branches are much stouter, and the manner of their subdivision is different. The slender branches of *Nematolites Grayi* can often be followed for long distances without undergoing any marked deflection from the same general direction, and the chief meshes are rhomboidal or triangular in form. In the present species, on the other hand, the new branches are apparently formed by the bifurcation of the older ones, which consequently repeatedly alter their line of direction, and the resultant meshes are subrectangular in form.

Locality—Barff, near Keswick. From the *Skiddaw slates.*

This species is named after Professor H. A. Nicholson, who was the first to make known the rich Graptolite fauna of the rocks of the Lake District.

Sp. 3. *Nematolites Hicksi*, Plate II., fig. 3.—It is possible that the *Nematolites* from the Arenig rocks of St David's, and identified by Mr Hopkinson and myself with the *Nemagraptus capillaris* of Emmons, may prove to be distinct. Should this eventually be found to be the case, it may be designated *Nematolites Hicksi*, after its discoverer, who was the first to attempt the subdivision of the Arenig rocks of South Wales.

The highly flexuous character of its main branches forms its chief peculiarity. The form of the meshes is as yet unknown.

Locality—Llanvirn Quarry, near St David's. From the *Upper Arenig rocks.*

Explanation of Plate.

Fig. 1. *Nemagraptus elegans*, Emm.; after Emmons: "American Geology," Plate i., fig. 6.

Fig. 2. *Nemagraptus capillaris*, Emm.; *ibid.*, Plate i., fig. 7.

Fig. 3. *Nematolites Hicksi* (sp. nov.) (?); Llanvirn, St David's.

Figs. 4, 5. *Nematolites Grayi* (sp. nov.); Shalloch Mill, Girvan.

Fig. 6. *Nematolites Nicholsoni* (sp. nov.); Barff, Keswick.

XVI. *Fossil Fishes from the Edinburghshire and Linlithgowshire Oil Shales.* By R. H. Traquair, Esq., M.D., F.G.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh.

(Read 18th December 1878.)

The strata from which the fish remains to be described or noticed in the present communication were obtained, are the bituminous shales now extensively wrought for the manufacture of paraffin oil at West Calder, and Oakbank, near Midcalder, in Edinburghshire, and at Broxburn, in Linlithgowshire. These shales are already well known for the fossil plants which they contain, but as yet no attempt has been made to describe or catalogue the fish remains which also occur in them, though much more sparingly. Mr C. W. Peach was the first who directed my attention to the fact that certain ironstone nodules found among the *débris* in the pit banks at West Calder occasionally contained remains of fishes; and during the year (1878) now drawing to a close I have, with the kind aid of several friends, been able to bring together a considerable number of similar relics from that locality, as well as from Oakbank and Broxburn. And before proceeding to their enumeration and description, I must express my best thanks besides to Mr Peach, also to Professor Geikie, director of the Scottish Geological Survey; the Rev. Professor Duns, of the New College, Edinburgh; Messrs John Gibson and T. Stock, assistants in the Natural History Department of the Edinburgh Museum; and Messrs Lumsden and Galletly, of Young's Paraffin Oil Works, West Calder, both for the loan of specimens and for information as to their localities.

I. Fishes from West Calder and Oakbank.

The geological position of the West Calder Oil Shales is in the uppermost or "Houston coal" group of the Calciferous Sandstone series, a set of strata intervening between the "Burdiehouse Limestone" and the Lower Marine Limestone series, and containing, besides the Houston coal seam, which has at various times been wrought in localities in the district, also the well-known "Binny Sandstone." The fish remains occur in the "deep shale," which lies at a considerable distance below the Houston coal, the Binny Sandstone intervening, and are principally found in hard pyritous nodules of clay ironstone, which form a band near the bottom of the seam. Such fossils are of rare occurrence in the shale itself.

From the complex manner in which the strata of the district are folded, as well as disturbed by innumerable faults, it is more difficult to determine the exact position of the shales wrought at Oakbank, about four miles to the north-east; but in Professor Geikie's opinion they belong to the same general horizon as those at West Calder. The fish remains, which they contain, occur in nodules which are very similar in character to those of the last-named locality.

(1.) *Acanthodes* sp.

The remarkable group of extinct fishes constituting the family *Acanthodidæ,* concerning whose structure and systematic position so much has still to be learned, is, as is well known, abundantly represented by genera and species in the Lower Old Red Sandstone of Scotland. Of these Old Red Acanthodians (*Acanthodes, Cheiracanthus, Diplacanthus, Euacanthus, Climatius, Parexus*) the writings of H. Miller, Agassiz, Sir Philip Grey-Egerton, and Powrie, contain abundant illustration. Above the Old Red Sandstone the family seems to have fallen away in numbers and importance, though the remains of fishes belonging to it are traceable through the carboniferous into the Lower Permian. The latter formation has in Germany, though only one genus (*Acanthodes*) is represented, yielded the beautiful specimens from which the elaborate descriptions of Quenstedt,* Troschel,† Roemer,‡ and Kner,§ have been drawn up.

A great deal has, however, yet to be done in the way of working out the *Acanthodidæ* of the carboniferous strata. Remains of Acanthodian fishes are, it is true, pretty generally diffused throughout this formation in Great Britain. Detached spines, bones, and portions of the shagreen-like scaly covering, are not uncommon in the Calciferous Sandstone series of Scotland, from the Wardie shales upwards, as well as in the "edge coal" strata of the Carboniferous Limestone series; while both in England and Scotland such relics are of frequent occurrence in the fish-bearing shales of the coal-

* Handbuch der Petrefactenkunde, Tübingen, 1851.

† Beobachtungen über die Fische in den Eisennieren des Saarbrücker Steinkohlengebirges, *Verh. naturh. Ver. des preuss. Rheinl.* xiv. 1857.

‡ Ueber Fisch und Pflanzen-führende Mergelschiefer des Rothliegendes, etc. Zeitsch. der deutschen geol. Gesellsch, ix. 1857.

§ Ueber *Conchopoma gadiforme,* nov. gen. & sp., und *Acanthodes* aus dem Rothliegenden von Lebach bei Saarbrücken in Rheinpreussen, Sitzungsb. Wien. Ac., lvii. 1868.

measures. But specimens which are at all entire are rare; indeed, it is only in the North Staffordshire district that any number of specimens approaching completeness have been found.

Three species of carboniferous Acanthodians have been described, and these are usually referred either to the genus *Acanthodes* of Agassiz, or to *Acanthodopsis* of Hancock and Atthey. And here the question as to genus is of very great interest. The genus *Acanthodes* was instituted by Agassiz to include these forms, in which, as in the type species *A. Bronnii* of the Lower Permian of Lebach and Saarbrücken, there are, besides the pectoral spines, two ventral, one dorsal, and one anal, all supporting their respective fins, and the dorsal being situated behind the anal one. In this category the following species have been included: From the Old Red Sandstone of Scotland—*A. pusillus*, Ag., *A. Peachii*, Egert., *A. corrugatus*, Egert., and *A. Mitchelli*, Egert.; from the carboniferous formation—*A. sulcatus*, Ag., and *A. Wardi*, Egert.; and from the Lower Permian of Germany—*A. Bronnii*, Ag., and *A. gracilis*, Beyrich. By Agassiz the teeth are stated to be "*fines*," and "*disposées en une simple rangée;*" and in *A. pusillus* he describes the mouth as being "*garnie de tres petites dents qui même sous une très-forte loupe ne paraissent que comme de petits points noirs.*" * Troschel could, however, find no certain evidence of teeth at all in *A. Bronnii*, nor Roemer in *A. gracilis;* but on the other hand, Kner describes both jaws in the former species as bearing "*feine kleine Spitzzähne in ziemlich dichter Reihe,*" in this respect corroborating the statement of Agassiz as to *A. pusillus*.

Messrs Hancock and Atthey, however, drew attention in 1868 to certain peculiar dentigerous bones, or jaws, which are not uncommon in the shale overlying the "Low Main" coal seam at Newsham, near Newcastle-on-Tyne.† Each of these bears five or six large triangular-looking teeth, laterally compressed, confluent at their bases, and having their sur-

* Poissons Fossiles du vieux Grés rouge, p. 35, 36.

† "Notes on the Remains of some Reptiles and Fishes from the Shales of the Northumberland Coal Field," *Ann. and Mag. Nat. Hist.* (4), vol. i., pp. 364-368.

faces finely and irregularly striated. In some instances the peculiar styliform bone—described by some authors (Römer, Grey-Egerton) as the mandible of *Acanthodes,* by others (Troschel, Kner) as the *hyoid*—was found lying closely along the inner and lower margin of the dentigerous bone in question. All doubt as to these jaws with their singular teeth being Acanthodian in their nature was, however, removed by their occurrence *in situ* in a few fragmentary specimens of fishes of this family, some of which Messrs Hancock and Atthey referred to the *Acanthodes Wardi* of Sir Philip Grey-Egerton, constituting for it, on account of the peculiar dentition, the new genus *Acanthodopsis;* others they referred to a new species of the same genus, viz., *Acanthodopsis Egertoni.*

There does not, however, appear to me to be any real evidence of the identity of *Acanthodopsis Wardi* of Hancock and Atthey with the *Acanthodes Wardi* of Egerton. I have carefully examined the specimens (now in the Newcastle Museum) which were used by Messrs Hancock and Atthey for their descriptions, and I must own that they seem to me to be too fragmentary to justify any such identification. It is also somewhat remarkable that in the North Staffordshire fish shales, where *Acanthodes Wardi* is abundant, the jaws of *Acanthodopsis* have not yet, so far as I am aware, been found; indeed, Mr Ward, whose experience as a collector in that district is so well known, writes to me that he has never yet seen the jaw in question. Although *Acanthodopsis* occurs sparingly in the coal measures of Scotland, as at Falkirk and at Smeaton, near Dalkeith, such jaws have also as yet never occurred in the Calciferous Sandstone series, or in the "edge coal" strata of the Carboniferous Limestone group, in which other Acanthodian remains are by no means uncommon.

The true dentition of the fish named *Acanthodes Wardi* by Sir Philip Grey-Egerton has not yet been determined, and until that is the case, I think it preferable to retain it in the genus *Acanthodes,* as distinct from *Acanthodopsis Wardi* of Hancock and Atthey. In similar circumstances, a similar treatment should be accorded to other *Acanthodes*-like fishes from the carboniferous formation.

Numerous remains of a pretty large Acanthodian fish have been collected at West Calder by Mr Peach, and at Oakbank by Messrs Gibson and Stock, which may be referred to *Acanthodes,* though it would be premature to identify them with any described species. They consist of fragments of the body; the best, from Oakbank, in the collection of Mr Gibson, displays nearly the entire pectoral fin, in addition to a crushed and unreadable portion of the head. The scales are proportionally minute, smooth, and shining on the outer surface, and without any trace, so far as I have seen, of the longitudinal furrow or *sulcus* described by Agassiz as characteristic of his *Acanthodes sulcatus* from Wardie. It is, however, unfortunate that *A. sulcatus* was founded upon a very small fragment (now in the Oxford Museum) of the scaly covering of the body, so that its satisfactory comparison with other fragmentary specimens is attended with difficulties. Meanwhile, it seems safer to wait for the acquisition of further material before deciding as to the species of these Acanthodians from West Calder and Oakbank.

(2.) *Nematoptychius Greenockii,* Ag. sp.

Pygopterus Greenockii—Agassiz: "Poissons Fossiles," t. ii., pt. 2, p. 78.
Nematoptychius Greenockii—Traquair: "Ann. and Mag. Nat. Hist." (4), xv., 1875, p. 258.

Several heads of this large and beautiful Palæoniscid fish have been found at Oakbank by Messrs Gibson and Stock, and there is one badly preserved in the collection of fossils at the West Calder Oil Works. One specimen in the collection of Mr Gibson shows, besides the head, a portion of the body, in the abdominal part of which there are contained portions of the shagreen-like scaly covering of a small *Acanthodes,* of which the larger fish had evidently made a meal shortly before its death.

The remains of *Nematoptychius Greenockii* are of frequent occurrence in the Lower Carboniferous rocks of Scotland. Besides West Calder, the following localities may be quoted:

In the Calciferous Sandstone Series—Wardie, and Water of

Leith near Juniper Green, in Edinburghshire; Burntisland and near Anstruther, in Fifeshire.

In the Carboniferous Limestone Series—Loanhead, West Edge near Gilmerton, and Borough Lee, in Edinburghshire; Possil, in Lanarkshire.

(3.) *Elonichthys tenuiserratus*, sp. nov.

Among the fish remains collected by the Geological Survey of Scotland—for the privilege of examining which I am indebted to the kindness of Professors Ramsay and Geikie—I observed a small portion of shale from Hermand, near West Calder, covered with dislocated scales of an apparently new species of *Elonichthys.* Subsequently Mr Stock confided to me for description a specimen contained in an ironstone nodule, which he found on the bank of a shale pit in the same district, and which presents us with the head and greater part of the body of a fish of the same species, the caudal and anal fins, however, being deficient, and the body scales jumbled up and squeezed together.

Description. — The head in Mr Stock's specimen is 2 inches in length, and, judging from the usual proportion which the head bears to the total in allied species, the entire length of the fish cannot have originally been less than 9 inches. The cranial roof-bones are minutely and closely granulated. The external facial bones are covered with very fine and closely placed raised striæ or ridges, which tend to become irregularly ramified and intercalated. The lower margin of the maxilla bears a number of large conical laniary teeth, whose apices are, however, concealed by the matrix; and besides these, a few of the more externally placed smaller teeth are also visible. About ten branchiostegal plates may be counted, passing from the interoperculum round beneath the powerfully developed mandible.

The pectoral fin is acuminate in shape, and equals in length two-thirds that of the head; about twenty rays may be counted in it, but it is also evident that the whole of the more delicate rays on its medial aspect are not exhibited. Excepting the first two or perhaps three on its lateral edge, which are comparatively short, and do not reach the apex, all the pectoral rays are articulated up to their origins, the articulations being tolerably close, although the joints for the most part appear a little longer than broad. In the case of the ray forming the lateral margin of the fin towards the apex, the joints are, however, shorter than elsewhere—in fact, shorter than broad. The marginal fulcra of the pectoral are very minute and closely set. The ventral fin is imperfectly preserved; its rays are seen to be coarser than those of the pectoral, but similarly articulated, the joints being longitudinally striated, and the fulcra coarser and more obliquely set. The dorsal is in still worse condition than the ventral, and is, moreover, displaced forwards by the distortion of the body. Only a few of the anterior dorsal fin-rays are seen, and these are tolerably coarse and divided by transverse articulations, which are so close as to render the joints nearly square; externally the rays are finely and closely striated longitudinally.

The scales are rather large; one from the middle of the flank in Mr Stock's specimen measures $\frac{1}{5}$ inch in height, exclusive of the articular spine, by $\frac{1}{6}$ inch in breadth; while most of those in the specimen belonging to the Scottish Geological Survey are a little larger. They have the usual shape found in the genus—the flank scales having their upper margin rather concave, and showing a well-marked articular spine, the lower margin being correspondingly convex, while the anterior marginal covered area is very narrow. The posterior margin is very minutely serrated—so minutely that the serrations are with difficulty perceptible, even with a strong lens. The exposed surface is sculptured with very delicate furrows, which form a pattern essentially similar to that seen in *E. striolatus* and other species of the *Robisoni* type; but here these furrows are much more numerous and minute, in proportion to the size of the scale. As in allied forms, the furrows commence oblique to the anterior margin of the scale, and proceeding downwards and backwards, curve round so as to become more or less parallel with the lower one; towards the middle of the scale they usually become faint, and more or less replaced by minute punctures, which are more especially brought out when the scale is held in certain positions. Towards the posterior margin the furrows become again more marked, and terminate between the minute serrations of the edge. No satisfactory view is afforded of the scale sculpture behind the region of the ventrals.

Remarks.—Scanty as are the materials for the description of *E. tenuiserratus*, its characters are so clear and striking that it cannot be confounded with any other species hitherto described. We have before us a fish allied to those species of *Elonichthys* which may be classed together as the "*Robisoni* type," but at once distinguishable from all of them by the fineness and closeness of the ornament on the cranial bones; and as regards the scales, by the extreme delicacy of their sculpture and the minuteness of their marginal serrations, which the comparatively large size of the scales renders all the more conspicuous. The pattern of the ridges on the facial bones differs also somewhat from that in allied forms; but for purposes of diagnosis, a single scale from the flank is sufficient.

(4.) *Elonichthys pectinatus*, Traquair.

Elonichthys (?) *pectinatus*—Traquair: "Proc. Roy. Soc., Edin.," May 1877, p. 430.

In the "Proceedings of the Royal Society of Edinburgh" for May 1877, I described, under the name of *Elonichthys* (?) *pectinatus*, certain scales from the Carboniferous Limestone Series of Gilmerton, Levenseat, and Carluke, referring them provisionally to that genus, until further information could be had regarding the fish to which they belonged. The description which I gave at that time I may here quote in full:

"Flank scales about $\frac{1}{3}$ inch broad, and usually a little higher, exclusive of the articular spine; moderately thick. Upper margin with prominent articular spine; anterior covered area narrow; exposed surface brilliantly ganoid, sculptured with oblique, sub-parallel prominent ridges, occasionally branching, anastomising, and intercalated, and terminating behind in delicate denticulations of the posterior margin; about seven or eight of these ridges in the space of $\frac{1}{8}$ inch. Under surface of scale with feebly marked keel; a narrow area along the posterior margin is obliquely grooved, the short grooves terminating between the denticulations of the posterior margin, so as to produce a pectinated appearance. Scales from apparently the ventral aspect are lower than broad, and with more produced anterior superior angles; others, from their more regularly rhomboidal shape and scanty development, or absence of the articular spine, and more prominent keel of the attached surface, were probably situated more towards the caudal extremity. In all cases the external sculpture is similar, and the under surface displays the same peculiar pectinated appearance at the posterior margin.

"Associated with these scales, there is on a specimen from Carluke, in the collection of Mr Grossart of Salsburgh, a small fragment of the edge of what must have been a pretty large jaw. This fragment is nearly $1\frac{1}{2}$ inches in length, and displays the stumps of five stout conical teeth, with traces of smaller ones external to them; the external surface of the bone is beautifully tuberculated."

I might also have added that the tubercles on the portion of jaw referred to are, when examined under a lens, seen to be ornamented with minute striæ passing upwards upon them from their bases.

From the oil shale pits at West Calder and Oakbank, Messrs Peach, Gibson, and Stock have collected a considerable number of specimens, which I must refer to the same species. Many of these consist, like the originals upon which the species was founded, only of masses of dislocated scales; there are, however, others which, though still rather fragmentary, throw a considerable amount of additional light upon the structure of the fish itself. All are contained in ironstone nodules, save one, which was shown to me by Mr Lumsden at the West Calder Oil Works, in which the scales are found imbedded in a portion of the oil shale itself.

Between the scales of the West Calder and Oakbank specimens, and those forming the original types of *E. pectinatus,* I can see no essential difference either in configuration or sculpture, although in the former the ridges are in some cases rather finer, and are also occasionally themselves ornamented with a few very delicate striæ running longitudinally or obliquely along their sides. Rarely is the internal surface of the scale exhibited, but in one case at least the posterior margin seen from this aspect is distinctly pectinated in the same peculiar manner as in those previously described.

A specimen in the collection of Mr Gibson shows a large portion of the body, with remains of the dorsal, ventral, and anal fins, and is 7½ inches in length by 5 inches in greatest depth. The nodule is unfortunately broken across just in front of the ventral and a little behind the anal fin; but, judging from the proportionate dimensions of the part of the body exhibited, the original length of the fish could not have been less than 18 inches. The fins are badly preserved, not much more than their bases being shown, and those are imperfect; the dorsal is placed opposite the interval between the ventral and the anal. The fin-rays are stout, their articulations are rather close, and where their internal surface is shown, it is brilliantly ganoid, and conspicuously striated longitudinally.

Another specimen belonging to Mr Gibson consists of a large clavicle, with a portion of the appended infraclavicular plate, and in connection with this clavicle there is the greater part of the pectoral fin. The portion of the fin preserved is nearly 2½ inches in length by 1¼ inches in breadth; but as the rays are abruptly disturbed and broken off, it is perfectly clear that the extremity of the fin is gone, and judging from what remains, its original length cannot have been less than 3 inches—probably more. A fish of very formidable proportions is therefore here indicated, at least for a member of the Palæoniscidæ. The principal rays of this pectoral are, as in *Elonichthys Egertoni*, and in the genera *Acrolepis* and *Nematoptychius*, unarticulated for some distance from their origin—as much as 1 inch at the lateral margin—beyond which they are closely jointed. Careful examination shows that the jointed portions of the rays were sculptured externally with longitudinal and, in some cases, oblique striæ.

In another specimen, also belonging to Mr Gibson, a portion of a large mandible is shown, which at its thickest part is no less than $1\frac{1}{16}$ inches in depth. A fracture displays, in vertical section, a large incurved conical tooth, whose height above the jaw-margin cannot, however, be accurately determined, as the apex is deficient. The outer surface of the dentary bone is sculptured with closely-set, sinuously-contorted, and interrupted ridges, passing into tubercles, the sides of which are again ornamented with delicate vertical striæ. On the edge of the specimen is also seen a portion, 3 inches in length, of the dentary margin of the maxilla, the outer surface of which is closely tuberculated in the same way as the portion of jaw shown in Mr Grossart's specimen from Carluke—the tubercles, sometimes round, sometimes confluent, being again ornamented with exceedingly delicate striæ. The maxillary teeth are, except the impression of a small external one, covered up by the intractable matrix; but the bone being broken longitudinally through a little above the dentary margin, the basal pulp cavities of four large laniary teeth are opened into in the space of $1\frac{1}{2}$ inches. The portion of maxillary margin exhibited is 3 inches in length, but it is broken off at both ends, and, judging from its curves and the thickness of the bone itself, it must have originally been considerably longer.

Mr Stock also possesses a specimen showing the posterior or expanded portion of the maxilla displayed, the outer surface of which is covered by a close tuberculation entirely similar to that above described, and the scales associated with it are sufficient for its identification as belonging to the same fish. Two large laniary teeth, with a few of the more externally placed smaller ones, are visible on the margin.

A nearly entire head is seen in another of Mr Gibson's specimens, and again in one collected by Mr Peach. In both the cranial bones are much crushed and broken, and their external sculpture not exhibited; but the skull is clearly seen to be constructed on the ordinary Palæoniscid type, with oblique suspensorium, wide extent of gape, etc. In Mr Peach's specimen, which is rather a small one, the left ramus of the mandible is shown in its entirety, and measures $2\frac{1}{9}$ inches in length, by $\frac{3}{16}$ inch in depth, near its posterior extremity. These proportions would indicate for Mr Gibson's fragmentary mandible, already described, an original length of at least $6\frac{1}{2}$ inches, and somewhere between 3 and 4 feet as the probable length of the entire fish to which it belonged.

Remarks.—This splendid Palæoniscid seems to have rivalled *Acrolepis Rankinei* in bulk, with which its remains may also, on superficial examination, be easily confounded. The scales of *Elonichthys pectinatus* may, however, always be easily distinguished by their greater relative thinness, by the narrowness of their covered area, and by the pectination of their posterior margins. These scale-features induce me to class the fish rather in *Elonichthys* than in *Acrolepis*, although it agrees with the latter genus in the structure of the pectoral fin. But the small *Elonichthys Egertoni* also has the principal rays of the pectoral unarticulated for about one-third of their length. The genus *Elonichthys* will therefore fall into two divisions—the first comprising those species (*E. semistriatus, striolatus, tenuiserratus,* etc.), in which the pectoral rays, except one or two short ones immediately on the lateral edge of the fin, are all articulated up to their origins; and the second those other species (*E. Egertoni, Portlockii, pectinatus*) in which the principal rays of the fin are unarticulated at their origin for about one-third of their length. The second division forms a transition to *Acrolepis.*

(5.) *Eurynotus* sp.

On a slab of shale in the collection at the West Calder Oil Works there are numerous scattered scales of an *Eurynotus*, which I cannot distinguish from those of *E. crenatus.* Mr Stock also possesses a small and not very perfect specimen of *Eurynotus* preserved in an ironstone nodule, from a pit in the vicinity, concerning which it is better at present to express no opinion as to species.

(6.) *Gyracanthus tuberculatus*, Ag.

A considerable portion of a large spine, lent to me by Mr D'Arcy W. Thompson, who obtained it from the West Calder

Oil Works. It occurred in the productive oil shale, and is not contained in a nodule.

(7.) Spine allied to *Sphenacanthus.*

A mere fragment found by Mr Peach at Hermand, West Calder. Another fragment, still more imperfect, is in the collection of Mr Gibson.

II. Fish from Broxburn.

The oil shales wrought at Broxburn, in Linlithgowshire, are considered by Professor Geikie to occupy a lower position in the series than those of West Calder and Oakbank. Fish remains seem to be excessively rare in the present workings, but I am indebted to the Rev. Professor Duns for the loan of a beautiful specimen of a hitherto undescribed fish, which he found some years ago on the bank of a shale pit now disused. I have, therefore, great pleasure in naming the species after its discoverer.

Elonichthys Dunsii, sp. nov.

Professor Duns's specimen presents us with a fish entire in all respects, save that the extremity of the tail is shown only as a somewhat obscure impression. In length it measures 6 inches, in greatest depth $1\frac{3}{4}$ inches. The shape is deeply fusiform, the depth of the body at the commencement of the dorsal fin being contained about three and a half times, the length of the head about five times, in the total. The head appears, therefore, short and deep; the anteriorly-placed orbit and projecting snout are well defined, as well as the wide gape and the oblique position of the hyomandibular element. A thin layer of the matrix obstinately adhering to the surface of the bones prevents their further description, save that the sculpture of the cranial roof-bones is seen to be of a finely tuberculo-rugose character; the lower end of the clavicle is, however, clearly exhibited, and is ornamented with rather coarse, well-defined, flattened rugæ. The scales, of which forty oblique bands may be counted between the shoulder and the commencement of the lower lobe of the caudal fin, are of medium size, and in their general form are similar to those of other species of *Elonichthys*. Their posterior margins show, even as far back as the termination of the dorsal fin, where the appearance tends to become obsolete, an *extremely delicate* oblique serration, which distinguishes them from the scales of every other species of the genus with which I am acquainted, save *E. tenuiserratus*. Immediately behind the shoulder girdle the scales are highly ornate, the free surface being marked by delicate furrows, interrupted, intercalated, and mostly parallel with the lower margin, tending also to pass into punctures posteriorly. Soon after passing this region, the furrows become limited to the anterior margin of each scale, and the greater part of the exposed area is covered with *thickly dotted* punctures.

The left pectoral fin is visible, as well as the anterior margin of that of the right side, but both are only seen through a thin layer of the matrix. They are acuminate in shape, each as long as the lower jaw, and their principal rays are clearly seen to be articulated up to their origins. Both ventrals are also exhibited, but in indifferent preservation. The dorsal is placed over the interval between the ventrals and anal; it is large, acuminate, and contains about thirty rays. These dichotomise towards their terminations; their articulations are longer than broad in the proximal halves of the longer rays, but distally, and in the short rays of the hinder part of the fin, they become very short. These ray-joints, brilliantly ganoid, are each marked by a longitudinal furrow, in front of which again are usually a few oblique streaks, the posterior margin being, like that of the scales of the body, ornamented by a *delicate oblique serrature*, the denticles of which point upwards and backwards. The anal fin is somewhat smaller than the dorsal, but possesses the same general configuration, and the same mode of ornamentation of its rays. The caudal is unfortunately very badly preserved as regards clearness of detail, though its general shape—strongly heterocercal and inequilobate—is traceable, partly in impression, partly as seen through a thin layer of matrix similar to that which has obscured the head bones, as well as portions of all the other fins. On the anterior margins of all the fins well-marked fulcra are observable.

I am indebted to the kindness of Mr John Henderson, Curator of the Phrenological Museum, Edinburgh, for a specimen from the Water of Leith, near Juniper Green (Wardie Shales), which is probably referable to the present species. Unfortunately the scales and fin-rays are so dislocated and jumbled up, that it is hardly possible to say more regarding it than that the scales, in configuration and sculpture, closely resemble those of Professor Duns's specimen.

Remarks.—Although the dentition of this species is still unknown, its position in the genus *Elonichthys* seems to be indicated by its general aspect, the configuration of its scales, and the structure and position of its fins. Its most salient peculiarities are the very minute denticulation of the posterior margins of the scales, and the serration of the posterior margins of the joints of the fin-rays—characters which, when taken together, distinguish it from every other species with which I am acquainted.

XVII. *Evidence as to the Predaceous Habits of the Larger Palæoniscidæ.* By R. H. Traquair, Esq., M.D., F.G.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh.

(Read 29th May 1879.)

That the larger fishes of the Carboniferous and other periods were, like those of the present day, in the habit of feeding upon their smaller brethren, is a fact long ago well attested by the frequency with which scales and small bones occur in coprolites, which, in our own district, constitute so abundant a fossil wherever fish remains are to be found. The mail-clad skins of the smaller Ganoids seem to have formed no protection against the powerful jaws and conical teeth of their superiors in bulk. The small jaw, from the German Kupferschiefer, named by Münster *Globulodus elegans*, were discovered in a coprolite.* The original specimen of

* Beiträge zur Petrefactenkunde, v., 1842, p. 47.

the large Liassic cœlacanth, *Holophagus gulo*, "has the stomach distended with a recently-swallowed *Dapedius*," which circumstance seems to have suggested the very expressive name given to the fish by Sir Philip Grey-Egerton.* Nor do the very formidable spines with which the fins of fishes of the genus *Acanthodes* were armed, seem to have formed any efficient obstacle to their being swallowed and digested; indeed, *Acanthodes* seems to have formed rather a common article of food with some of the larger *Palæoniscidæ*; for Acanthodian spines may be very frequently detected lying in the abdominal cavities of large specimens of *Rhabdolepis*—a Palæoniscid genus common in the ironstone nodules of Saarbrücken and Lebach in Rhenish Prussia.

Of the larger Palæoniscidæ of our Scottish Lower Carboniferous strata, none would seem to be better adapted for a life of the kind usually termed "predaceous" than *Nematoptychius Greenockii*. Its slender body, covered with comparatively small scales, and its large fins, bespeak a rapid swimmer, while its powerful jaws, armed with formidable incurved conical teeth, and, above all, its enormous extent of gape, would enable it to capture and swallow with ease other fishes of a very considerable size, including also those strongly-spined Acanthodians, which I have already mentioned as frequently forming the prey of the Lower Permian *Rhabdolepis*.

I have, in my recent paper on the Fishes of the Edinburghshire and Linlithgowshire Oil Shales, mentioned a specimen of *Nematoptychius Greenockii* from Oakbank, in whose abdomen distinct remains of an *Acanthodes* are to be found. And I have just lately obtained from the blackband ironstone of Borough Lee, near Dryden (Middle Carboniferous Limestone series), an example of the same species, which affords a still better instance of the same phenomenon. In its abdomen there may be seen, lying over the region of the ventral fins, first, the slender styliform bone of an *Acanthodes*, variously considered by different authors as belonging to the mandible or to the hyoid apparatus; then, proceeding from behind forwards, we find the two pectoral spines each $1\frac{1}{4}$

* Dec. Geol. Survey, x., 1861, p. 19.

inches in length, and having their apices pointing towards the mouth of the larger fish; then a smaller one, probably one of the ventral spines; lastly, there are here and there exposed portions of the shagreen-like scaly covering, the little quadrangular scales being mostly still in apposition.

It might be suggested that here we have simply the remains of two fishes accidentally squeezed together, one above the other. But careful examination of the specimen, and comparison of it with the "counterpart," indisputably demonstrates that the Acanthodian remains are situated, not outside the body of the *Nematoptychius*, but *between* its right and left abdominal walls. For as the stone has so split, that part of the substance of the large fish adheres to one slab, and part to the other, the scales of the two sides of the body can readily be distinguished, separated by a thin layer of matrix. And looking at the slab on which the *Nematoptychius* seems to lie on its right side, nothing can be clearer than the position of the Acanthodian remains *below* the left and *above* the right body wall, and imbedded in the thin separating layer of matrix to which I have alluded. More of the *Acanthodes* could certainly be exhibited by careful working out, but so obstinately does the aforesaid layer of matrix adhere to the delicate shagreen-like scales, save where it has already split off naturally, that it is hardly possible to clear it away without injury to the latter. Enough is otherwise shown to demonstrate the relative position of the two fishes to each other.

In conclusion, two points may be noted in connection with the specimen chronicled above:

1. The swallowed fish must have been of very considerable size in proportion to its captor, judging from the length of its pectoral spines. This shows rather forcibly that the enormously wide gape characteristic of the Palæoniscidæ was not bestowed in vain upon the larger species of the family.

2. The *Acanthodes* was swallowed head foremost, as is clearly shown by the position of its remains in the body of the larger fish. This must necessarily have been the case, as in any other position its formidable spines would have proved an insuperable obstacle to its being swallowed at all.

XVIII. *Note on the Occurrence of the Stockdove* (Columba ænas) *in Berwickshire.* By Robert Gray, Esq., F.R.S.E.

(Read 19th March 1879.)

In April last year, shortly after the concluding meeting of the session had taken place, I was favoured with a note from Mr Charles Watson, solicitor, Dunse, in which he informed me that the stockdove was a well-known bird in Berwickshire, and must have bred there in some numbers for several years. I at once wrote to that gentleman to say that his communication was of the greatest interest to me, and that I should be glad if he would enable me to verify the information, by sending me a specimen of the bird, and thus give me an opportunity of submitting it at a meeting of this Society. Mr Watson most kindly replied that he would have pleasure in complying with my request in time for an early meeting of the present session, and he would, doubtless, have done so before this time, had the birds not shifted their quarters at the commencement of the severe weather which has been so prevalent during the present winter. On the 11th of this month, Mr Watson, in a letter which I received from him, mentioned that he had some time ago asked Mr Hay of Dunse Castle, to allow his gamekeeper to procure a specimen, and that on the morning of that day one had been brought to him, which he had at once sent off to my address. Mr Watson added that the keeper had seen more than a dozen of these birds on the day in question. About three months previously, the flocks frequenting the woods at Dunse Castle had all left the district, but had returned a few days before the specimen now exhibited was shot. On asking Mr Watson for further information, which I might communicate to the Society this evening, I was favoured with a second communication, in which he writes as follows:

"Clouds, Dunse, N.B., 13*th March* 1879.

"About a year ago Mr Robert Wait, bird-stuffer here, brought to me a dove which had been shot by the gamekeeper at Dunse Castle. I at once was satisfied it was a stockdove, and on making inquiries, found that numbers of these birds had bred in the woods about Dunse Castle for several years. They had first attracted the keeper's attention by the difference of their call. They are increasing every year in numbers. Shortly after seeing the bird, I observed in a report of a meeting of the Royal Physical Society a notice of its occurrence in Perthshire, and I then wrote to you on the subject. At the commencement of the snowstorm in December last the colony migrated, I suppose, to the coast, and returned about a week ago.

"Last year the keeper, Alexander Hewit, secured a pair of young birds from the nest, and has them still. They are rather wild, but perhaps that arises more from want of society than from inherent wildness. They are perfect beauties."

From this information, it would appear that the stockdove has been a regular visitant in the woods of Dunse Castle, and in all probability other parts of Berwickshire, for years past, and that it has regularly bred there. Ornithologists are certainly indebted to Mr Watson for having recognised this interesting bird when submitted to him last year, and for having announced the fact of its being now a native of Scotland. Personally I have to thank him for having brought the facts now communicated under my notice, and I now place them on record in the *Proceedings* as facts of interest, inasmuch as they give an extended range to the distribution of the stockdove in Britain.

XIX. *Note on the Occurrence of the Starry Ray* (Raia radiata *of Donovan*), *in the Firth of Forth.* By Chas. W. Peach, Esq., A.L.S.

(Read 19th March 1879.)

A short time ago Mr G. Dickson Moffat, fish merchant, of 38 Dundas Street, sent me two fine specimens of the Starry Ray, *Raia radiata* of Donovan and of Fleming's, "British Animals," p. 170, sp. 20. As it is rare to me, and was so both to Yarrell and Couch, the former having seen one from Berwick and two from the Firth of Forth, the latter only one ("the dried skin" Yarrell had), I have thought it might be interesting to the members to exhibit mine to-night. Yarrell has figured and described this ray at page 585, vol. ii., second edition, of "The British Fishes." The figure was taken from the one got in Berwick Bay—a female specimen—and it agrees well with the specimens I now exhibit, although more so when they were fresh and their colours bright. Yarrell's figure was taken from a female example; mine are both females, and agree in length with it and other particulars.

Couch's figure of this fish, plate xxiii., page 103 of his "History of the Fishes of the British Islands," was taken from Donovan's plate. Couch gives no dimensions, etc., and as I have not Donovan's work, I am unable to give particulars as to size, etc., or locality. There is, however, sufficient in the figure to identify it as a starry ray. I rather think it must have been a larger specimen than mine, judging by the large spines and robust appearance shown in the plate. Couch adds nothing to the description given by Yarrell.

My specimens were taken in the Firth of Forth; Parnell sent Mr Yarrell two from the same locality. I regret that I have not been able to examine Parnell's "Fishes of the Firth of Forth." I am not aware that I ever saw any other specimen of this pretty fish. If I had, I am sure that its well-marked character would not have escaped my notice. To "educate" our young friends has been a strong inducement to bring them here, as well as to express my best thanks to Mr Moffat for his kindness in sending me such a welcome present.

XX. *Note on the Harvest Mouse* (Mus messorius). By A. B. Herbert, Esq.

(Read 16th April 1879.)

The harvest mouse (*mus messorius*) designated by Pallas *Mus minutus,* is the smallest of British quadrupeds, and seems not to have been known as a distinct species till Gilbert White called attention to it in the year 1767. They breed as many as eight or nine at a litter, in a round nest composed of the blades of grass and wheat. White thus describes one of these nests: "It was most artificially plaited and composed of the blades of wheat, perfectly round, and about the size of a cricket ball, with the aperture so ingeniously closed that there was no discovering to what part it belonged. It was so compact and well filled that it would roll across the table without being discomposed, though it contained eight little mice, which were naked and blind. This wonderful procreant cradle, an elegant instance of the efforts of instinct, was found in a wheat field suspended in the head of the thistle."

They are found in Hampshire, Gloucestershire, Devonshire, Warwickshire, and probably in many other English counties, also in Wales, and, I am informed, are sometimes to be met with in Scotland. Mr Gray, secretary of this Society, has mentioned that he has procured specimens from various counties, the farthest north being Kincardineshire. Their food consists of all kinds of grain, but especially oats. Those I now exhibit are fed on oats, wheat, soaked bread and milk, and canary seed, and are very partial to the latter. They are fond of flies, and would probably eat other insects also. The Rev. W. Bingley says they lay up in their burrows a store of grain for the winter. I have placed the four I possess in an empty aquarium, with glass sides and perforated zinc top, and in this fixed a small apple bough, with a few pieces of string hanging from it. They are wonderfully agile in springing from one twig to another, and running up and down the strings, and their tails being prehensile, they steady themselves by curling these round the twigs and strings, and often suspend themselves momentarily by their tails before dropping to the floor of the cage. The prehensile nature of this member must be of great assistance to them in ascending and descending the straws of grain. They seem capable of much domestication, and have no offensive smell like the common house mice. I procured them from Surrey, and they met with an adventure in transit, being detained in St Martin le Grand for forty-eight hours, the post office authorities refusing to forward them, as the conveyance of live animals by post is contrary to the official regulations.

My Surrey correspondent informs me that in some seasons they are not uncommon in oat ricks in that county, but sometimes they are scarce and difficult to procure. I have not met with any recorded instance of their rearing their young in confinement. There can be no doubt this is the smallest British quadruped, as it takes six full grown mice to weigh an ounce. It is said that dogs will eat them, but cats will not.

XXI. *Miscellaneous Notes.*

1. *On Spawning Season of* Hyas araneus.—In December last I collected three specimens of this crab in spawn, all taken in the Firth of Forth, off Newhaven, two of which are now exhibited. The spawn is attached to eight tubes, four arranged on each side of the apron, which is well shown in the larger specimen. In Bell's "British Crustacea," it is said, on page 34, "Mr Hailstone states that this crab spawns in February; this, however, cannot be universally the case, as I took several females at Sandgate early in May, in the year 1843, every one of which was carrying her load of spawns." It would appear, however, that the season of spawning of this species extends over a much longer period than was generally believed.—*Robert Kidston,* 19*th February* 1879.

2. *On Ramose Form of* Plantago maritima.—The variety of *Plantago maritima,* which I now show to the Society, was collected by me near Banff last September. Its peculiarity lies in its flowering heads being ramose. The leaves were of the usual form. The root, which was growing beside a great number of the ordinary type, had from twenty to twenty-five flowering heads, measuring about 12 inches each, and did not present any appearance of deformity, but was the only specimen of the kind I observed.

I have not found any reference in botanical literature to varieties of this sort in *Plantago maritima.*

For comparison, I have made a diagram of this variety, alongside of the typical form.—*Robert Kidston,* 19*th February* 1879.

3. *On the Occurrence of the Grasshopper Warbler* (Calamodyta locustella, Lath.) *in Midlothian.*—On 28th May last, while walking on the Old Penicuik Road, about a mile beyond Morningside Toll, my attention was attracted by a sound resembling that of some large gryllus, which proceeded from a clump of whin in the field immediately opposite Mortonhall west gate. As daylight was nearly gone—it being about half-past eight in the evening—it was not easy to discover the little warbler. This, however, only required a little patience, and with the assistance of my brother, who resides at a farm near the spot, I was fortunate enough to secure the specimen—a male—which is now exhibited. This was the only one observed.—*W. Evans,* 19*th March* 1879 (*communicated by the Secretary*).

4. *White-winged Crossbill* (Loxia leucoptera).—On 12th July 1878, two of these birds—male and female—alighted on the Anchor Line steamer "Victoria," when about five hundred miles from Newfoundland, on the outward voyage from Glasgow to New York. It was our sixth day from Glasgow, and the wind had been blowing from the west pretty strongly all the time. Both birds were caught alive, and that now exhibited is one of them. The other, the female, died the day after it was taken.—*W. Evans,* 19*th March* 1879 (*communicated by the Secretary*).

5. *On the Nesting of the Woodcock* (Scolopax rusticola) *in Midlothian.*—The nest was placed among coarse grass in a wood principally composed of alder, about a mile and a half above Penicuik, on the south bank of the Esk. The eggs were taken on the 1st July 1870, but had then been left for some days by the parent birds, which had been disturbed by people felling trees in the vicinity. There were four eggs in the nest, but incubation was so far advanced that only two could be preserved.—*William Evans,* 16*th April* 1879 (*communicated by the Secretary*).

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CIX.

Wednesday, 19th November 1879.—RAMSAY H. TRAQUAIR, Esq., M.D., President, in the Chair.

The CHAIRMAN delivered the following opening address:

GENTLEMEN,—This evening the Royal Physical Society of Edinburgh enters upon its one hundred and ninth session, and I must heartily congratulate the members present upon the fact that, old as the Society is—in fact, the oldest in Edinburgh—it does not at present show any signs of disease or decay. Our Society has indeed had its periods of sickliness, but has surmounted them all, and now displays a greater amount of vigour and health than it has done for many years. Including ordinary, non-resident, corresponding, and honorary members, our roll now musters 229 names. Mere numbers, however, it may well be said, do not constitute any criterion of the efficiency of a society whose object is supposed to be the promotion of scientific study and research, although in this case, as in the case of a private individual, the word "prosperity" must always mean one thing, and that—a well-filled purse. But the fasciculus of our *Proceedings* for the past session, now in the press, will show when it appears that we have amongst us a goodly number of members who are devoting themselves heartily to practical work in the various branches of science in which they are interested, and that their work is not quite in vain.

I need hardly say, what all of you must already feel, how much of this renewed vigour is due to the ability, the enthusiasm, and the unflagging industry of our worthy secretary. For by its secretary a society like ours will rise or fall; without a secretary around whom men will rally, and with whom they will consider it an honour and a pleasure to be associated, any society will languish and finally expire. The treasurer also has a most important share in the well-being of a society. If the secretary supplies the nervous force, the treasurer gathers in a very necessary kind of material food, without which the body will starve. And we may, I think, also congratulate ourselves that we have secured the services, as treasurer, of a gentleman whose business capacity and training, as well as his zeal for the prosperity of the Society, eminently fit him for the task which he has undertaken.

Our first meeting for the present session has, however, its aspects of sadness as well as of rejoicing, for during the past year Death has taken from us more than one of our prominent members. We must all of us deeply regret that we shall never again see amongst us the genial and familiar face of our old and respected friend, Dr M'Bain, so many years an active member of this Society, of which he was twice president, and the contributor to its *Proceedings* of so many able and interesting papers. A hand more able for the task than mine will, however, perform the duty of laying before you a suitable memoir of our departed friend, for Mr Grieve, whose acquaintance with the late Dr M'Bain was long-standing and intimate, has undertaken to do so at our next ordinary meeting.

We have likewise to deplore the loss of our late treasurer, Mr E. W. Dallas, a zealous fellow-member, a regular attender of our meetings, and one who, in the office whose duties he latterly undertook, most efficiently co-operated with the secretary in reviving the prosperity of the Society. Mr Dallas, brother of the eminent assistant-secretary of the Geological Society of London, was a man of wide sympathies and extensive culture, and his amiable disposition, the interest which he took in the well-being of our Society, and the zeal with which he performed the duties of treasurer, awaken our sincerest regrets at his loss, and entitle his memory to our lasting respect.

By the death of Professor David Page of Newcastle-on-Tyne, one of the most eminent names upon our roll of corresponding members has been struck off. A native of Scotland, his face was long familiar to us as a citizen of Edinburgh, as a lecturer, as a member of our scientific societies, until his removal to Newcastle to fill the Chair of Geology in the newly established College of Physical Science there. In the prime of life overtaken by a lingering malady, Dr Page devoted his time and applied his extensive stores of knowledge to the production of those clearly-written handbooks, which have made his name so widely known as a teacher of Geology, for many must be the students who, like myself, have derived their first notions of the science from his works.

It is now exactly twenty years ago since I first joined the Royal Physical Society of Edinburgh. I well remember the feelings of awe and reverence with which I first surveyed the circle of members sitting around the table in the old room at No. 6 York Place, among whom were many well-known naturalists now departed from us, such as Dr Strethill Wright, Mr Alexander Bryson, Mr Andrew Murray, Dr M'Bain, and Dr Coldstream; others I am glad to see are still with us, and taking an interest in the life and progress of the Society. In those days the Society was, intellectually at least, in a flourishing condition, for besides the honoured names which I have just mentioned as taking an active part in its proceedings, there still rested upon it the shadow and influence of two eminent men, whom it was never my good fortune to see, both having been called to their last resting-place shortly before my admission. These men were John Fleming and Hugh Miller.

Of Fleming's merits as a naturalist it is superfluous for me to speak. His name is known to every student, and will be ever remembered in the annals of British Natural History as that of one of the most eminent men of his time.

Among the many ways in which Science profited by the labours of Fleming was the interest which he took in palæontology, a branch of inquiry which at his time was much neglected in Scotland, and the collection of fossils which he left behind him contains a large number of original types, the value of which can only be properly appreciated by those who have themselves worked in this department. His contributions to carboniferous palæontology chiefly relate to invertebrate forms of life; but he was also one of the first to discover and to publish the occurrence of the remains of fishes in the Old Red Sandstone of Scotland.

And the enthusiasm of Hugh Miller as a collector, and his wonderfully vigorous and graphic style as a writer, have been in a very remarkable way the means of arousing an interest in these strange old fishes which inhabited the waters in which the Old Red Sandstone—so important an element in the geological structure of Scotland—was deposited.

Now, as it is my duty this evening to resign my position of president, to which you did me the honour three years ago to elect me, and in so doing to address you upon some topic connected with our scientific work, what better subject can I choose than the history of the progress of our knowledge of Scottish Fossil Ichthyology, a branch of study in which these two illustrious deceased members of our Society took so deep an interest?

A tolerably uninteresting subject withal, some may say, for the spell of the writings of Agassiz and of Hugh Miller seems to have died away, and the entire subject of fossil remains seems at present not to occupy a very exalted position in the estimation of the general public. The notion seems to be pretty extensively abroad that the study of fossils is merely the most uninteresting branch of *geology*, and that he who occupies himself with their investigation has no claim to the dignity either of the geologist or biologist, but is a mere "palæontologist," a paltry sort of creature, whose utmost function is to follow in the wake of the geologist, drawing up long lists of long names of things found in this stratum or in that, and whose work, after all, is of very doubtful value or importance. Moreover, it is extensively supposed that the appropriate place to bring forward a "palæontological" communication is the meeting room of a Geological Society, or section of a Society, not that of a Zoological or Botanical one.

True it is, that the study of organic remains affords most valuable assistance to the geologist in his investigations into the history of the earth's crust; true it is also, that the researches of the geologist reciprocally invest such studies with their crowning interest. But true it is, nevertheless, that genuine scientific palæontology is essentially a part of zoology or botany, as the case may be, and is no more a subordinate department of geology than are the sciences of physics, chemistry, mineralogy, or meteorology, or any other branch of knowledge which the geologist may call to his aid. The man, who satisfactorily investigates the structure, or determines the systematic position of a fish or reptile *preserved in stone*, is as much a zoologist as he who describes a similar creature *preserved in spirits*, though with this difference, that the former task is in some points rather the more difficult, seeing that we have only the hard parts to go upon, and these generally in a crushed, fragmentary, or scattered condition. And without a genuine interest in, as well as a thorough knowledge of recent biology, no one can hope to produce work of any value in palæontology. He can only blunder, or, at the best, become a mere manufacturer of so-called genera and species, and such blundering and manufacturing can only tend to bring his subject into disrepute, and to perpetuate that artificial separation between the study of recent and of fossil organisms which is so much to be deplored.

Viewed in this, as it seems to me, the only proper light, the study of organic remains becomes invested with intense interest. Wonderful indeed is the variety of strange and unaccustomed forms, now no longer living, which the rocks disclose to us. But more than this, if any further light is to be thrown upon the vexed question of Evolution, it is through palæontology, working hand in hand with recent morphology and embryology, that the light must come.

And to the student of vertebrate morphology no class can be of greater interest than that of fishes, and among these the strange forms which stand, as it were, on the confines of the type of the modern fish, and that of vertebrata higher in the scale, and which, represented in the present era only by a few isolated forms, attained an immense development in ancient periods of the world's history. And for the study of these, we may safely say that, on the whole, no country affords better opportunities than this northern division of our Island of Great Britain.

Although works containing notices of fossil fishes had appeared on the Continent as early as the fifteenth century, we find no mention of such remains in Scotland until David Ure, in his "History of Rutherglen and East Kilbride," which was published in 1793, figured, among other carboniferous fossils, several relics of the fishes of that epoch. These are mostly the teeth of *Selachii* or sharks, but there is also a figure representing what is most undoubtedly a portion of the mandible of the gigantic ganoid fish now known as *Rhizodus Hibberti.* In those days, however, there were very few people in Scotland who troubled themselves about fossils, and it was not until the end of the third and commencement of the fourth decades of the present century that its palæichthyological treasures began to attract any real attention.

In the year 1827 the Rev. Prof. Sedgwick and Mr, afterwards Sir Roderick, Murchison, who had been exploring the sedimentary rocks of the north of Scotland, despatched to Baron Cuvier, for his opinion, a number of fossil fishes which they had found in the dark schists of Caithness; other specimens they sent also to Messrs Valenciennes and Pentland. In 1828 the first-named gentlemen communicated the results of their labours to the Geological Society of London, in a paper entitled, "On the Structure and Relations of the Deposits contained between the Primary Rocks and the Oolitic Series in the North of Scotland," and in this paper they founded the genus *Dipterus,* giving excellent figures of four supposed species. Baron Cuvier's opinion regarding these fishes was to the effect that they were allied to the *Lepidosteus,* or bony pike of North America, and belonged, like it, to his division of *Malacopterygii abdominales.* The genus *Osteolepis* was also mentioned on the authority of Valenciennes and Pentland, and a figure is also given of what is apparently a plate of *Coccosteus,* but which the authors at the time considered as having belonged to a "tortoise nearly allied to Trionyx."

But in 1827 Dr Fleming had also obtained from the Upper Old Red Sandstone of Drumdryan, near Cupar, in Fifeshire, certain organic remains, of which in the same year he published a preliminary notice in a local newspaper. These were, in fact, the scales of the fish, which afterwards received the now well-known name of *Holoptychius.*

A year afterwards, scales and plates of fishes were found in the upper "Old Red" of Clashbennie, in Perthshire, and were by some, among whom, according to tradition, was no less a personage than Dr Anderson of Newburgh, at first considered to be *oyster shells!* But Fleming, who lost no time in going to see them, at once perceived their real nature, and accordingly prepared a short notice, "On the Occurrence of the Scales of Vertebrated Animals in the Old Red Sandstone of Fifeshire," which he read before the Wernerian Society of Edinburgh in May 1830, and which was published in the *Edinburgh Journal of Natural and Geographical Science* for February 1831. In this little paper, illustrated by a plate, the Clashbennie fossils are also noticed, and one of them, a portion of the body of a fish, was supposed by him to be "probably identical with the *Dipterus macropterygius* of Professor Sedgwick and Mr Murchison," but from the figure it is impossible to hazard a guess as to the genus to which it really belongs. Another (fig. 3), of which he says that, "in external appearance it bears a very close resemblance to some of the scales on the common sturgeon," looks like a plate of *Pterichthys major.*

Immediately after these beginnings were being made in opening out the rich storehouse of ancient fish-life contained in the Scottish Old Red Sandstone strata, the equally interesting treasures of the carboniferous rocks in the neighbourhood of Edinburgh had begun to attract notice. The greatest possible interest was excited among Edinburgh naturalists by Dr Samuel Hibbert's discovery of the fossiliferous nature of the limestone of Burdiehouse, a member of the Lower Carboniferous series, and the Royal Society of Edinburgh co-operated energetically with that gentleman in securing a large collection of the animal remains which it contained. These comprised not only entire specimens of numerous small fishes, but also large detached spines and scales, and, above all, enormous conical teeth, some of which attained a length of $3\frac{3}{4}$ inches, and a width of $1\frac{1}{2}$ inches at the base. These teeth were really identical with some which Ure had forty years previously recognised as belonging to a fish, but his figures had long since been forgotten, and it was therefore not astonishing that Dr Hibbert, whose practical knowledge as a zoologist was perhaps not quite equal to his enthusiasm as a collector, should have rushed to the conclusion that he had unearthed the remains of a huge *reptile.* One of these teeth was figured by Hibbert and considered as "Saurian," in a paper read by him before the Royal Society of Edinburgh on 17th February 1834.

The dawn of a new era in fossil ichthyology had already commenced, for in the year 1833 the first *Livraison* of Agassiz's "Recherches sur les Poissons Fossiles" was given to the world.

We have already seen that, long before the publication of Ure's "History of Rutherglen," fossil fish-remains had in other countries attracted attention, and as years passed on towards the period at which we have now arrived, a goodly array of continental writers had published accounts and figures of fossil fishes from various strata. Of these may be mentioned: Mylius, Knorr and Walchner, Wolfart, Scheuchzer, Volta, Bronn, Cuvier, and De Blainville; and a few also in England, such as Lhwyd, Mantell, and Sowerby, had made observations upon similar fossils which had come under their notice. Large collections, both public and private, had also been formed. But as yet no satisfactory basis had been found for the comparison of fossil with living forms, and the vast treasures which were to be added to our knowledge of the succession of ichthyic life on the globe were, it may be said, as yet entirely unknown. It was reserved for Agassiz to lay the first secure foundations for this knowledge, and to become, as he is so often and so worthily styled, the father of fossil ichthyology.

Upon the studies to which he now directed his attention, and which were so largely to contribute to his world-wide reputation, Agassiz brought to bear the indispensable qualifications of an intimate acquaintance with recent ichthyology as well as with zoology and comparative anatomy in general. And in pursuing his investigations into the ichthyology of bygone ages, he soon became aware that no satisfactory place could be found in the Cuvierian system of classification for an extensive array of extinct fishes, which prevailed especially during the great palæozoic and secondary epochs. They bore affinity both to the sturgeon, classed by Cuvier among the *Pisces cartilaginei*, and to the American *Lepidosteus* and African *Polypterus*, whose place was then considered to be in the Malacopterygian or soft-finned division of the *Pisces Ossei*. The point in their configuration, by which Agassiz was more especially struck, was their possession of strong, bony, and usually glistening scales, the last-mentioned peculiarity suggesting the term "ganoid," as expressive of their distinctive aspect. The study of these ancient "enamelled-scaled" fishes seems to have formed the spring to the conception of his new classification of fishes, according to their scales, into the four orders of *Ganoidei*, *Placoidei*, *Ctenoidei*, and *Cycloidei*. Working on the basis of this classification, he commenced the publication of his great work, and had already, as he tells us, become acquainted with six hundred species of fossil fishes, when, in 1834, he visited Great Britain for the first time, and his studies received a fresh impetus from the wealth of new forms which he found in English collections. In Scotland, too, collectors had been bestirring themselves, for besides what we have already noticed as having been done by Messrs Sedgwick and Murchison, and by Dr Hibbert and the Royal Society of Edinburgh, Professor Traill had made a valuable collection from the Old Red Sandstone of Orkney; Dr Knight of Aberdeen from the same formation at Gamrie; Lord Greenock had discovered the richness, in fish-remains, of the carboniferous shales at Wardie; and many Scottish specimens had also been collected by Professor Jameson, Mr Jamieson Torrie, Professor Buckland, and others.

The British Association met that year at Edinburgh, and on Wednesday, the 10th of September, Agassiz was introduced by Dr Buckland to the geological section immediately after Dr Hibbert had read a paper, in which he considered the gigantic teeth and bones found at Burdiehouse to "resemble those of Saurian reptiles." Their piscine nature was, however, at once detected by the accomplished Swiss naturalist, and the requisite material having been willingly handed over to him, he prepared and read on the following Friday a "Report on the Fossil Fishes of Scotland," in which several new genera are named. Most of the Scottish material obtained by Agassiz at this time was published in detail in the fasciculus of his great work, which appeared in 1835, the Devonian forms including. the genera *Cephalaspis*, *Acanthodes*, *Cheiracanthus*, *Cheirolepis*, *Dipterus*, and *Osteolepis*; while those from Carboniferous rocks were referred to *Amblypterus*, *Palæoniscus*, *Eurynotus*, *Pygopterus*, *Megalichthys*, *Gyracanthus*, *Tristichius*, *Ctenoptychius*, etc.

Agassiz revisited Scotland in 1842, and was present at the meeting of the British Association held that year at Glasgow. By this time the material for the further study and description of Scottish fossil fish-remains had vastly increased. Large collections from the Old Red Sandstone beds of Cromarty and Morayshire had been made by Hugh Miller, Dr Malcolmson, Lady Gordon-Cumming, and Mr Alexander Robertson. The collections of Lord Enniskillen and Sir Philip Grey-Egerton, which already, at the time of Agassiz's first visit to Great Britain, afforded a magnificent display of English and foreign species, now contained a choice selection also from Scotland. Carboniferous forms had also been assiduously collected by Dr Rankin of Carluke, and others. The large accession of material from the Old Red Sandstone enabled Agassiz in 1842 to lay before the British Association a "Report on the Fossil Fishes of the Devonian System," which finishes with a list of fifty-five species belonging to twenty genera.

His great work, the "Recherches sur les Poissons Fossiles" was completed in 1843, and in it was inserted a general list of all the fossil fishes which had till then come under his notice. Here we find ninety-nine species named from Scottish deposits, but, unfortunately, descriptions only of twenty-five were included in the text. The others he reserved for a projected series of supplementary monographs, of which only one ever appeared, namely, that on the fishes of the Old Red Sandstone, which was completed in 1846. In this work sixty-seven Scottish species are figured and described, and some improvements in classification effected by the establishment of the new families of *Cephalaspidæ*, *Acanthodidæ*, and *Saurodipterini*, the two former being dismembered from the old heterogeneous *Lepidoidei*, and the latter partly from the *Lepidoidei* and partly from the so-called *Sauroidei*.

But the undescribed carboniferous species enumerated in his larger work remained undescribed, and to many of these there is now no longer any clue. It is evident that in such cases, should the identity of any of them with species subsequently described under different names by other authors be satisfactorily proved, Agassiz's names can have no right to priority, but must be simply cancelled.

In offering a few words of comment upon the labours of Agassiz in this department, the highest tribute of honour must be paid to him for the position to which he raised the science of fossil ichthyology, as well as for the enormous amount of work which he accomplished in so short a time. Eminent as well in other branches of zoology, his name will go down to posterity as that of one of the greatest naturalists of the present century. To him we owe the establishment of the order of Ganoid fishes, the description of an enormous array of genera and species, and the first valuable generalisations as to the history and succession of ichthyic life on the globe. An opponent of the so-called vertebral theory of the skull, as held by Oken, and modified by Owen and others, as well as of the doctrine of descent, he nevertheless pointed out what, as Professor Marsh says, " is now thought to be one of the strongest points in favour of evolution," namely, the correspondence between the heterocercal character of the tail in the embryos of modern osseous fishes, and the prevalence of that form among the adult fishes of the older formations, stating, in fact, that " les poissons fossiles du vieux grès rouge répresentent réellement l'âge embryonique du règne des poissons." But it is hardly possible for the zoologist of the present day to suppress some feeling of wonder that a man, so well versed in general zoology and anatomy as Agassiz, should have based his classification of fishes upon characters so trivial as the mere external aspect of their scales, or that he should have distinguished many of the families into which he divided the order of Ganoids by characters equally superficial. We may quote, for instance, his inclusion among the Ganoids of the Pipe-fishes, Siluroids, Globe-fishes, and Trunk-fishes, merely on account of their bony scutes; the entirely artificial nature of the distinction which he drew between his Ganoid families of "Lepidoids" and "Sauroids," and the consequent utterly heterogeneous character of both; the similarly unsatisfactory nature of his family of *Cœlacanthi*, into which he even introduced the recent Teleostean *Arapaima*;—and so on. However, it is at the same time only natural that he should have been imperfectly acquainted with the anatomy of the ancient Ganoids, considering the as yet comparatively scanty material at his disposal, and it is also evident that, had he devoted more time to the elucidation of osteological detail, he could not possibly have gone over the same enormous amount of ground within so limited a period.

Agassiz's classification of fishes was at first eagerly accepted by geologists and others, largely on account of its supposed convenience. It could not, however, stand the test of anatomical inquiry, and was soon superseded by the system proposed by Johannes Müller in 1844, which, with various minor modifications, is the one still adhered to by most zoologists. Such, however, was the influence of Agassiz, and such the supposed "convenience" of his system, that we find it in use, especially amongst geologists and "palæontologists," years after Müller's great paper "Ueber den Bau und die Grenzen der Ganoiden" was published.

To us in Scotland, no fossil fish can be more interesting than that huge creature, whose laniary teeth, sometimes four or five inches in length, suggested the idea of a "Saurian reptile" to Dr Hibbert, when he first came upon the fossil riches of the Burdiehouse Limestone. We have seen that, at the meeting of the British Association in 1834, Agassiz dispelled the reptilian fancy concerning these remains, and on that occasion he also bestowed on this mighty fish the not inappropriate name of *Megalichthys Hibberti.* With its remains, however, those of a much smaller fish, with glossy angular scales, were at the time unfortunately confounded, but there can be no doubt that the name *Megalichthys* was suggested by the large teeth, and properly belonged to their possessor. Nevertheless, some time afterwards, on visiting Leeds, and finding in the Museum there the head of an example of the *smaller* fish, Agassiz described and figured *it* in a subsequent number of the "Poissons Fossiles" as *Megalichthys Hibberti,* while for the real and original *Megalichthys,* along with some Old Red species he founded the genus *Holoptychius.* Professor Owen, however, in his well-known work, "Odontography" (1840-45), elevated the Carboniferous "*Holoptychius*" *Hibberti* into the new genus *Rhizodus,* giving also many important details regarding the microscopic structure of the teeth. The claims of *Rhizodus* to generic distinction were stoutly disputed by Agassiz in his work on the fishes of the Old Red Sandstone. Subsequent investigation has, however, not only proved the validity of *Rhizodus* as a genus, but also that it cannot even be included in the same family with *Holoptychius.*

In the same work ("Odontography") Professor Owen described the remarkable microscopic structure of the conical teeth from the Old Red Sandstone of Morayshire, to which he gave the name of *Dendrodus.*

The next writer on Scottish fossil fishes who claims our attention is our own countryman, Hugh Miller. We all know the wonderful history of this remarkable man; how that, born of humble parents, educated at a village school, and entering upon life first as a quarryman, then as a stonemason, he finally became the editor of an Edinburgh newspaper, and one of the most eloquent writers of the English language that Scotland has produced. The attention of his leisure moments was early drawn to Natural History, and his wonder and interest being excited by the rich deposits of fossils, both Jurassic and Old Red, which he found near his native place of Cromarty, he in time amassed a magnificent collection both from these deposits and from the Carboniferous rocks of the neighbourhood of Edinburgh, which is now safely housed in our Museum of Science and Art. To fishes Hugh Miller devoted his chief attention, and his collection of Old Red forms furnished many of the types described and figured by Agassiz in his "Monographie des Poissons Fossiles du Vieux Grès Rouge," and many were also figured by himself in his own works.

Hugh Miller's fame, however, rests considerably more upon his literary than upon his purely scientific achievements, and he did much more for the progress of fossil ichthyology by the interest which his wonderfully graphic powers of popular exposition excited in the subject, than by original research of a technical character. Yet what he did accomplish in the latter direction shows that he had all the eye, the tastes, and the instincts of the true scientific man, and we can hardly suppress a sigh of regret, when we think what Hugh Miller *might* have done, had he had a professional education from the beginning, and had he been able to devote his life to the prosecution of original research, while steering clear of the troubled waters of ecclesiastical controversy.

Among such of Hugh Miller's works as deal principally with geological and palæontological science, beyond a doubt his healthiest and happiest effort is the "Old Red Sandstone," also one of his earliest (1841). Amidst the fascinating popular descriptions of the scenery, geological structure, and fossil fishes of the region, in which he first wrought as a geologist, we find some genuine touches of original palæontological observation, which quite sufficiently indicate what his powers in that direction might have been, had they been properly developed. We find, for instance, that he was quite aware that *Cheirolepis* was not an Acanthodian, though it was classed by Agassiz in that family. We find a very creditable restoration of *Osteolepis*, infinitely superior to that given by Agassiz some years afterwards, and hardly inferior to that given by the accomplished Pander; and we find him correctly interpreting as the *ventral* surface of *Pterichthys* that aspect of the creature erroneously represented by Agassiz as the dorsal. In his "Footprints of the Creator," published in 1849, he also showed that Agassiz's *Polyphractus*, supposed by him to be a genus allied to *Pterichthys*, was nothing more than the cranial shield of a *Dipterus*, and we find chronicled his discovery of the dentition of *Dipterus*, which, with the structure of the palatal aspect of the skull, here also beautifully figured, afterwards proved of such importance in determining the affinity of that genus to the recent *Dipnoi*. Many important original observations and figures are here also given regarding the cranial osteology of *Osteolepis* and *Diplopterus*, as well as of the gigantic *Asterolepis*, though, misled by Agassiz, he did not recognise the affinity of the latter genus to *Coccosteus*, though he described one of its median dorsal plates as "hyoid," and though he also attributed to it the scales, teeth, and jaws of a large *Glyptolepis*, a fish belonging to a totally different family. The work was, however, mainly written as a counterblast to the well-known publication, the "Vestiges of Creation," and is almost entirely occupied with a fierce denunciation of the doctrine of Evolution. Bitter and impassioned indeed are the words with which the volume concludes. The doctrine of Evolution was at that time, however, still in its crude Lamarckian stage. What would poor Hugh Miller have thought, we may imagine, had he lived to the present day when the genius of Darwin has given to the theory of Descent an entirely new impulse and aspect, and has totally revolutionised all our ideas as to zoological classification and morphology!

We may now pass to the consideration of what was done by Professor M'Coy while engaged in naming and describing the palæozoic fossils of the Woodwardian Museum at Cambridge, among which were a considerable number of Scottish fossil fish-remains, principally from the Old Red Flags of Orkney. Professor M'Coy's work among these, published in the "Annals and Magazine of Natural History" for 1848, is more of a systematic than anatomical character; he assiduously set himself to work in naming and describing genera and species, but it is greatly to be feared that the enormous field over which his other palæontological researches extended had not afforded him the time and opportunity to acquire the necessary experience in deciphering fish-remains, without which the liability to error is not only natural but imminent. He did not seem, for instance, to realise the extreme caution which should be exercised in accepting proportional measurements as specific characters in the case of palæozoic fishes; how different specimens of the very same species may be distorted, squeezed up, or lengthened out into forms apparently the most diverse; and how that different modes of preservation, different degrees of perfection of specimens, afford room for the occurrence of fallacies in observation, the avoidance of which requires all the acuteness which a practised eye can muster. Hence it is to be feared that some of M'Coy's genera, and many of his species of Ganoids at least, must fall to the ground. For instance, regarding the genus *Triplopterus,* said to differ from *Osteolepis* by having only one dorsal fin, I can, from examination of the original specimen, fully confirm the suspicion expressed by Pander that it is only an *Osteolepis* compressed from above downwards so as to exhibit both ventral fins, one of which was interpreted by M'Coy as the single dorsal and its fellow as the opposed anal fin!

To M'Coy we owe, however, the separation of the true *Cephalaspidæ* from the other fishes, *Pterichthys* and *Coccosteus,* with which Agassiz had associated them, and the establishment of the latter as a group by themselves under the name of *Placodermata.* And to him we also owe the term "diphycercal," applied to that form of fish-tail in which the vertebral axis is, as in the heterocercal form, gradually attenuated, but runs straight backwards instead of turning up, and the fin-rays being developed equally, or nearly so, above and below, a more or less rhombic and symmetrical form of caudal fin is produced.

Regarding the diphycercal tail of *Diplopterus,* he remarks,—"Those who think the theory of 'progressive development' worth refuting, may be glad to find that some of the oldest known perfect remains of fishes have not exclusively heterocercal embryonic types of tail as was hitherto supposed." Here, in the first place, we are, I think, justified in altogether objecting to the spirit in which this remark is made. It is the truth, and nothing but the truth, which the true man of science is "glad to find," not merely the corroboration of some pet preconceived idea of his own. In the second place, our author was completely out of his reckoning. The diphycercal tail is in reality a *more primitive or embryonic* form than even the heterocercal, of which the modern homocercal tail is again a further specialisation. That this is the case is evident enough to any one who will carefully compare a proper series of tails of recent and fossil fishes, but Professor Alexander Agassiz has recently put the matter in a perfectly clear and unmistakable light by showing that the tail in embryo *Pleuronectidæ* is first diphycercal (leptocardial), then heterocercal, and finally assumes the homocercal form of the adult in which the heterocercy becomes to external appearance completely obliterated.

At this stage of our sketch of the history of Scottish Fossil Ichthyology, it will be appropriate to refer to what has been done by Sir Philip Grey-Egerton, glad as we all are that the veteran naturalist is still living amongst us, and continuing to take the warmest interest in the progress of the science to which he has himself contributed so much.

Sir Philip has not in his writings sought to alter the classification of Agassiz save in one or two points of secondary importance, but he has busied himself with the description of new genera and species, so largely supplied by his own magnificent collection as well as by that of his close personal friend, the Earl of Enniskillen, to whom also the friends of fossil ichthyology owe a lasting debt of gratitude. Although Sir Philip's descriptions mainly relate to fishes from the newer formations in England, he has also made some important contributions to our knowledge of Scottish forms. In his paper on *Pterichthys* (1848), written in conjunction with Hugh Miller, he corrected some of the mistakes into which Agassiz had fallen with regard to the arrangement of the plates in that genus. In another communication, "On the Nomenclature of the Devonian Fishes," he offered some able criticisms on Professor M'Coy's work in that department, and added as a supplement a series of interesting extracts from letters by Hugh Miller on the structure of *Coccosteus.* The tenth decade of the Geological Survey, published in 1861, contains also from Sir Philip's pen a description of *Tristichopterus alatus,* one of Mr Peach's most interesting discoveries in the Old Red Sandstone of John o'Groats, as well as of several beautiful little Acanthodian fishes, two from Caithness, also discovered by Mr Peach, and others from the grey beds of Forfarshire, brought to light by several industrious Forfarshire collectors, among whom were the Rev. Hugh Mitchell, the Rev. Henry Brewster, Mr Walter M'Nicol, and Mr Powrie of Reswallie, of whom more anon. To Scottish carboniferous ichthyology Sir Philip Grey-Egerton also contributed descriptions of two new selachian species, *Ctenacanthus hybodoides* and *C. nodosus;* and his paper on the probable identity of Agassiz's genera, *Pleuracanthus* and *Diplodus,* is also of equal importance to the investigator of the fossil contents of the Scottish as of the English coal measures.

A third great era in the history of palæozoic ichthyology may be said to have commenced with the publication of the researches of the distinguished Russian naturalist, Dr Christian Heinrich Pander. With his first great work, the "Monographie der Fossilen Fische des Silurischen Systems des Russisch-baltischen Gouvernements," published in 1856, we have here nothing to do, save to remark that if the singular little tooth-like bodies, known as "conodonts," be in reality what many at the present day suppose them to be, namely, the teeth of Myxinoid fishes, then we shall have abundant evidence of the prevalence of these lowly organised fishes far back in Lower Silurian times. It is his three subsequent publications, on the "Placodermi," on the "Ctenodipterini," and on the "Saurodipterini, etc.," appearing respectively in 1857, 1858, and 1860, which attract our attention, dealing as they do with the fishes of the Old Red Sandstone, and very largely with Scottish specimens. Fish remains are of frequent occurrence in the Old Red Sandstone of Russia; many had been previously described by Eichwald as far back as 1839, as well as by Agassiz in his Monograph of the fishes of the Old Red Sandstone. These remains are, however, mostly very fragmentary; to read them aright, comparison with more entire fishes was necessary, and this want was supplied by the liberality and enthusiasm of a member of the Russian Academy, Herr von Hamel, who undertook a journey to Scotland, and, having collected a large number of specimens both in Caithness and in Orkney, packed them in barrels, and shipped them off bodily to St Petersburg. There they were placed at Pander's disposal for description, and the results are embodied in the three works last quoted. In these works Pander does not concern himself very much with species, but in one case, that of *Pterichthys*, he maintained that Agassiz and Eichwald together had upon its fragmentary remains constructed certainly not less than fourteen genera, and that five others probably belonged to the same category. British palæontologists have, however, not yet accepted his views as to the necessity for cancelling the name *Pterichthys*, on the ground that the fragments previously named *Asterolepis* by Eichwald in reality belonged to the *Pterichthys* of Agassiz, and that consequently the name *Homosteus* of Asmuss must be substituted for *Asterolepis* of Agassiz and Hugh Miller. The question is certainly a very difficult and delicate one, owing to the very fragmentary nature of the remains from which Eichwald took his descriptions and figures. The main feature in Pander's work was his elucidation of structure, and his clear insight into the fact that only by careful and laborious investigation into the structural features of the skeleton, external and internal, can we hope to determine the natural affinities of fossil fishes. Here his achievements surpassed all that had been previously done in palæozoic ichthyology. The structure of the *Placodermata* (*Pterichthys*, *Coccosteus*, *Asterolepis*, *Heterosteus*) is minutely described and illustrated, as also of the *Saurodipterini* (*Osteolepis*, *Diplopterus*). A like treatment is accorded to *Dipterus*, for which he institutes the family *Ctenodipterini*, in which he also provisionally includes *Ceratodus*, then only known as a mesozoic fossil, and to *Cheirolepis*, which he also erects into a distinct family, fully corroborating the views of Hugh Miller and of Giebel as to its place not being among the *Acanthodei*, as Agassiz had imagined, as well as indicating that he was not unaware of its resemblance to *Palæoniscus*. The singularly beautiful and complicated microscopic structure of the Old Red Sandstone teeth, so well known as *Dendrodus*, *Lamnodus*, etc., is minutely described and magnificently delineated, but we shall see that he was not quite so successful in his conception of his family of "Dendrodonts," from which he excluded *Holoptychius* and *Glyptolepis,* making the latter indeed into the type of yet another distinct family.

From his elaborate and truly scientific researches, Pander derived one interesting generalisation, which presently rose to extreme importance. Johannes Müller had long before shown that the recent *Lepidosteus* and *Polypterus,* classed together by Agassiz in one family, that of the so-called *Sauroidei,* were representatives of totally distinct groups of Ganoids; but among all the fossil fishes of the order, he could for *Polypterus* find no ally. Pander, however, pointed out that, far from *Polypterus* having no ally in past ages, it is to it rather than to *Lepidosteus* that the affinities of many of the Old Red Sandstone Ganoids point, and more especially those of the group known as *Saurodipterini.*

The researches of Pander were soon afterwards brilliantly followed up by the publication, in 1861, of Professor Huxley's masterly "Essay on the Systematic Arrangement of the Fishes of the Devonian Epoch." Huxley had already, in 1858, published observations on the genera *Cephalaspis* and *Pteraspis,* and the Rev. Dr Anderson's "Monograph" of the Yellow Sandstone of Dura Den and "its remarkable fossil remains," which appeared in 1857, is rescued from oblivion and contempt by its including descriptions, furnished by Huxley, of the new genera *Glyptolæmus* and *Phaneropleuron,* with observations on the genus *Holoptychius.* The study of these interesting forms led Professor Huxley to re-examine the whole subject of the classification of the Ganoids, and especially of those of the Old Red Sandstone, and his results appeared in the essay above quoted, which forms part of the Tenth "Decade" of the Geological Survey.

Pander, we have seen, noticed the fact that many of the Old Red Sandstone Ganoids were more allied to *Polypterus* than to *Lepidosteus.* Huxley, proceeding farther in the same direction, instituted the sub-order *Crossopterygidæ,* of which *Polypterus* and *Calamoichthys* are the sole living representatives, but which in palæozoic times included an extensive assemblage of forms, collectively equivalent to Agassiz's *Cœlacanthi* and *Saurodip-*

terini. The heterogeneous nature of Agassiz's "*Cœlacanthi*" was pointed out, and the term very properly limited to the peculiar genera *Cœlacanthus, Undina, Holophagus,* and *Macropoma,* none of which are, however, found in the Old Red Sandstone. The remaining Agassizian cœlacanths (*Holoptychius, Glyptolepis,* etc.) were placed in a new family, that of the *Glyptodipterini,* and here are also included forms both with rounded and rhombic scales. Pander's family of "Dendrodonts" he will not have, considering it extremely probable that *Dendrodus* and its allies will turn out to be the teeth of fishes belonging to the *Glyptodipterini.* But the Russian author's family of *Ctenodipterini* and Agassiz's *Saurodipterini* are retained and likewise placed in the Crossopterygian sub-order, which lastly includes also the *Phaneropleurini,* constituted by the singular genus *Phaneropleuron.*

The next important point in Professor Huxley's "Essay" is the attention which he drew to the singular ties which connect the recent genus *Lepidosiren* (the Australian *Ceratodus* being at that time still undiscovered) with the cycloidal-scaled members of the *Crossopterygidæ.* And although he was not fully aware of the extreme closeness of the relationship between the recent Sirenoids and one of his Crossopterygian families, the *Ctenodipterini,* he, nevertheless, touched the spring which subsequently disclosed to us the true position of that family, when he compared the teeth of *Lepidosiren* with those of *Dipterus.*

On the other hand the American bony pike or *Lepidosteus* is made the living type of another great assemblage, of which the Old Red Sandstone genus *Cheirolepis* "ought perhaps to be regarded as the earliest known form." To this sub-order of *Lepidosteidæ* merely a passing and imperfect notice is accorded, but it is nevertheless clear that the author means it to embrace both the heterocercal *Palæoniscidæ* of the Upper Palæozoic rocks, and that great array of semi-heterocercal rhombic scaled forms (*Lepidotus, Dapedius, Pholidophorus,* etc.), which in mesozoic times constituted the great bulk of the Ganoid Order.

These two great sub-orders of *Crossopterygidæ* and *Lepi-*

dosteidæ, with the addition of the recent *Amiadæ,* are equivalent to Johannes Müller's *Ganoidei Holostei.* The other sub-order of the Berlin anatomist, that of the *Chondrostei* or Sturgeons, was accepted, and to it the remarkable Old Red family of *Cephalaspidæ* was referred, provisionally at least; while into a fifth sub-order was erected the problematic group of *Acanthodidæ,* which, in their organisation, seem to combine so many of the characters both of Ganoids and of Sharks.

Undoubtedly, the weakest point in Professor Huxley's "Essay" is the attempt which he made to show, by comparison of the exoskeletal plates of *Coccosteus* with the bones visible on the exterior of the skeleton of many recent Siluroids, that there was a possibility at least of the enigmatical group of *Placodermata* turning out to belong to the great order of *Teleostei,* or ordinary bony fishes, "hitherto supposed to be entirely absent from formations of Palæozoic age." Recent discoveries in the Palæozoic rocks of America point, as we shall presently see, to another, and perhaps more probable solution of the question.

The Twelfth Decade of the Geological Survey, published in 1866, contains a description, by Professor Huxley, of a beautiful specimen of the Glyptodipterine *Glyptopomus minor* from the Old Red of Elgin, and also an exposition of the structure of the family *Cœlacanthidæ* as restricted in the celebrated "Essay." Though the descriptions of *Cœlacanthidæ* are taken from English specimens of the family from the carboniferous to the chalk inclusive, they are equally important as regards Scottish fossil ichthyology, as the remains of the type-genus *Cœlacanthus* are of frequent occurrence in the Carboniferous rocks of the northern part of our island.

Professor Huxley's writings on fossil fishes supply us indeed with a pattern of the method and spirit in which such investigations should be conducted. Few in number as they are, they have nevertheless contributed more to the real scientific advancement of palæozoic ichthyology than the works of any other living author.

I have already mentioned the name of Mr Powrie of Reswallie in connection with the beautiful Acanthodian fishes from Forfarshire, figured by Sir Philip Grey-Egerton in the

Tenth Decade. Mr Powrie has also himself contributed several papers on the fishes of these beds, and to him we owe the definition of the genus *Euacanthus*, comprising four species, and also of a new species of *Parexus*.

The remarkable group of *Cephalaspidæ*, so characteristic of the Old Red Sandstone in particular localities, has been ably monographed by Professor E. Ray Lankester, whose work, in two parts, appeared in the volumes of the Palæontographical Society for 1868 and 1870.

The true affinities of the Old Red Sandstone genus *Dipterus*, and the carboniferous *Ctenodus*, foreshadowed by Professor Huxley in 1861, were thoroughly cleared up by the discovery of the living *Ceratodus Forsteri* in the rivers of Queensland. The *Ctenododipterini* were definitely placed among the *Dipnoi* by Dr Günther in his account of the structure of *Ceratodus* (*Phil. Trans.*, 1871), and subsequent observation has amply confirmed the correctness of his views on this point.

The discovery in the Devonian rocks of North America of the gigantic Placoderm, named by Professor Newberry *Dinichthys*, seems at last to throw some light on the position of that remarkable group of extinct fishes. In *Dinichthys* we have a form, apparently closely allied to *Coccosteus*, but also possessed of a dentition in many respects resembling that of the recent *Lepidosiren*. It seems, therefore, not unlikely that the *Placodermata* will eventually turn out to have been an aberrant group of loricated *Dipnoi*.

Recent progress with regard to the structure and affinities of Scottish Carboniferous fishes is so inseparably connected with the study of the fishes of the same great period in England, that here the sister kingdoms cannot easily be treated separately, except as regards local and stratigraphical lists of genera and species. Descriptive papers dealing with English specimens are of equal importance to the student resident in Scotland. Scottish fossil ichthyology is therefore equally indebted to Professor Young for his descriptions (published in 1866) of the remarkable Platysomid genera *Amphicentrum* (= *Cheirodus*, M'Coy) and *Mesolepis*, as well as of the little *Platysomus parvulus*, a species named but not described by Agassiz, as all of them occur in the Scottish coal measures, although Professor Young's descriptions were taken from the more perfect examples furnished by the North Staffordshire district. Professor Young, in the same paper, also correctly pointed out the affinity to *Mesolepis*, and consequently also to *Platysomus*, of our well-known Scottish Lower Carboniferous genus *Eurynotus*, but I fear we cannot accept his sub-order *Lepidopleuridæ*, in which he sought to include both the Platysomid and Pycnodont fishes. His paper on "Carboniferous Glyptodipterines" (*Rhizodopsis*, *Rhizodus*, etc.), also published in 1866, deals largely with Scottish specimens, and with forms which constantly come under the notice of the Scottish collector. Professor Young has given, besides, several other notices of fish remains from the Carboniferous rocks of the West of Scotland, as has also Mr James Thomson, of Glasgow, among whose contributions may be specially mentioned his description and figure of an enormous *Acanthodes* from the Palace Craig Ironstone of Lanarkshire. Of purely local work, a very creditable example, though requiring some revision, is the list of carboniferous fishes in the "Catalogue of the Western Scottish Fossils," compiled by Messrs Young and Armstrong, published first in the *Transactions* of the Geological Society of Glasgow, and afterwards issued as one of the "British Association Guide Books" on the occasion of the meeting of that body at Glasgow in 1876.

I cannot conclude this part of our subject without alluding to the great services which have accrued to Scottish fossil ichthyology by the singular abilities, as an observer and collector, of our genial friend Mr C. W. Peach. Mr Peach's keen eye has, in whatever part of the country he has been located, been always on the outlook for something new in Natural History, whether recent or fossil; and in the case of fossil fishes it has not looked in vain. To him we owe the discovery of the Old Red forms *Tristichopterus alatus*, *Pterichthys Dickii*, *Acanthodes Peachii*, *Acanthodes coriaceus;* and the large collections which he made in various parts of Caithness, selections from which occupy important places in many of our museums, afford valuable material for the study of the structure, species, and distribution of the Old Red fishes of the north of Scotland.

To the late Mr Robert Dick, of Thurso, Hugh Miller was indebted for many of his most valuable specimens from the Caithness Flags, and these, along with the others which passed into the possession of the late Mr John Miller, are, I am glad to say, safely under cover in the Museum of Science and Art.

Here we must for the present take leave of our subject. Much remains still to be done both as regards general research into the structure and classification of palæozoic fishes, and as regards the rectification of species, and the compiling of reliable catalogues of those which occur as well in Scotland as in other divisions of our common country of Great Britain. The work must, however, necessarily be slow, as nothing is more injurious to the cause of palæontology than undue haste, whether in descriptive work or in attempted generalisation.

I fear I have wearied you out with long names and tiresome abstracts and lists of what to most people are very dry and technical works. But my task is accomplished if I have succeeded in clearly laying before you the facts that Scotland presents an unrivalled field for the study of palæozoic ichthyology, and that the study of Scottish fossil fishes has, in former days at least, occupied the attention of men of eminence and power. And more especially, I have tried to impress upon you that palæontology, however intimately connected with geology, is neither a part of geology nor a science by itself, but is simply a part of biology, and that the study of fossil organisms must always be thoroughly unsatisfactory unless they are dealt with according to the same method as recent ones, and by men of the same biological training.

I. *On the Occurrence of a Small Naticiform Gasteropod, showing Colour-Bands, in the Cement Stone Group of Fifeshire.* By R. ETHERIDGE, Jun., Esq., President. [Plate III.]

(Read 21st January 1880.)

Introduction.—In a paper on the "Invertebrate Fauna of the Wardie Shales,"* I described, amongst other fossils, a

* Quart. Jour. Geol. Soc., Lond., xxxiv., p. 18.

small Gasteropod found at Drumsheugh, near Dean Bridge, by Mr Gall, and previously to this at Raw Camps Quarry, by Mr J. Bennie, and to which I gave the name of *Littorina Scotoburdigalensis.* Mr Gall's specimens, lent to me through Mr John Henderson, were clear of the matrix, but not in a good state of preservation, and only enabled me to draw up the very meagre description referred to above, and which still left much to be desired. Those found by Mr Bennie constituted a band of thin, shelly limestone at the base of the Burdiehouse Limestone at Raw Camps Quarry, and locally known as "Buckie-fake." As may be supposed from the nature of the rock, specimens suitable for description were almost unobtainable, but Mr Bennie was fortunate enough to find one or two specimens of what appeared to be the same shell in the black shale connected with the shelly limestone. It was upon this material that my previous description was drawn up. The occurrence of this little shell in beds which had previously proved, comparatively speaking, so unproductive of Molluscan life, was a point of much interest.

The great augmentation which has taken place within the last three or four years in the number of recorded species of Invertebrata from the Lower Carboniferous rocks of Scotland is almost entirely due to the careful and painstaking researches of Messrs James Bennie and John Henderson, who have conjointly brought to light a by no means inconsiderable fauna from what were before considered barren and unprofitable rocks. In fact, it may be said, that with the exception of the late Mr Salter's investigations, since the days of Fleming, Hibbert, and Rhind, little had been done towards an elucidation of the invertebrate denizens of the old seas in which those beds were accumulated, until Messrs Bennie and Henderson commenced their labours. Under these circumstances, it may well be imagined with what pleasure I have from time to time examined their gatherings. Mr Bennie has lately forwarded me many examples of a small shell, from Craigkelly, apparently identical with that met with at Drumsheugh and Raw Camps, and rendered all the more interesting by the preservation of its colour-bands. In addition to this, Mr Bennie has obtained a specimen direct from a mass of decomposed "buckie-fake," so that we now have much more satisfactory material for placing this little Gasteropod on a firm basis. The material thus to hand is briefly this:

a. Specimens from the Shale in connection with the Shelly Limestone at Raw Camps Quarry, Collection of the Geological Survey of Scotland—Mr Bennie.

b. Specimens from Shale of the Wardie Series at Drumsheugh, in the collection of Mr Gall.

c. Specimens from the Shale of Craigkelly Quarry, obtained by Mr Bennie.

d. A specimen and portions of others from decomposed Shelly Limestone at Raw Camps Quarry—Mr Bennie.

Description of the Specimens.—When first described, these little shells were, as before stated, referred to the genus *Littorina.* After a lengthened and careful consideration of them, and comparison with many genera both of recent and extinct Mollusca, I have come to the conclusion they must be referred to a separate genus, allied to *Platyostoma* (Conrad), a genus met with in the Silurian and Devonian rocks of the United States, and for which I propose the slightly distinctive name of *Platyostomella.* Reasons for this step will be given subsequently. I shall in the first place give the generic and specific characters and observations thereon, and afterwards pass on to a consideration of the generic affinities.

GENUS PLATYOSTOMA—*Conrad.*

(Jour. Acad. Nat. Sciences, Philadelphia, viii., p. 275.)

SUB-GENUS PLATYOSTOMELLA, *s-gen. nov.*

Char.—Shell dextral globoso-naticiform; spire low; body whirl much expanded; aperture rotund-ovate, or transversely-broad-oval; outer lip thickened and inner reflected; the former rounded, with its upper portion almost at right angles to the inner or collumellar lip, which is remarkably straight, direct, prominent, and pronounced, sometimes so far reflected as to form a small callosity, but plain, never twisted or plaited. Umbilicus probably present. Surface marked with fine microscopic striæ of growth.

Platyostomella Scotoburdigalensis—*Etheridge, Jun.*
[Pl. III., Figs. 1-9.]

Littorina Scotoburdigalensis. Eth. Jun., Quart. Jour. Geol. Soc., 1878, xxxiv., p. 18, Pl. II., Figs. 26, 27.

Sp. Char.—Shell small, thin, and naticiform in shape, of from 3½ to 4 whirls, the last or body whirl being large and far exceeding the united measurements of the others; spire short and more or less depressed, but not flattened. Each whirl is somewhat flattened above, near its union with the preceding whirl, the line of separation, or suture, being well marked, and to some extent channelled, the larger the specimens the more marked the channelling; body whirl inflated and somewhat prolonged in the direction of its growth. Aperture vertically-round-oval, higher than wide; outer lip thickened and erect; inner lip reflected, to a greater or less extent, over the nearly straight pillar to form a flattened callosity. The surface is ornamented with the finest possible sharp, thread-like, close, uninterrupted, oblique striæ, with longitudinal, or transverse bands of colour.

Obs.—The channelling of the suture is seen in a more pronounced form only in the larger specimens, but in some of the latter it is particularly well marked (Pl. III., Fig. 1), in others it is not more than ordinarily so. The spire varies in height to some extent; in certain individuals it is depressed, giving to the shell quite a *neritina*-like aspect, in others it is more elevated and distinct. This is more particularly the case with those specimens obtained from the "Buckie-fake," although both forms are present amongst the examples from Fifeshire. The thread-like lines of growth which cross the whirls obliquely, are, as a rule, very finely preserved (Pl. III., Fig. 9), but occasionally they are only to be seen on the shoulder of each whirl just below the suture; this is a very characteristic feature of the genus *Naticopsis*. The callosity is of variable extent and development. In some examples the reflection of the inner lip hardly amounts to this character, being merely a thickening (Pl. III., Fig. 7); in others, on the contrary, there is a decided spreading outwards (Pl. III., Fig. 7*a*). In a few of those with the callosity little developed, and in some young specimens, I believe I can detect a small umbilicus; but when the inner lip is at all reflected, the shell is to all intents and purposes non-umbilicate.

Not the least interesting feature about these little shells is the retention of the bands of colour. This phenomenon is occasionally met with in Carboniferous Mollusca, more particularly those from the Derbyshire Limestones. It has been noticed in some forms of *Terebratula*, *Lingula*, and *Aviculopecten*, and in some Gasteropoda. In the present instance the bands of colour are displayed after two different patterns, horizontal and vertical to the longer axis of the shell, and always confined to the body whirl. The horizontal bands are two in number in every case (Pl. III., Figs. 4 and 5), one occupying the periphery, or most prominent point of the whirl (Pl. III., Fig. 4), the other much lower down towards the base (Pl. III., Fig. 5). These bands are of variable width, in some cases broad, and occupying nearly the whole of the whirl, in others quite narrow, linear, and far apart. In the second variety the colour bands are much more numerous, and more or less vertical to the longer axis, *i.e.*, they follow and coincide with the thread-like lines of growth.

Even amongst this latter form of the Craigkelly univalve variation is likewise apparent. In one specimen the bands of colour are numerous (Pl. III., Fig. 1), in others less so (Pl. III., Fig. 3), and further apart; in one placed at equal distances apart, in another arranged in contiguous pairs (Pl. III., Fig. 2), with a wide interspace separating them; lastly, the bands are either direct, or zig-zag (Pl. III., Fig. 6), and in some instances broken or interrupted in their course over the body whirl. In no case have both vertical and horizontal bands been observed in the same specimen.

Generic Affinities.—We may now pass on to consider the affinities of these remarkable little shells. In the first place, some writers might possibly be induced to separate the shell from Raw Camps, from that found at the Craigkelly Quarry, on the strength of the somewhat higher spire of the former variety; but when we consider to how great a length variation undoubtedly goes in some of the commoner Mollusca of our shores at the present day, I think the little fossils from these localities may be allowed to remain as one and the same.

In the globular form, depressed spire, ventricose body whirl, and thick reflected inner lip these shells more or less resemble the genus *Ampullaria;* or so far as the form is concerned, they are not unlike some *Neritinæ.* If, however, our shells possess an umbilicus they cannot be referable to either of these genera, to say nothing of the internal absorption seen in *Neritina,* and of which we here know nothing, or of the denticulated inner lip of the latter genus, which is certainly not present in our little fossils.

The globular few-whirled form and small spire equally relate them to *Natica* as to *Ampullaria,* and they further agree with the former in the callous inner lip, covering and obliterating the umbilicus, if it existed. There is, however, a group of Palæozoic shells, British and North American, consisting of the genera *Naticopsis* (M'Coy), *Platyostoma* (Conrad), and *Strophostylus* (Hall), all closely united, with many characters in common, so that it is at times difficult to separate them, but still, when a series of individuals are collected, it is at once seen that they distribute themselves in these groups, more or less separated by distinctive characters. The abbreviated descriptions of these genera, taken from their respective authors, are as follows:

Genus *Naticopsis* (M'Coy, 1844).—Globose elliptical shells, with a small spire of few convex whirls; a large, broad, ovate aperture, rounded in front. The columella is thick, callous, flattened, and either plain or obliquely striated. (?) Umbilicus present and small. Operculum concentric, and non-spiral.

Genus *Platyostoma* (Conrad).—Globose shells with low spires; aperture very large, sub-orbicular, and dilated. Outer and inner, or columellar lip, thickened and reflected; last volution, or whirl, much expanded.

Genus *Strophostylus* (Hall, 1879).*—Sub- (or ovoid) globose shells with low spires, and a large ventricose body whirl; aperture round-ovate, or transversely broad-oval; outer lip

* Pal., N. York, iii., p. 303.

thin, not reflected; columellar or inner lip not reflected, but twisted or spirally grooved within. Umbilicus none.

Naticopsis, according to the original description,* differs from the typical *Natica*, in the absence of an umbilicus, and in the presence of a peculiar operculum and flattened columella. In an amended description,† published in 1853, Professor M'Coy modified his previous definition by stating that a "minute umbilicus only visible in the casts" existed. Practically, this reduces the dissimilarity between *Natica* and *Naticopsis* to the presence of the concentric instead of spiral operculum of the former, and the flattened columella. My own impression is that Professor M'Coy is right in both his descriptions; in other words, in young forms of *Naticopsis*, or perhaps even in some species, the umbilicus may be visible; in others, on the contrary, hid by the inner lip, which is usually reflected to a greater or less extent.

Writing still more recently, the eminent American Palæontologists, Messrs Meek and Worthen, point out ‡ that, whether *Naticopsis* be umbilicate or not, its separation from *Natica* is ensured by the condition of the operculum. In the latter it has a spiral structure, but in *Naticopsis* the operculum according to the above authorities is thick and shelly, oval or subcircular in form, with a lateral or sub-marginal nucleus, and shows not the slightest traces of the spiral or sub-spiral structure, and articulating projection of the *Neritidæ*. On the inner side the operculum of *Naticopsis* shows a distinct uniform scar of attachment, and on the outside the fine, but distinctly concentric, lines of growth. The Geological collection of the British Museum contains a very fine example of *Naticopsis elliptica* (Phill. *sp.* ?), with the operculum in place, and I am able in consequence to confirm many of the preceding observations made by Meek and Worthen. As before stated, the little shells now under consideration were formerly referred by me to the genus *Littorina*, but from wretched materials. A study of Mr Bennie's recent gatherings, which I be-

* Synop. Carb. Lime Foss., Ireland, 1844, p. 33.

† Brit. Pal. Foss., pp. 301 and 543.

‡ Illinois Geol. Survey Report, ii., p. 364.

lieve to be identical with the above, lead me to believe them distinct from *Naticopsis,* and for these reasons—the inner lip is not reflected to the same extent as in *Naticopsis.* In no single instance have I seen it plaited, or striated, and the remarkably straight, continuous, and direct course it pursues is so very unlike the callous, reflecting, corresponding structure in M'Coy's genus, that I do not see how our little shell could be considered as congeneric with its species. The umbilicus being a debatable point, it is perhaps better at present not to refer to it as a means of comparison. One point of resemblance exists with *Naticopsis,* in the stronger form of the fine striæ immediately around the suture, and also with some species of the genus, in the deep channelling of the latter.

In washing the shale in which *P. Scotoburdigalensis* occurs, Mr Bennie endeavoured to obtain traces of opercula, but I am sorry to say without success. The acquisition of this structure would go far towards proving, or on the other hand disproving, the view of its affinity now advocated.

Another point which presents itself is—does the condition under which *P. Scotoburdigalensis* is met with at Raw Camps and Craigkelly represent the mature or immature form? I think the well-defined mouth, thickened outer, and reflected inner lip can point only to one conclusion—that the shells are mature. This is, in a great measure, borne out by the great quantity in which the shell is found, and in no case at these localities exceeding a certain size, although in itself very small.

From *Strophostylus* (Hall), the little shells I have termed *Platyostomella,* are distinguished at once by the reflected lip, both inner and outer, and by the absence of twisting or spiral-grooving on the former. The general form is, to some extent, similar, as, indeed, it is in the whole of this group, *Naticopsis, Strophostylus,* and *Platyostoma.* Again, if an umbilicus exists in *Platyostomella,* there is still here a further departure from *Strophostylus,* as Professor Hall distinctly says there is none in the latter.

The resemblance to *Platyostoma,* on the other hand, is very marked, especially in the form of the mouth, reflected or thickened lips in particular, and the almost at right-angles-position of the upper portion of the outer lip in regard to the longer axis of the shell. In contrast to this, is the much more prominent, outstanding, and longer inner lip, giving to the aperture a somewhat more angular appearance. Lastly, there is no evidence of an umbilicus in *Platyostoma*, which, if it exists in *Platyostomella*, as I suspect it does, will form a further point of divergence. To express the general resemblance to Conrad's genus, and, at the same the trivial differences, I have proposed the name here used.

Loc. and Horizon.—Raw Camps Quarry, near Midcalder, in a bed of shelly limestone, known as "Buckie-fake," at the base of the Burdiehouse or Queensferry Limestone (*Mr J. Bennie*); Drumsheugh, near Dean Bridge, Edinburgh, in shale (?) (*Mr Gall*); Craigkelly Quarry, near Burntisland, in shale associated with *Spirortis pusillus* (Martin); Entromostraca, and fragmentary bivalves (*Mr J. Bennie*), where it occurs in thousands. The little bivalve is an aviculiform shell, but I have not seen sufficiently well preserved specimens to venture on a description.

At a point on the Fife coast, near Fifeness, a bed of limy-shale occurs in the Lower Carboniferous, or Calciferous Sandstone series, which there constitute the coast line, crammed with a form of *Naticopsis* in almost as great a profusion as the *Platyostomella* is to be found at Craigkelly. The following is a description of this shell:

Genus Naticopsis—*M'Coy*, 1844.

(Synop. Carb. Lime Foss., Ireland, p. 33; Brit. Pal. Foss., fas. 3, pp. 301 and 543.)

Naticopsis, sp. ind. (Pl. III., Figs. 10-12).

Sp. Char.—Shell, in general form, more or less oval, globose, with little or no obliquity, of four or five convex whirls. Body whirl convex, inflated, greatly exceeding the other combined whirls in size, which form a short but well-marked spire. The upper part of the body whirl, or that next the suture horizontally flattened to a greater or less extent, producing a shoulder-like appearance. Suture, especially that between the two last whirls, well marked and channelled rather deeply; mouth irregularly oval, longer than wide; outer lip sharp and erect; inner lip thickened, and reflected over the body whirl to form a more or less developed, elongated callosity, without platings or other markings. Surface usually plain, but in some specimens finely striated over the whole surface, especially that of the last, or body whirl. Umbilicus, no distinct trace.

Obs.—This little shell, of which the largest specimens before me measure about three and a quarter lines in length, has many points in common with a much larger species of the genus, *Naticopsis plicistria* (Phillips),* with the type specimens of which I have carefully compared it. So much so is this the case, that I hesitate to apply to the present shell a distinctive name, although the two forms are in all probability distinct, and it is difficult to consider one which does not increase beyond the size mentioned above, so far as the specimens show, identical with one assuming gigantic proportions in comparison, an average size of *N. plicistria* being one inch seven lines long.

The two shells resemble one another in the great disproportion of the body whirl to the others, it being in each case many times larger, in the shoulder-like form of the upper part of the body whirl, in the deep channelled condition of the sutures, and in the form of the mouth. On the other hand, they differ in the great inequality of the size, in the generally more oblique form of *N. plicistria,* in the more pronounced and larger spire of the Fifeness specimens in proportion to the total size of the entire shell in each case, and in the absence on the columellar lip of the latter of the oblique striæ or ridges seen in *N. plicistria.*

It will be better to avoid giving this shell any definite name at present, but in the event of its proving distinct both from *N. plicistria* and the other described forms of *Naticopsis,* it may perhaps be called *N. communis.*

Loc. and Horizon.—Shore near Fifeness, N.E. coast of Fife; in the Calciferous Sandstone or Lower Carboniferous series—Coll. Geol. Survey, Scotland, and Mus. Pract. Geol., collected by the late Mr R. Gibbs.

* Geol. Yorkshire, p. 225, t. 14, f. 25.

Description of Plate III.

Platyostomella Scotoburdigalensis.

Fig. 1. An example seen from above, showing the deeply channelled suture of the body whirl, and the single, equidistant, vertical colour-bands. Fig. 1*a*. The same specimen, seen from the side. Craigkelly Quarry.

Fig. 2. Another specimen, seen from above, in which the colour-bands are arranged in pairs. Craigkelly Quarry.

Fig. 3. A very small individual, in which the colour-bands are less in number and further apart. Craigkelly Quarry.

Fig. 4. An example of the second variety, seen rather obliquely from the side, with one transverse colour-band exposed to view. Craigkelly Quarry.

Fig. 5. Another similar specimen, seen more from the side, and somewhat from below, with two colour-bands visible. Craigkelly Quarry.

Fig. 6. A further specimen of the vertically-banded variety, in which the bands of colour are to some extent zig-zag. Craigkelly Quarry.

Fig. 7. An example without colour-bands retained, seen from in-front, exposing the mouth, with the reflected margins of the lips, and the straight, strong, inner, or columellar lip. Fig. 7*a*. Another example, in which the mouth is somewhat imperfect, but the reflection of the inner lip is well shown. Craigkelly Quarry.

Fig. 8. One of the original specimens from the shale associated with the "Buckie-fake" of Raw Camps Quarry, near Midcalder, without colour-bands. Fig. 8*a*. Mouth of the same.

Fig. 9. A specimen in which the fine microscopic striæ are seen to advantage. Craigkelly Quarry.

Naticopsis, sp. ind.

Fig. 10. A specimen, seen from the back. Fifeness.

Fig. 11. The largest example observed, showing the mouth, with its sharp outer lip, and reflected inner lip. Fifeness.

Fig. 12. Another and somewhat more elongated example. The short spire is well seen in both Figs. 11 and 12.

(The Figs. 1-9 are multiplied ten diameters; the size of Figs. 10-12 is shown by the indicators. The whole of the originals are in the collection of the Geological Survey of Scotland; those of Figs. 1-9 were collected by Mr James Bennie; and those of Figs. 10-12 by the late Mr Richard Gibbs.)

II. *The Algæ of the Firth of Forth.* By George William Traill, Esq. (Communicated by Professor Duns.)

(Read 17th December 1879.)

In submitting to the Royal Physical Society of Edinburgh the following list of the Algæ of the Firth of Forth, I bear in mind that the district has been worked in former years by such distinguished naturalists and successful collectors as

Lightfoot ("Flora Scotica," 1789), Greville ("Flora Edinensis," 1824, and "Algæ Britannicæ," 1830), M'Bain (see List of Algæ in "East Neuk of Fife," 1st edition, 1862), Sir J. Richardson, Arnott, Hassall, and others. On consulting these and other sources of information on the subject, however, I find that little appears to have been done in particularising the localities where many of the rarer species are obtained; and since these are, for the most part, described so vaguely as to afford but little help to other collectors, it has been my endeavour to remedy this by going over the ground afresh, and stating the localities as explicitly as possible. A number of new species and many good localities are also now for the first time recorded, so that it is hoped the list may be found of service to those studying the Algæ of the Firth of Forth.

The classification adopted is that of the late Professor Harvey, as modified and improved by Professor Agardh of Sweden.

CHLOROSPERMEÆ.

Order CONFERVACEÆ.

Cladophora rupestris, . . . Common, between tide marks.

" *laetevirens*, . . . Rocks to the east of Lady's Tower, Elie; fine at Chapelness, Earlsferry (*G. W. T.*); fine at Prestonpans (*G. W. T.*), between tide marks.

" *refracta*, . . . Rocks to the east of Lady's Tower, Elie; very fine at Kincraig pools, Earlsferry, near low water (*G. W. T.*).

" *albida*, . . . Elie (*M'Bain*).

" *lanosa*, . . . Black Rocks, Leith, on *Furcellaria fastigiata* (*Arnott* and *Greville*); Longniddry Point, parasitic on *Polyides lumbricalis* and on some of the smaller algæ (*G. W. T.*); Elie, at the Lady's Tower, etc., near low water.

Cladophora uncialis, . . Lady's Tower, Elie (*M'Bain*), and Fish Rock, Earlsferry (*G. W. T.*), on the surface of flat rocks, near low water; abundant.

„ *arcta*, . . . Rarely, and of small size, in pools, near low water, at Lady's Tower, Elie (*M'Bain* and *G. W. T.*).

„ *glaucescens*, . . Do., do.

Chætomorpha ærea, . . . Elie (*M'Bain*).

„ *implexa*, . . Caroline Park Rocks, near Edinburgh, in Spring, intimately attached to tufts of *Sphacelaria cirrhosa* (*Greville*); Elie (*M'Bain*).

„ *tortuosa*, . . Black Rocks, Leith (*Arnott* and *Greville*); Elie (*M'Bain* and *G. W. T.*); very fine and large at Rudden's Point, east of Largo Bay, in shallow pools, at half tide, July 1879 (*G. W. T.*); Longniddry, common (*G. W. T.*).

„ *melagonium*, Elie; Kincraig, Earlsferry, fine and common in rock pools, at low water (*G. W. T.*); Joppa, in pools, at low water (*G. W. T.*).

Order OSCILLATORIACEÆ.

Calothrix confervicola, . . Common in Autumn on small algæ, between tide marks.

Order SIPHONACEÆ.

Bryopsis plumosa, . . . Joppa pools (original locality); abundant in shallow pools between Levenhall and Drummore (*G. W. T.*); common and fine in shallow pools at Prestonpans (*G. W. T.*); very fine and abundant in shallow pools, from half tide to low water, at Longniddry Point (*G. W. T.*); pools "beyond Kincraig" (*M'Bain*); pools at M'Duff's Cave (*G. W. T.*).

Bryopsis hypnoides, . . . At Prestonpans, on the authority of the late *Dr Hassall*, but the species seems now to have disappeared. Plants somewhat resembling *Bryopsis hypnoides* are found at Prestonpans, Drummore, and Joppa, but are referred by competent authorities to delicate forms of *Bryopsis plumosa* (*G. W. T.*, 1879).

Order ULVACEÆ.

Porphyra laciniata, . . . Common, between tide marks.

„ *vulgaris*, . . . Common at many places, such as Joppa pools.

Ulva latissima, ... Common.

„ *lactuca*, ... Elie; west of Kincraig, Earlsferry, where there is a fresh-water stream (*G. W. T.*); sometimes at the fresh-water stream at Joppa (*G. W. T.*); at Longniddry (*G. W. T.*); at the three last localities at half tide.

„ *linza*, ... Pools at Caroline Park Rocks (*Greville*); fine at the Joppa pools (*G. W. T.*); Elie (*M'Bain*), at about half tide.

Enteromorpha compressa, . Common.

Enteromorpha intestinalis,	Common, chiefly where fresh-water streams run into the sea.
„ *erecta,* . .	Firth of Forth, not infrequent, as at Burntisland, in rock pools (*Greville*); Lady's Tower, Elie (*G. W. T.*), at about half tide.
Bangia fusca-purpureo, .	Burntisland Pier (*Arnott*).

MELANOSPERMEÆ.

Order CHORDARIACEÆ.

Chordaria flagelliformis, .	Common, between tide marks.
Elachista fucicola, . . .	On *Fucus serratus* and *vesiculosus,* common.
„ *flaccida,* . . .	Frequent, chiefly on *Fucus nodosus* and *vesiculosus* (*Gre ville*).
„ *scutulata,* . . .	Not uncommon on *Himanthalia lorea,* Elie (*M'Bain* and *G. W. T.*).
Leathesia tuberiformis, . .	Common at Longniddry, Kincraig, etc., from half tide to low water.
Mesogloia virescens, . . .	Common at the Elie district, especially in pools midway between Lady's Tower and St Monance, at half tide, 1879 (*G. W. T.*).
„ *vermicularis,* . .	Elie, but much less frequent than the above.
Ralfsia verrucosa, . . .	Common, between tide marks.

Order DICTYOTACEÆ.

Asperococcus echinatus, . .	Near Pettycur and Kirkcaldy (*Greville*); abundant in shallow pools, near high water, at Chapelness, Earlsferry, usually parasitic on *Cladophora*

rupestris, and having *Myriotrichia filiformis* as a parasite; fine in July 1879 (*G. W. T.*). In shallow pools at the west side of the Lady's Tower, Elie.

Asperococcus, var. *vermicularis*, Associated with the above at Chapelness (*G. W. T.*).

Dictyota dichotoma, . . . In rock pools, Black Rocks, Leith, and Newhaven (*Lightfoot*); Aberdour (*Greville*); near low water, Elie (*M'Bain*).

Dictyosiphon fœniculaceus, Common, Joppa, etc., in rock pools, at about half tide—sometimes parasitical on other algæ.

Litosiphon pusillus, . . . On old fronds of *Chorda filum*, Elie, rare.

" *laminariæ*, . . Firth of Forth (*Arnott*); near Burntisland, on *Punctaria plantaginea* (*Greville*); on *Alaria* fronds and frondlets, fine, Lady's Tower, Elie, and Chapelness pools, Earlsferry (*G. W. T.*).

Punctaria plantaginea, . . Caroline Park, not common (*Greville*); Elie (*M'Bain*); Earlsferry, to the east of Kincraig, in shallow sandy pools, from half tide to low water (*G. W. T.*).

Taonia atomaria, . . . A single specimen in *rejectamenta*, near Portobello (*Greville*).

Order Ectocarpaceæ.

Cladostephus verticillatus, . In rock pools (*Lightfoot*); pools, Lady's Tower, rare (*M'Bain*).

" *spongiosus*, . Caroline Park (*Richardson*); near Newhaven and near

	Kirkcaldy (*Greville*); abundant at Longniddry, on rocks, near low water (*G. W. T.*).
Chætopteris plumosa,* . .	Firth of Forth (*Richardson* and *Greville*); Joppa (*Rev. D. Landsborough, jun.*, about 1848), where it is still found fine in muddy pools, at low tides; Caroline Park Rocks, in muddy pools, at low water (*G. W. T.*); Longniddry (*G. W. T.*); fine and abundant in a clear pool in a creek, in the shade, at M'Duff's Cave, near Earlsferry (*G. W. T.*); cast ashore, Elie (*M'Bain*).
Ectocarpus siliculosus, . .	Near Caroline Park (*Greville*); Joppa, Longniddry, Lady's Tower, Elie, etc., in pools.
„ *tomentosus*, . .	Not uncommon on algæ, chiefly on *Fucus vesiculosus.*
„ *littoralis*,. . .	Common on fuci between tide marks.
„ *granulosus*, . .	Kincraig, Earlsferry, July 1879, stunted (*G. W. T.*); Caroline Park Rocks, August 1879, stunted (*G. W. T.*); Joppa, September 1879, good (*G. W. T.*); Drummore Rocks, September 1879, good (*G. W. T.*)—in each case in fruit, and growing on the rock, in pools, near low water; *first time recorded.*
„ *sphærophorus*, .	Rarely on *Polysiphonia nigres-*

* Since the above was written, the fruit of this species, new to Britain, has been discovered by G. W. Traill on Firth of Forth plants. *Plurilocular sporangia* on long pedicels in December, and *unilocular sporangia* in abundance in January and February 1880.

cens, Lady's Tower, Elie (*M'Bain*); common, and in fruit, in July 1879, on *Ptilota elegans,* at Lady's Tower (*G. W. T.*).

Myriotrichia filiformis, . . Parasitic on *Asperococcus echinatus,* in clear shallow pools, near high water, W.S.W. of M'Duff's Chapel, Earlsferry, common in July 1879 (*G. W. T.*); in shallow pools at the west side of the Lady's Tower, near high water, on *Asperococcus echinatus,* but not common (*G. W. T.*); occasionally at Joppa on *Chorda lomentaria* (*G. W. T.*); *first time recorded.*

Sphacelaria scoparia, . . Firth of Forth (*Greville*); not frequent.

" *cirrhosa,* . . Not uncommon in the Firth of Forth (*Greville*); Elie (*M'Bain*); Kincraig pools, Earlsferry, especially in a creek near M'Duff's Cave, parasitic on *Chætopteris plumosa* (*G. W. T.*).

" *radicans,* . . Black Rocks, Leith (*Arnott* and *Greville*); at Caroline Park Rocks and at Joppa, in some abundance, at both places on muddy sandstone, at low tides (*G. W. T.*).

" *racemosa,* . . Found by *Sir J. Richardson* in fruit in February 1821, on rocks opposite Caroline Park, but this species, though repeatedly searched for, has eluded the vigilance of subsequent collectors of the Firth of Forth Algæ.

Order FUCACEÆ.

Cystoseira granulata, . .	About Leith and Newhaven (*Yalden*), but never found since the time of *Lightfoot.*
Fucodium canaliculatum, .	Common, between high water and half tide.
„ *nodosum*, . . .	Do., do.
Fucus vesiculosus, . . .	Common, between tide marks.
„ *ceranoides*, ...	Near Cramond (*Maughan*).
„ *serratus*, ...	Common, at half tide.
Halidrys siliquosa, . . .	Not uncommon at many places; abundant at Earlsferry; stunted variety at Caroline Park Rocks at half tide.
Himanthalia lorea, . . .	Common at rocky exposed places, such as Lady's Tower, Elie, near low water.

Order LAMINARIACEÆ.

Alaria esculenta, ...	Exposed places at low water. Common at the Elie district.
Chorda filum, ...	Common, chiefly in quiet sandy bays.
„ *tomentosa*, . . .	Cast ashore in some abundance from deep water some 300 or 400 yards E.S.E. of M'Duff's Cave, Earlsferry, July 1879 (*G. W. T.*); *first time recorded.*
„ *lomentaria*, . . .	Common in tide pools.
Laminaria digitata, . . .	Common on rocks at low water and in deep water.
„ *saccharina*, . .	Do., do.
„ *phyllitis*, . .	Not uncommon at many places; usually abundant in Spring in the Joppa pools at low water (*G. W. T.*).
„ *fascia*, . . .	Joppa pools, at half tide, early Summer (*G. W. T.*); *first time recorded.*

Sacchorhiza bulbosa, . . Exposed places, at low water, such as Kincraig, but not common.

Order SPOROCHNACEÆ.

Arthrocladia villosa, . . Found by *Dr Hassall* only "near Prestonpans."

Desmarestia ligulata, . . At Newhaven, but not common (*Lightfoot*); Caroline Park Rocks (*Maughan*), but at both places in *rejectamenta*.

" *aculeata*, . . Seafield Rocks, Fife (*Greville*); cast ashore, Elie (*M'Bain*); growing in pools in fine large bushy plants, at the low water of spring tides, 200 or 300 yards E.S.E. of M'Duff's Cave, Earlsferry, 1879 (*G. W. T.*).

" *viridis*, . . . Near Caroline Park Rocks (*Richardson*); Seafield Rocks, Fife, and near Dysart, Fife (*Greville*); cast ashore, Elie (*M'Bain*); growing in fine large bushy plants associated with *D. aculeata* at Earlsferry as above, 1879 (*G. W. T.*).

Sporochnus pedunculatus, . Found on fishermens' nets at Prestonpans by the late *Dr Hassall*.

RHODOSPERMEÆ.

Order CERAMIACEÆ.

Callithamnion plumula, . Opposite Caroline Park (*Richardson*); rarely at Joppa and Elie, at both places of small size, near low water.

" *Turneri*, . Elie (*M'Bain*); on *Polyides lumbricalis* and other small algæ, near low water, at Kincraig, Earlsferry (*G. W. T.*).

" *arbuscula*, . Firth of Forth (*Arnott* and

Greville); opposite Caroline Park (*Richardson*); Joppa, Elie, etc., not uncommon; very fine, and in fine fruit of both kinds, in the shade, on reefs near low water, below South Street, Elie, September 1879 (*G. W. T.*).

Callithamnion Brodiæi, . On reefs at low water, in the shade, at Earlsferry, to the east of the Fish Rock (*G. W. T.*); in fine fruit September 1879; *first time recorded.*

" *Hookeri*, . Joppa, on mud-covered rocks at half tide; Kincraig, Earlsferry; very abundant and fine at Lady's Tower, Elie.

" *roseum*, . . Joppa and Caroline Park Rocks (*Richardson*); at Kincraig, near Earlsferry, chiefly in a creek near M'Duff's Cave, in the shade, not uncommon (*G. W. T.*).

" *polyspermum*, Elie (*M'Bain*); Kincraig, Earlsferry (*G. W. T.*); Largo Pier (*Dr Landsborough*); Joppa and Caroline Park Rocks at half tide, in the shade (*G. W. T.*).

" *granulatum*, Largo Pier (*Dr Landsborough*).

" *Rothii*, . . Abundant on the large stones under the woodwork of Leith Pier (*Greville*, 1824); on the east side of the East Pier, Leith, between high water and half tide, but not abundant in 1879; abundant at Joppa, on rocks, near high water (*G. W. T.*); Caroline Park Rocks (*Richardson*); in caves at Kincraig, Earlsferry (*M'Bain*).

Callithamnion Daviesii, .	Elie (*M'Bain*).
" *virgatulum*,	(*Secundatum Ag.*). Common on *Rhodymenia palmata*, near low water, at Lady's Tower, Elie (*G. W. T.*); *first time recorded.*
Ceramium rubrum, . . .	Common, between tide marks, on rocks, and on small algæ.
" *Deslongchampsii*,	Firth of Forth (*Greville*); Joppa (*G. W. T.*); plentiful at Longniddry (*G. W. T.*); Kincraig, Earlsferry (*G. W. T.*); plentiful on *Ptilota elegans* at the east side of the Lady's Tower, Elie (*G. W. T.*), from half tide to low water.
" *diaphanum*, .	Not uncommon on rocks and small algæ between tide marks.
" *fastigiatum*, .	Firth of Forth (*Greville*); Joppa (*Rev. D. Landsborough, jun.*).
" *flabelligerum*, .	Joppa, Longniddry, Elie, etc., not uncommon in pools at about half tide (*G. W. T.*); *first time recorded.*
" *ciliatum*, . .	Opposite Caroline Park (*Richardson*); Elie (*M'Bain*), on rocks at the pier.
" *acanthonotum*, .	Joppa; fine at Longniddry (*G. W. T.*); Elie (*M'Bain*); common at Kincraig, Earlsferry (*G. W. T.*); not uncommon in the Firth of Forth generally, on rocks from half tide to low water.
Corynospora pedicellata, .	At Joppa in a pool, in fine fruit, November 1848 (*Rev. D. Landsborough, jun.*).
Griffithsia corallina, . .	Dredged, Elie (*M'Bain*).
" *setacea*, . . .	Cast ashore, Elie (*M'Bain*); growing in pools off Earlsferry

	Links at the low water of spring tides (*G. W. T.*); common at Longniddry (*G. W. T.*); at Joppa, but of small size, on rocks at low tides (*G. W. T.*).
Halurus equisetifolius, . .	Found by *Mr Yalden* about 1770 (*Lightfoot*); but never since met with.
Ptilota plumosa, ...	On *Laminaria digitata*, but seldom of large size in the Firth of Forth, though very large and fine at Dunbar.
„ *elegans*, ...	Fine at Lady's Tower, Elie, from half tide to low water, on perpendicular sides of rocks, shaded by fuci (*G. W. T.*).

Order CHONDRIEÆ.

Polyides lumbricalis, . .	Caroline Park Rocks (*Maughan*); near Kirkcaldy (*Stewart* and *Greville*); Elie; Fish Rock, Earlsferry, at low water (*G. W. T.*).
Lomentaria articulata, . .	Not uncommon on rocks near low water at rocky coasts, such as Elie, etc.; on rocks and fuci at Longniddry (*G. W. T.*).
„ *kaliformis*, . .	Cast ashore at Largo (*M'Bain*).
Laurencia pinnatifida, . .	Not uncommon between tide marks at exposed places, but generally small.
„ *hybrida*, . . .	At Joppa, Caroline Park, etc., above half tide, not uncommon (*G. W. T.*).
„ *obtusa*, . . .	Firth of Forth, very rare (*Greville*).

Order CORALLINACEÆ.

Corallina officinalis, . . .	Common in rock pools, between tide marks.

Jania rubens, ...	Elie (*M'Bain*), on algæ between tide marks.
Melobesia polymorpha, . .	Common.
,, *pustulata,* . . .	On *Gigartina mamillosa*, Joppa (*G. W. T.*).

Order CRYPTONEMIACEÆ.

Ahnfeldtia plicata, . . .	Chiefly on the Fife coast (*Greville*); Lady's Tower, Elie; Longniddry Point (*G. W. T.*); at the two last places in sandy pools at low water; Caroline Park Rocks.
Callophyllis laciniata, . .	Elie on *Laminariæ;* in *rejectamenta*, Firth of Forth (*Greville*).
Catenella opuntia, . . .	Caroline Park (*Greville*); Kincraig Caves (*M'Bain*), but stunted; near Musselburgh (*Lightfoot*); abundant on a long reef at Longniddry at about high-water mark, on the shady parts of the reef, 1879 (*G. W. T.*).
Chondrus crispus, . . .	Common on rocks at low water.
Chylocladia clavellosa, . .	Caroline Park (*Greville*); Elie (*M'Bain*); growing on sandy rocks near the limit of the low water of spring tides between Kincraig and Chapelness, Earlsferry (*G. W. T.*).
Cystoclonium purpurascens,	Between Newhaven and Caroline Park (*Greville*); common at the Elie district; chiefly in rock pools from half tide to low water.
,, var. *cirrhosa,*	Characteristic at Kincraig, Earlsferry; in rock pools near low water (*G. W. T.*).
Dumontia filiformis, . .	Common from half tide to low water.

Dumontia filiformis, var. *crispata*, At Joppa at half tide, where a fresh-water stream enters the sea.

Furcellaria fastigiata, . . Common, Elie, etc.; chiefly in sandy pools near low water.

Gigartina mamillosa, . . Common on rocks at low water.

Gloiosiphonia capillaris, . In a pool W.S.W. of M'Duff's Chapel, Earlsferry, near low water (*G. W. T.*); in pools at low water some 250 yards E.S.E. of M'Duff's Cave, Kincraig, 1879 (*G. W. T.*); also washed ashore there; *first time recorded.*

Phyllophora rubens, . . . Dredged in the Firth of Forth (*Greville*).

" *membranifolia*, Firth of Forth, frequent (*Greville*); between tide marks, Elie (*M'Bain*).

" *Brodiæi*, . . Joppa (*Sir J. Richardson*); near Caroline Park (*Stewart*); Black Rocks, Leith (*Greville*); Fish Rock, Earlsferry, 1879 (*G. W. T.*); Longniddry (*G. W. T.*); in sandy pools at low water at the two last-noted localities.

Schizymenia edulis, . . . Black Rocks, Leith (*Sir J. E. Smith*); at low tides among the large stones between Newhaven and Caroline Park (*Greville*); near the Lady's Tower, Elie (*M'Bain*); common at the Fish Rock, Earlsferry, and uncovered at low tides (*G. W. T.*); very large in creeks at Kincraig (*G. W. T.*), but nearly always submerged.

Order GELIDIACEÆ.

Gelidium corneum, var. *Clavatum*, Caroline Park Rocks (*Richardson*).

Order RHODOMELACEÆ.

Dasya coccinea, ... Near Kirkcaldy (*Greville*); at Elie, on *Laminaria* roots; rather rare (*M'Bain* and *G. W. T.*).

Odonthalia dentata, . . . Growing abundantly between Burntisland and Starley Burn (*Greville*); Elie (*M'Bain*); growing at Joppa at low water of spring tides, and sometimes cast ashore there from deep water in abundance (*G. W. T.*).

Polysiphonia urceolata,. . Seafield Rocks, Fife (*Greville*); Chapelness, Earlsferry, common (*G. W. T.*); Elie (*M'Bain*); Caroline Park Rocks (*G. W. T.*); Joppa (*G. W. T.*), near low water.

„ *fibrata*, . . Common at Earlsferry and Elie, especially at Chapelness and Lady's Tower, in shallow pools from half tide to low water, August and September.

„ *elongella*, . . Earlsferry and Elie, near low water; rather rare.

„ *elongata*, . . Caroline Park (*Richardson*); near Kirkcaldy (*Greville*), in both cases among *rejectamenta*; Elie (*M'Bain*); at Kincraig, Earlsferry, chiefly on stones and old shells, and seldom between tide marks, in fine fruit of both kinds, in July 1879 (*G. W. T.*).

Polysiphonia violacea, . .	Not uncommon in shallow sandy pools, near low water, to the east of the Fish Rock, Earlsferry (*G. W. T.*), in fruit in August; Elie, east of the Lady's Tower.
" *Brodiæi*, . .	Elie, at the Lady's Tower; fine in pools at Kincraig, at low water, at the basaltic columns, July 1879 (*G. W. T.*); fronds 7 or 8 inches long.
" *nigrescens*, .	Common in pools between tide marks.
" *atro-rubescens*,	Wardie (*Richardson*); Caroline Park (*Greville*); Elie (*M'Bain*); common and fine on sand-covered rocks at the low water of spring tides, opposite Earlsferry Links, 1879 (*G. W. T.*); fronds 6 inches long.
" *fastigiata*, .	Common on *Fucus nodosus*, between high water and half tide.
" *parasitica*, .	At Newhaven, on the larger marine plants, rare (*Richardson*); on *Melobesia*, at low water, rare, Elie, and cast ashore there.
" *byssoides*, . .	Opposite Seafield Baths, on the larger algæ, very rare (*Richardson*); cast ashore at Earlsferry, attached to shells, in July 1877 (*G. W. T.*).
Rhodomela lycopodioides, .	Opposite Seafield Tower, Fife (*Greville*); not uncommon on *Laminaria* stalks, Earlsferry, etc., cast ashore from deep water.
" *subfusca*, . . .	Common in pools, especially at Caroline Park Rocks, in March.

Order Rhodymeniaceæ.

Euthora cristata, ... Only one specimen among *rejectamenta*, July 1823 (*Greville*).

Maugeria sanguinea, . . Fine at Lady's Tower, Elie (*M'Bain*); common at the Fish Rock, Earlsferry, dry at low tides, underneath shelving rocks (*G. W. T.*); Longniddry (*G. W. T.*); cast ashore at Joppa.

Plocamium coccineum, . . Common at Earlsferry, etc.; narrow variety at the Black Rocks, Leith.

Rhodymenia palmata, . . Common.

Rhodophyllis bifida, . . . On algæ, Elie (*M'Bain*).

Order Sphærococcoideæ.

Delesseria sinuosa, . . . Elie; Joppa, in one pool only, annually, at half tide, underneath a boulder (*G. W. T.*); Black Rocks, Leith, etc.

" *alata*, ... Common at many places on rocks and algæ, at low water.

" *hypoglossum*, . . Near Caroline Park Rocks (*Richardson*); opposite Seafield Baths, very rare (*Greville*); occasionally parasitic on *Odonthalia dentata*, at Joppa (*G. W. T.*); near Lady's Tower, Elie (*M'Bain*).

Nitophyllum laceratum, . Firth of Forth (*Lightfoot*); rarely in *rejectamenta* (*Mrs Martin; Greville*); Elie, cast ashore on *Laminaria digitata*, but rare.

" *punctatum*, . Among *rejectamenta*, Firth of Forth, very rare (*Greville*); on algæ, Lady's Tower, Elie (*M'Bain*); on *Desmarestia aculeata*, at Longniddry, 1879 (*G. W. T.*).

Order SQUAMARIÆ.

Cruoria pellita, ... On stems of *Laminaria digitata* and on stones, Earlsferry (*G. W. T.*); *first time recorded.*

III. *On the Distribution of the Goosander* (Mergus merganser) *in Scotland during the Breeding Season.* By J. HAMILTON BUCHANAN, Esq.

(Read 17th December 1879.)

The goosander (*Mergus merganser*) is a well-known bird in Northern Europe, and is met with in many counties in England as a regular winter visitant.

In Scotland, it is, perhaps, more widely and abundantly distributed; and of late years it has been known to remain and breed in some of the more remote parts of the country. So far as one can judge, it appears to be extending its breeding range southwards. Mr John Macgillivray found it breeding, in 1840, near Loch Maddy, from whence Dr Dewar obtained a nest of eggs in 1858. Mr Gray, in his "Birds of the West of Scotland," seems to have no doubt of the fact of the breeding of the goosander in North Uist; but Mr Harvie-Brown, who has visited the locality, does not consider it properly authenticated, nor the ground the least likely to harbour the birds in the breeding season. In the "Birds of the West of Scotland," page 403, Mr Gray, in referring to Dr Dewar's nest, writes as follows: "One of the eggs taken at that time is in my possession; it is larger than a merganser's egg, cream coloured, slightly darker in shade, and easily recognised when placed in a group of eggs belonging to the common species." Mr Harvie-Brown, on the other hand, who has seen the eggs taken by Dr Dewar, is of the opinion that they are those of the red-breasted merganser.

The goosander makes a deep, well built, and spacious nest, generally in the hole of a decayed tree. It is composed almost entirely of the bird's own soft down, placed upon a substratum of small chips and pieces of the decayed wood of the tree in which the nest is situated. It is sometimes placed on the ground under the shelter of the forking roots of trees, or on a sloping bank by the margin of one of our Scottish lochs. There are, however, no trees in North Uist, except in garden enclosures, but Mr Gray has informed me that the nest taken by Dr Dewar was among sedge, so that the bird most probably adapts the situation of its nest to the locality in which it breeds.

The first Scottish nest which can be considered as indisputable was procured from the north of Perthshire, in 1871, by Mr Harvie-Brown, and as the circumstances of the capture may not prove uninteresting, Mr Brown has kindly allowed me to transcribe the following passage from his Egg Book:

"On the 29th July 1870 a gamekeeper in Perthshire gave me the following piece of information, *ex ore*—'I got a nest too, for the first time this year, of the dun diver. It was in the hole of an old tree, and had ten eggs. I had the bird in my hand.' In 1871 this keeper, with permission of the lessee of the shootings, was employed by me to collect birds' eggs for Captain Feilden and myself. No directions were given to him regarding ducks' eggs or down, as sufficient importance had not been attached to his communication of July 1870. Under date of May 1871, the keeper writes: 'I have some eggs which I shall be glad to send to you, if you care for them. They are as follows—dun divers, etc.' At this time I was in Norway. The eggs were sent to Dunipace unblown during my absence. They contained full-grown chicks; no down was sent with them. They were blown by the keeper and his son at Dunipace. One egg was destroyed in blowing and two others were badly broken, but the pieces were carefully preserved. On my return home I compared these eggs with eggs of scoters and goosanders taken this season (1871) in Norway, and also with a number of mergansers' eggs collected by Captain Feilden and myself in the Hebrides and Sutherland, and, after a careful examination, I came to the conclusion that they could scarcely belong to any other species than to the goosander. I then wrote to the keeper, asking him to try to secure a portion of the down from the nest. Towards the middle of September I received his answer, in which he enclosed a single feather in every respect answering to a feather from the flank of a female goosander in our collection. The feather was sent to Mr H. E. Dresser, who confirmed my comparison, and in answer said—'I congratulate you on the first recorded Scottish nest of *Mergus merganser*.'"

In the *Field* of July 29th and August 12th 1871—the same year in which Mr Harvie-Brown obtained eggs in Perthshire—Mr J. Graham (James Street, Liverpool) records that he saw a female goosander, accompanied by seven young ones, on Loch Awe, Argyleshire, and that in 1868 he saw the same in Orkney.

Mr J. Watson, in a letter to Mr Harvie-Brown, under date of November 1872, states that he took a nest that season in the "west of Scotland." "The nest contained six eggs, and was placed on a ledge of rock quite open and within three feet of the water."

In 1873, Captain Feilden and Mr Harvie-Brown saw two goosanders, on the 13th and 14th of June, at the same locality from whence Mr Brown obtained the eggs in 1871. In 1876 Mr Dresser and Mr Brown found the nest at the same spot. The eggs had, however, been unfortunately taken, but the down was left. The keepers and shepherds are in the habit of destroying the eggs, on account of the supposed harm the birds do to fish. In 1877, Mr Brown knew of the goosanders breeding again at this locality.

Mr Malloch, naturalist, Perth, informs me that he saw a brood of nine young birds at the same spot on the 1st of August 1878. This was probably a second hatch, as the boatman informed him that he had taken the eggs in June for a London gentleman.

A pair of goosanders have frequented the Tay, about eight miles above Perth, during the whole of last summer, and from this one may infer that they possibly breed somewhere in that locality.

In 1877 I knew of a nest on the banks of the Teith, near Callander, a detailed description of which will be found in my List of the Birds of the Parish of Callander, published in this Society's *Proceedings*, and in 1878 I have reason to believe that there was at least one nest on one of the lochs in the south-west of Perthshire.

The Rev. Alexander Stewart, Ballachulish, has informed me that it probably breeds in Mull, and also on Loch Craignish, near the northern end of the Crinan Canal. His reasons for thinking so are that he saw an old female goosander and a young bird not many weeks old shot on Loch Sunart, opposite Glenborrodale, in Ardnamurchan, and he has no doubt that it nested on one of the fresh-water lakes or salt-water lochs of the Island of Mull. This was in 1867. In August 1869, Mr Stewart saw a young goosander which Mr Mulholland of the yacht "Hecla" had shot at the mouth of Loch Craignish, and which was believed to have been bred in that immediate neighbourhood. He is also inclined to believe that about twenty-five or thirty years ago goosanders bred on an island on Loch Arcaig, near Lochiel's Castle of Auchnacarry.

I have been told that they occur on the Tweed during summer, but I have been unable to procure any direct evidence of their breeding there.

There is an egg in the Dunrobin Museum, taken near Tongue, which is reputed to be that of a goosander, and Mr Sim of Aberdeen informs me that he has had what he considers to be goosanders' eggs from that locality; but Mr Harvie-Brown, who has paid much attention to the ornithology of Sutherland, does not consider that it occurs in that county during the breeding season.

In "Scenes of Animal Life and Character from Nature and Recollection," by Mrs Hugh Blackburn, mention is made of the goosander nesting on an island in Loch Ailort.

A gamekeeper near Aberfeldy writes to me that he saw this year (1879) a pair of goosanders on Loch Tay, on the 20th of May, and although he could not find their nest, it is most probable that they were breeding somewhere in that neighbourhood.

There can be but little doubt that the goosander has bred in Scotland much oftener than in the few instances which I have given, but it is extremely difficult to obtain reliable information on the subject, as the majority of gamekeepers and shepherds, who have the most frequent opportunities for observation, confound it with either the shieldrake or merganser.

In collecting the foregoing notes I have to express my indebtedness to several gentlemen who have obligingly and readily answered my questions with reference to the breeding of this interesting bird, and especially to the Rev. Alex. Stewart, The Manse, Ballachulish; Mr Mackenzie, Dornoch; Mr Gray, etc., etc., as well as to Mr Malloch, naturalist, Perth, and Mr Sim, naturalist, Aberdeen. I am also more than obliged to Mr J. A. Harvie-Brown of Dunipace, for the extract from his Egg Book, and for much other valuable assistance and advice.

IV. *On the Invertebrate Fauna of Lamlash Bay.* By WILLIAM ABBOTT HERDMAN, Esq., B.Sc. [Plate IV.]

(Read 21st January 1880.)

Lamlash Bay has probably been as much worked by the naturalist's dredge as any other area of similar extent on the coast of Scotland, yet the published lists of the animals found in it are, as regards many groups, far from being exhaustive.

Dr Landsborough, in his "Excursions to Arran" (1852), gives a list of the *Mollusca* and *Foraminifera* which had been found there by himself and others.

A more complete marine fauna of the district is to be found in Bryce's "Geology of Arran and Clydesdale." The lists in this work were drawn up by Dr Miles, and include the species dredged by Dr Landsborough and Major Martin, in addition to those obtained by Dr Greville and Dr Miles himself, which latter constitute the list given in a paper published in the British Association Report for 1856. These conjoined lists were finally revised and supplemented by Dr Carpenter, and appear in this their most complete form in the 4th edition of Dr Bryce's work (1872). As far as regards the *Mollusca* and *Echinodermata*, they are very full.

In the summer of 1877 upwards of twenty members of the Birmingham Natural History and Microscopical Society visited Arran and dredged for a week, chiefly in Lamlash Bay, where they found two species (*Thyone papillosa* and *Elysia viridis*) not previously recorded. A large party of members of the same society returned to Lamlash in the following summer (1878) and took three species of Nudibranchs, two at least of which were new to the locality.

These, as far as I am aware, are the only published lists of the fauna of Lamlash Bay. From the fact that each successive investigator has been able to add to the recorded fauna, it may reasonably be inferred that further work will not be fruitless, and that, although this part of the coast has received more than its just share of attention from marine zoologists, much dredging and careful investigation will still be required before we can have anything like an accurate knowledge of the inhabitants of even this much searched locality.

I ought to mention that very complete lists of the *Foraminifera*, *Actinozoa*, *Ostracoda*, and *Mollusca* of the Clyde district are to be found in the "Fauna and Flora of the West of Scotland," published by the British Association. Doubtless most of the species would also be found at Lamlash if those groups were as thoroughly worked out there as they have been at Cumbrae.

My chief dredging ground was at the north and south entrances to the bay and along the Lamlash side of Holy Island. A few hauls were taken in most of the other parts of the bay, but the localities above specified were found to be the most productive.

At each place where the dredge was let down the depth was carefully ascertained, and, except when the haul was very poor, a list was kept of the animals brought up in the net. There are forty-three such lists which I have arranged in twelve stations or localities referred to by their numbers in the following record.

Among the animals collected between tide marks the locality of those species which rarely occurred is given. The others are marked "littoral." Those taken only at spring tides, or by wading beyond low water-mark, are designated as "upper laminarian."

The Ascidians were especially interesting to me, and engaged a good deal of my attention.

As I wish to examine them carefully, and have not yet had sufficient time, the list of *Tunicata* is reserved for a future paper.

LIST OF STATIONS.

Station. [See Plate IV.]

No. 1. Depth $3\frac{1}{2}$ to $7\frac{1}{2}$ fathoms.
Bottom seaweedy, chiefly *Laminaria*.

No. 2. Depth 14 to 21 fathoms.
Bottom zoophytic and shelly.

No. 3. Depth 2 to 5 fathoms.
Bottom seaweedy.

No. 4. Depth 10 to 20 fathoms.
Bottom nullipore, dead shells, and algæ.

No. 5. Depth 10 fathoms.
Bottom algæ and zoophytes.

No. 6. Depth 15 to 25 fathoms.
Bottom zoophytic.

No. 7. Depth 5 to 15 fathoms.
Bottom sand, shells, and zoophytes.

No. 8. Depth 14 to 16 fathoms.
Bottom zoophytic and shelly.

No. 9. Depth 3 to 10 fathoms.
Bottom sandy and zoophytic.

No. 10. Depth 7 to 13 fathoms.
Bottom nullipore.

No. 11. Depth 9 to 13 fathoms.
Bottom nullipore.

No. 12. Depth 10 to 15 fathoms.
Bottom nullipore and shells.

The ground covered by these stations is, as far as I am capable of judging, the best part of the bay for dredging purposes. The remainder of the area is mostly clean sand.

LIST OF SPECIES.

PORIFERA.

I. Calcarea—

Grantia compressa (Fabr.).
G. ciliata (Fabr.).
Leucosolenia botryoides (Ell. and Sol.).
L. coriacea (Flem.).

II. Silicea—

Cliona celata (Grant).
In *Pecten opercularis.*
Halichondria panicea (Pall.).
Dysidia fragilis (Mont.).
A few specimens which I am unable to determine.

COELENTERATA.

HYDROIDA.

I. Athecata—

Clavidæ.

Clava multicornis (Forsk.).
Litt., on *Fucus*, etc.

Hydractiniidæ.

Hydractinia echinata (Flem.).
Always on shells inhabited by *Pagurus.* Stations 5, 9, 11; also upper lam., King's Cross.

Corynidæ.

Coryne pusilla (Gaertn.).
Litt., on *Fucus*, etc.
C. vaginata (Hincks).
Litt., in rock pools, King's Cross.
Syncoryne sarsii (Lovén.).
Litt., King's Cross.

Eudendriidæ.

Eudendrium rameum (Pall.).
Stations 2, 6.
E. ramosum (Linn.).
Stations 4, 6, 7.

ATRACTYLIDÆ.

Bougainvillia ramosa (Van Ben.).
Stations 2, 5.

TUBULARIIDÆ.

Tubularia coronata (Abildg.).
Station 4. On *Laminaria* growing from (*a*) wreck near Holy Isle, (*b*) buoy.

T. simplex (Alder).
Stations 3, 7, 8, 10, 12.

II. THECAPHORA—

CAMPANULARIIDÆ.

Clytia johnstoni (Alder).
Upper lam.

Obelia geniculata (Linn.).
Upper lam., on *Laminaria* and *Zostera.*

O. dichotoma (Linn.).
Litt.

O. flabellata (Hincks).
Litt., on *Fucus.*

Campanularia verticillata (Linn.).
Station 2.

C. flexuosa (Hincks).
Litt. Also Station 3.

LAFOEIDÆ.

Lafoëa dumosa (Flem.).
Stations 2, 4, 5.

L. fruticosa (Sars).
Station 2.

Filellum serpens (Hass.).
On other zoophytes. Stations 4, 6.

HALECIIDÆ.

Halecium halecinum (Linn.).
Stations 2, 4, 6, 8, 9, 10, 11, 12.

H. beanii (Johnst.).
Station 2.

Sertulariidæ.

Sertularella polyzonias (Linn.).
Stations 2, 5, 6, 7, 9, 10, 11.

S. rugosa (Linn.).
Upper lam., King's Cross and Clachland.

Diphasia rosacea (Linn.).
Station 2.

D. pinaster (Ell. and Sol.).
Station 1.

D. tamarisca (Linn.).
Stations 2, 4.

Sertularia pumila (Linn.).
Litt.

S. filicula (Ell. and Sol.).
Stations 2, 4, 6.

Hydrallmania falcata (Linn.).
Station 6.

Plumulariidæ.

Antennularia antennina (Linn.).
Stations 6, 8.

A. ramosa (Lam.).
Stations 2, 4, 5, 6, 7.

Plumularia pinnata (Linn.).
Stations 2, 6, 7, 8, 12.

P. setacea (Ell.).
Stations 5, 11.

MEDUSOID GONOPHORES.

(Taken in the Surface-net at the south end of the Bay.)

Oceania octona (Flem.).
Thaumantias thompsoni (Forb.).
T. aeronautica (Forb.).
Euphysa aurata (Forb.).
One specimen.

ACALEPHA.

Cyanœa capillata (Bast.).
Aurelia aurita (Linn.).

ACTINIARIA.

In considering its *Malacodermata*, Lamlash Bay must be included in Gosse's "Hebridean Province" (extending from Cantyre to the Orkneys). The author of the "Actinologia Britannica" records, in the table of geographical distribution, only six species as inhabiting this province. Of these six, four have been taken very rarely and only in other parts of the area, thus reducing the list of those likely to occur at Lamlash to two species. These two along with three others are given by Dr Miles. I am able to add three more, of which the localities are given below.

SAGARTIADÆ.

Actinoloba dianthus (Ell.).

Litt. and upper lam. Occurs in two localities; (*a*) in small pools in the basalt at King's Cross are a few specimens of the variety *sindonea;* (*b*) sticking to a wreck on a sandbank near the pier are many specimens of the varieties *sindonea* and *rubida.*

Sagartia bellis (Ell. and Sol.).

Litt., near King's Cross.

S. troglodytes (Johnst.).

Litt.

Adamsia palliata (Bohadsch).

Stations 2, 3, 4, 6, 7. This is a common species, especially in the southern part of the bay. Its beautifully spotted body and streaming rose-coloured acontia were to be seen in the dredge almost every haul in the neighbourhood of the buoy. It was always in conjunction with *Pagurus prideauxii.*

Also upper lam., sands, King's Cross.

ANTHEADÆ.

Anthea cereus (Ell. and Sol.).

Litt. and upper lam., attached to *Fucus* and *Zostera.* Probably the most abundant species of anemone at Lamlash. The majority of the specimens seem to belong to Gosse's variety *rustica.* Two of var. *smaragdina* and one of *alabastrina* also occurred.

ACTINIADÆ.

Actinia mesembryanthemum (Ell. and Sol.).

Litt.

BUNODIDÆ.

Tealia crassicornis (Müll.), including *T. coriacea* (Cuv.).

Litt.

CAPNEADÆ.

Corynactis viridis (Allman).

Under a large stone at low water-mark near Clachland Point.

ECHINODERMATA.

CRINOIDEA.

Comatula rosacea (Linck).

Stations 2, 4, 5, 6, 7, 11, 12. This was dredged frequently, but always in the mature condition. It was probably too late in the season to take it in the stalked stage. The curious ecto-parasite *Myzostomum* occurs in abundance on some specimens of *Comatula,* while others are entirely free from it.

OPHIURIDEA.

Ophioglypha lacertosa (Penn.).

Stations 4, 6, 7. One very large specimen measured $1\frac{1}{16}$ inches across the disc.

O. albida (Forb.).

Stations 2, 7, 10.

Ophiothryx rosula (Forb.) = *O. fragilis* (Müll.).

Stations 2, 6, 7, 10, 12.

Ophiocoma nigra (Müll.).
Stations 2, 4, 6, 7, 10, 12. Orange variety common.

Ophiopholis bellis (Forb.) = *O. aculeata* (Müll.).
Stations 6, 7, 10. Forbes mentions a variety having a yellow star on the red disc. Some of my specimens had these colours transposed, the disc being yellow, and marked with a red star.

Amphiuma neglecta (Forb.) = *A. elegans* (Leach).
Litt. and upper lam.

ASTEROIDEA.

Asterias glacialis (Linn.).
Stations 3, 11, 12.

A. rubens (Linn.).
Stations 3, 6, 7, 8, and litt.

Solaster papposus (Linn.).
Stations 3, 12, and litt.

Cribella oculata (Penn.).
Station 12, and upper lam., Clachland Point.

Palmipes placenta (Penn.) = *P. membranaceus* (Retz.).
Station 4.

Porania pulvillus (Müll.).
Stations 2, 4, 6, 10, 11, 12, and upper lam.

Luidia savignii (Aud.) = *L. fragillissima* (Forb.).
Upper lam., King's Cross on sand.

Astropecten irregularis (Penn.).
Station 4.

ECHINOIDEA.

Echinus esculentus (Linn.).
Stations 1, 6, 10, 11, 12, and upper lam.

E. miliaris (Leske).
Stations 4, 6, 7.

Echinocardium cordatum (Penn.).
Upper lam., King's Cross, in a sand bank.

Echinocyamus angulosus (Leske) = *E. pusillus* (Forb.).
Stations 10, 11, 12.

I did not meet with any *Holothuridea*, although a *Chirodota* and a *Thyone* have been recorded as dredged in the bay.

VERMES.

ANNELIDA.

GYMNOCOPA.

Tomopteridæ.

Tomopteris onisciformis (Eschsch.).
In tow net.

NOTOBRANCHIATA.

Maldanidæ.

Clymene borealis.
Owenia filiformis (D. Ch.) = *Ammochares ottonis* (Gr.).

Polynoidæ.

Lepidonotus squamatus (Linn.).
Evarne impar (Johnst.).
Nychia cirrosa (Pall.).
Harmothoe imbricata (Linn.).
Polynoe floccosa (Sav.).
Halosydna gelatinosa (Sars).

Sigalionidæ.

Sigalion mathildæ (Aud. and Ed.).

Nephthyidæ.

Nephthys longisetosa (Oerst.).

Phyllodocidæ.

Eulalia viridis (O. F. Müll.).

Syllidæ.

Syllis armillaris (O. F. Müll.).

NEREIDÆ.

Nereis pelagica (Linn.).
N. diversicolor (O. F. Müll.).
N. dumerilii (Aud. and Ed.).

OPHELIIDÆ.

Ammotrypane aulogaster (Rath.).

ARENICOLIDÆ.

Arenicola piscatorum (Lam.).

CEPHALOBRANCHIATA.

PHERUSIDÆ.

Trophonia plumosa (O. F. Müll.).

AMPHICTENEIDÆ.

Pectinaria belgica (Pall.).
Amphictene auricoma (O. F. Müll.).
Nicomache lumbricalis (Fabr.).

SABELLIDÆ.

Sabella penicillus (Linn.).
S. pavonina (Sav.).
Protula protensa (Gr.).

SERPULIDÆ.

Serpula serrulata.
S. vermicularis (Ell.).
Pomatocerus triqueter (Mont.).
Spirorbis nautiloides (Lam.).

There are some other Annelides which I am unable to name; also a few *Turbellaria,* and several *Gephyrea.*

POLYZOA.

CHEILOSTOMATA.

CELLULARIADÆ.

Canda reptans (Pall.).
Upper lam., on *Zostera.*

Scrupocellaria scruposa (Linn.).
Stations 2, 4, 6, 7.

SCRUPARIADÆ.

Scruparia chelata (Linn.).
Stations 8, 11.

Hippothoa divaricata (Lam.).
Station 4.

Ætea truncata (Landsb.).
Stations 2, 4.

GEMELLARIADÆ.

Gemellaria loricata (Linn.).
Stations 2, 6.

BICELLARIADÆ.

Bicellaria ciliata (Linn.).
Station 8.

FLUSTRADÆ.

Flustra foliacea (Linn.).
Station 2.

Carbasea papyrea (Pall.).
Station 9.

MEMBRANIPORIDÆ.

Membranipora membranacea (Linn.).
Stations 1, 4, 7.

M. pilosa (Linn.).
Station 3.

Lepralia coccinea (Abildg.).
Station 4.

L. ciliata (Linn.).
Stations 1, 4.

L. trispinosa (Johnst.).
Station 6.

L. biforis (Thomp.).
Station 7.

L. hyalina (Linn.).
Station 7.

Lepralia peachii (Johnst.).
Station 4.

L. variolosa (Johnst.).
Stations 4, 12.

L. annulata (Fabr.).
Stations 4, 11.

L. tenuis (Hass.).
Station 1.

L. hassalli (Johnst.).
Station 4.

CELLEPORIDÆ.

Cellepora pumicosa (Linn.).
Station 4.

C. ramulosa (Linn.).
Station 1.

ESCHARIDÆ.

Eschara foliacea (Ell. and Sol.).
Stations 4, 9.

CTENOSTOMATA.

VESICULARIADÆ.

Bowerbankia imbricata (Adams).
Station 2.

Valkeria sp.
Station 5.

ALCYONIADÆ.

Alcyonidium hirsutum (Flem.).
Station 6.

Flustrella hispida (Fabr.).
Station 5.

CYCLOSTOMATA.

CRISIADÆ.

Crisidia cornuta (Linn.).
Station 7.

Crisia eburnea (Linn.).

Station 6.

C. denticulata (Lam.).

Stations 3, 4, 5.

TUBULIPORIDÆ.

Tubulipora flabellaris (Johnst.).

Station 7.

T. serpens (Linn.).

Station 1.

Diastopora patina (Lam.).

Stations 1, 4.

Discoporella hispida (Flem.).

Station 4.

ENTOPROCTA.

PEDICELLINIDÆ.

Pedicellina echinata (Sars).

Stations 2, 6, 8, 9. Generally on *Plumularia pinnata.*

CRUSTACEA.

DECAPODA.

LEPTOPODIADÆ.

Stenorhynchus phalangium (Penn.).

Stations 2, 3, 4, 5, 6, 7, 11, 12.

Inachus dorsettensis (Penn.).

Stations 6, 7, 8, 9.

MAIADÆ.

Hyas araneus (Linn.).

Litt. and upper lam., King's Cross.

H. coarctatus (Leach).

Station 2.

PARTHENOPIDÆ.

Eurynome aspera (Leach).

Stations 6, 7, 8, 11. One is a female with eggs. It was taken in the end of August, two months later than the spawning time given in Bell's "British Crustacea."

Canceridæ.

Cancer pagurus (Linn.).

Litt. and upper lam.

Portunidæ.

Carcinas mœnas (Penn.).

Litt.

Portunus puber (Linn.).

Station 3, and upper lam., King's Cross.

P. arcuatus (Leach).

Stations 3, 11.

P. depurator (Linn.).

Station 3.

Leucosiadæ.

Ebalia pennantii (Leach).

Station 12.

Paguridæ.

Pagurus bernhardus (Linn.).

Stations 4, 5, 11; also litt. and upper lam.

P. prideauxii (Leach).

Stations 2, 3, 4, 6, 7, and upper lam., King's Cross.

P. cuanensis (Thomp.).

Station 11; also upper lam., Clachland. One specimen was in a shell of *Aporrhais pes-pelecani*.

Porcellanadæ.

Porcellana platycheles (Penn.).

Station 7. Litt., King's Cross and Clachland Point. One specimen is interesting. Its left great leg is normal, the other is represented by a roundish knob slightly bilobed at the end. The limb has evidently been lost, and this is a new one in process of budding.

Porcellana longicornis (Penn.).

Stations 7, 12. Frequently in the nullipore "nests" made by *Lima hians.*

Galathea squamifera (Leach).

Station 3. Upper lam., King's Cross, and Clachland Point. Among some specimens from Clachland one has an abnormal rostrum, there being five lateral spines on its left side. Four is the proper number, and forms a specific character. The additional spine is placed anteriorly, but is truly lateral, not being caused by a bifurcation of the central spine.

G. nexa (Embl.).

Station 10. I have only one specimen, and it has a curious swelling on the carapace, increasing the posterior half of the thorax on the right side to twice its normal size.

G. andrewsii (Kin.).

Stations 2, 4, 5, 6, 7, 10. Very common.

Crangonidæ.

Crangon vulgaris (Fabr.).

Station 4.

Palæmonidæ.

Hippolyte varians (Leach).

Station 10.

Pandalus annulicornis (Leach).

Stations 3, 11, 12.

Palæmon serratus (?) (Penn.).

Station 5.

P. squilla (Fabr.).

Stations 7, 9, 10.

AMPHIPODA.

Gammaridæ.

Montagua monoculoides (Mont.).
Upper lam.
Anonyx holbolli (Kroy.).
Ampelisca gaimardii (Kroy.).
Monoculoides stimpsoni (Sp. Bate.).
Dexamine spinosa (Leach).
Gammarus locusta (Linn.).
Station 3.

Corophiidæ.

Amphithoe rubricata (Leach).
Station 3.
Podocerus pulchellus (M. Edw.).
On *Laminaria* at the buoy.

Hyperiidæ.

Lestrigonus kinahani (Sp. Bate.).
In *Aurelia aurita.*
Hyperia galba (Mont.).
In *Aurelia aurita.*

Caprellidæ.

Proto pedata (Flem.).
Protella phasma (Mont.).
Station 6.
Caprella linearis (Linn.).
C. hystrix (Kröy.).
C. acanthifera (Leach).

ISOPODA.

Idotea tricuspidata (Desmar.).
Station 12, and litt.

CIRRIPEDIA.

Balanus balanoides (Linn.).
Litt.

B. porcatus (Da Costa).
Stations 6, 7.

There are a number of small crustaceans, taken in the surface-net, which I have not yet had time to go over. Most of them seem to be *Copepoda*.

PANTOPODA.

Pycnogonum littorale (Fabr.).
King's Cross and Clachland.

Nymphon gracile (Fabr.).
Station 4.

Pallene brevirostris (Johnst.).
Station 2.

MOLLUSCA.

LAMELLIBRANCHIATA.

Anomiidæ.

Anomia ephippium (Linn.).
Stations 4, 5.

Ostraeidæ.

Ostraea edulis (Linn.).
Station 6.

Pectinidæ.

Pecten opercularis (Linn.).
Stations 9, 10.

P. varius (Linn.).
Station 11. A single valve in a *Lima's* "nest."

P. tigrinus (Müll.).
Station 6.

P. tigrinus, var. *costata.*
Station 6.

Pecten similis (Lask.).
Station 7.

P. maximus (Linn.).
Stations 6, 7, 12.

Lima hians (Gmel.).
Stations 6, 9, 10, 11, 12. Common off the north end of Holy Isle. It builds its nest out of the nullipore *Melobesia calcarea* which forms the bottom there.

MYTILIDÆ.

Mytilus edulis (Linn.).
On wreck, Holy Isle, etc.

M. modiolus (Linn.).
Upper lam., King's Cross.

M. phascolinus (Phil.).
Upper lam., King's Cross.

Modiolaria discors (Linn.).
Litt., in pools, King's Cross.

ARCIDÆ.

Nucula nucleus (Linn.).
Stations 2, 12.

N. nitida (Sower.).
Stations 7, 11.

KELLIIDÆ.

Lepton nitidum (Turt.).
Station 4.

LUCINIDÆ.

Lucina borealis (Linn.).
Litt., north of Lamlash.

Axinus flexuosus (Mont.).
Station 12.

CARDIIDÆ.

Cardium echinatum (Linn.).
Station 7.

Cardium exiguum (Gmel.).
Station 9.

C. nodosum (Turt.).
Station 7.

C. edule (Linn.).
Litt., sands, Lamlash.

C. norvegicum (Speng.).
Station 8.

CYPRINIDÆ.

Cyprina islandica (Linn.).
Station 6.

Astarte sulcata (Da Costa).
Station 12.

A. compressa (Mont.).
Station 12.

Circe minima (Mont.).
Stations 9, 11.

VENERIDÆ.

Venus exoleta (Linn.).
Station 9.

V. lincta (Pulten.).
Station 9.

V. fasciata (Da Costa).
Station 12.

V. ovata (Penn.).
Station 7.

V. gallina (Linn.).
Stations 5, 7.

Tapes virginea (Linn.).
Station 10.

T. pullastra (Mont.).
Litt., near King's Cross.

TELLINIDÆ.

Tellina balthica (Linn.).
Litt.

T. tenuis (Da Costa).
Litt. and upper lam., Station 3.

Tellina fabula (Gronov.).
Upper lam., and Station 3.

T. donacina (Linn.).
Stations 9, 11.

Psammobia ferroensis (Chemn.).
Station 6.

P. vespertina (Chemn.).
Station 6.

MACTRIDÆ.

Mactra solida (Linn.).
Litt., sands, Lamlash.

M. solida, var. *truncata.*
Litt. and upper lam.

M. subtruncata (Da Costa).
Litt. and upper lam.

M. subtruncata, var. *striata.*
Station 3.

SOLENIDÆ.

Solen pellucidus (Penn.).
Station 9.

S. ensis (Linn.).
Upper lam., sands, Lamlash.

S. siliqua (Linn.).
Litt. and upper lam.

ANATINIDÆ.

Thracia papyracea (Poli).
Sands, Lamlash.

MYIDÆ.

Mya truncata (Linn.).
Litt., sands, near King's Cross.

SAXICAVIDÆ.

Saxicava rugosa (Linn.).
Stations 6, 7.

S. rugosa, var. *minuta.*
Station 5.

S. rugosa, var. *præcisa.*
Upper lam., Clachland.

Pholadidæ.

Pholas crispata (Linn.).
Upper lam., in sandstone, Lamlash.

Teredinidæ.

Teredo norvegica (Spengl.).
In pieces of old pier, Holy Isle.

SCAPHOPODA.

Dentaliidæ.

Dentalium entalis (Linn.).
Station 12.

GASTROPODA.

Prosobranchiata—

Chitonidæ.

Chiton cinereus (Linn.).
Stations 4, 6.

C. marginatus (Penn.).
Litt.

C. ruber (Lowe).
Station 4.

C. marmoreus (Fabr.).
Station 7.

Patellidæ.

Patella vulgata (Linn.).
Litt.

Helcion pellucidum (Linn.).
Upper lam., Clachland, and Station 8.

Tectura testudinalis (Müll.).
Stations 4, 8.

T. virginea (Müll.).
Stations 4, 6.

T. fulva (Müll.).
Station 10.

FISSURELLIDÆ.

Emarginula fissura (Linn.).
Stations 4, 6.

E. fissura, var. *subdepressa*.
Station 10.

CAPULIDÆ.

Capulus hungaricus (Linn.).
Stations 11, 12.

TROCHIDÆ.

Trochus magus (Linn.).
Stations 5, 6, 9.

T. magus, var. *alba*.
Station 4.

T. tumidus (Mont.).
Stations 6, 9.

T. cinerarius (Linn.).
Litt.

T. umbilicatus (Mont.).
Litt.

T millegranus (Phil.).
Stations 4, 7, 8.

T. zizyphinus (Linn.).
Stations 4, 6.

LITTORINIDÆ.

Lacuna divaricata (Fabr.).
Upper lam.

L. pallidula (Da Costa).
Upper lam.

Littorina obtusata (Linn.).
Litt.

L. rudis (Maton).
Litt.

L. littorea (Linn.).
Litt.

Rissoa parva (Da Costa).
Upper lam.

Rissoa soluta (Phil.).
Station 4.

R. membranacea (Adams).
Upper lam., on *Chondrus crispa.*

Hydrobia ulvæ (Penn.).
Litt., north of Lamlash.

Turritellidæ.

Turritella terebra (Linn.).
Litt., sands, Lamlash.

Pyramidellidæ.

Odostomia rissoides (Hanl.).
Upper lam., Clachland.

Naticidæ.

Natica alderi (Forb.).
Stations 5, 12.

N. montacuti (Forb.).
Station 10.

Velutinidæ.

Velutina laevigata (Penn.).
Station 4.

Aporrhaidæ.

Aporrhais pes-pelecani (Linn.).
Station 11.

Cerithiidæ.

Cerithium reticulatum (Da Costa).
Station 11.

Buccinidæ.

Purpura lapillus (Linn.).
Litt.

Buccinum undatum (Linn.).
Upper lam., King's Cross.

MURICIDÆ.

Trophon truncatus (Ström.).
Station 6.

Fusus antiquus (Linn.).
Station 2.

F. gracilis (Da Costa).
Station 4.

NASSIDÆ.

Nassa reticulata (Linn.).
Station 5.

N. incrassata (Ström.).
Upper lam., King's Cross.

PLEUROTOMATIDÆ.

Defrancia leufroyi (Michaud).
Station 10.

D. linearis (Mont.).
Station 6.

CYPRÆIDÆ.

Cypræa europæa (Mont.).
Upper lam., King's Cross and Clachland.

NUDIBRANCHIATA—

DORIDIDÆ.

Doris testudinaria (Riss.) = *D. planata* (Ald.).
Station 8.

D. tuberculata (Cuv.).
Litt. and upper lam., and Station 3.

D. pilosa (Müll.).
Upper lam., Clachland.

D. bilamellata (Linn.).
Litt. and upper lam., Clachland.

POLYCERIDÆ.

Goniodoris nodosa (Mont.).
Upper lam., Clachland.

Polycera quadrilineata (Müll.).
Upper lam., King's Cross, and Stations 4, 7.

TRIOPIDÆ.

Ancula cristata (Ald. and Han.).
Station 5.

EOLIDIDÆ.

Eolis papillosa (Linn.).
Litt., King's Cross.

E. coronata (Forb.).
Stations 2, 4, 9.

E. rufibranchialis (Johnst.).
Stations 7, 10.

E. tricolor (?) (Forb.).
Station 5.

CEPHALOPODA.

Eledone cirrhosus.
Upper lam., King's Cross.

In regard to the distribution of species in the bay, I am convinced that the number of dredgings was not nearly sufficient to warrant me in drawing conclusions in any detail; still, a few cases impressed themselves strongly on me, and may, I think, be mentioned with safety. Three species of Hydroids—*Halecium halecinum, Sertularella polyzonias,* and *Plumularia pinnata*—seem to range over all the area explored. Many others were found at one or a few places only, but none appeared specially characteristic of any particular spot. Among Echinoderms, *Comatula* and *Porania* were very generally distributed, while *Palmipes* and *Astropecten* were only taken at the south end of Holy Isle. *Echinocyamus* on the other hand occurred only at Stations 10, 11, and 12, off the north end of Holy Isle.

In the *Crustacea* we find *Stenorhynchus phalangium* and *Galathea andrewsii* in all parts of the bay, while *Eurynome* *aspera* and *Inachus dorsettensis* are only seen in the northern half of the bay, and *Pagurus prideauxii* only in the southern half. Among the Molluscs rather a well-marked case is seen in *Lima*, which is only found in the northern part of the bay, and in greatest abundance off the north end of Holy Isle—about Station 10.

V. *The "Pitchstone"* (Vitreous Basalt) *of Eskdale: A Retrospect and Comparison of Geological Methods.* By Archibald Geikie, LL.D., F.R.S., Director of the Geological Survey of Scotland, and Murchison Professor of Geology and Mineralogy in the University of Edinburgh. [Plates V. and VI.]

(Read 18th February 1880.)

Part I.—Retrospective.

In a remote pastoral valley among the southern uplands of Scotland a group of green hills rises on the west side of the river Esk, not far from the manse of Eskdalemuir. These eminences, known in the district by the names of Wat Carrick, Watch Craig, and Castle Hill, stand out from among the gentle grassy slopes of the dale with a certain ruggedness, or at least with a broken character of summit, which forms a pleasing relief from the monotony of the surrounding undulations. They were introduced to the attention of geologists in the beginning of this century, by Professor Jameson of Edinburgh,* but since that early date, so far as I am aware, no further geological description of them has been given. As they offer in themselves matter of considerable interest, and since the questions they raise naturally bring out into strong contrast former and present methods of geological research, I have t hought that in recalling them once more to notice, it might ɞ profitable to offer at the same time a brief review of the state of geology in this country at the date of Jameson's observations, more especially with reference to the interpretation of what we now know as igneous rocks.

* Mineralogical Description of Dumfriesshire, 8vo, pp. 185, Edinburgh, 1805. The Dedication of this work is dated "College of Edinburgh, October 10, 1804."

Looking back to the two closing decades of last century, we find Geology in the full vigour of its spring-time at Edinburgh. In the year 1785, Hutton, after many years of patient but enthusiastic research, at last communicated his "Theory of the Earth" to the Royal Society of Edinburgh.* The publication of this great memoir, and of its enlargement ten years afterwards into two octavo volumes,† marked one of the most notable epochs in the progress of science. Geological dynamics were now treated with the bold, broad, far-reaching hand of a consummate master. Men were taught that instead of indulging in the construction of fanciful systems of cosmogony, it was their first duty to study the actual records of the earth's history which have been preserved among the rocks. They were told that the interpretation of these records was supplied by familiar and daily operations upon the earth's surface; that the existing economy of nature was alone to be employed in the investigation of past time, and that no imaginary causes of change were to be invoked merely because those now in progress seemed on a cursory view inadequate to explain the vicissitudes through which the planet had passed. One prominent feature in the Huttonian theory was the recognition of a vast cycle of revolutions, of which the evidence could be traced in the rocks of the earth's surface. Hutton found everywhere proofs of continual disintegration. The soil under his feet was in his eyes a monument of the decay of the terrestrial surface, alike necessary for the well-being of plants and animals and for the formation of land hereafter to be upraised from the bed of the sea. In the strata composing most of the dry land he saw the ruins of a former world—*débris* that had been worn from earlier continents, and had been laid down upon the floor of the sea. In the heated interior of the globe he recognised a

* Theory of the Earth; or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe, by James Hutton, M.D.; *Trans. Roy. Soc. Edin.*, i., pp. 209-304, read March 7 and April 4, 1783.

† Theory of the Earth, with proofs and illustrations, in 4 parts, 2 vols. 8vo, Edinburgh, 1795. [A third volume in MS. is referred to by Playfair (*Trans. Roy. Soc. Edin.*, v., part iii., p. 86) as having been left by the author, but it was never published, and no trace of its existence can now be found.]

grand source of energy, whereby the marine sediments, compressed and hardened into stone, are from time to time elevated into new land.

Living in a country where so many conspicuous memorials of ancient volcanic activity obtrude themselves on the notice of every passing traveller, Hutton at an early date recognised the fact that, while stratified rocks have been hardened and upheaved through the operations of underground heat, they have likewise been invaded by masses of molten rock that have risen from below. He observed this circumstance among rocks of different ages in a region remote from any active volcano, and in which he found no trace of volcanic cones or craters. In Glen Tilt he discovered, as he had anticipated, that the granite of the Highlands sends out veins into the surrounding rocks in such a manner as to show that it must once have been in a state of fusion. So great was his glee over this corroboration of his theoretical deductions that, as his biographer narrates, the Highland gillies who accompanied him concluded that nothing less than the discovery of a vein of silver or gold could call forth such exultation.* In the lowlands of Scotland also he instanced many examples of rocks that had certainly been erupted in a molten condition, and had been injected among the ordinary sedimentary strata.†

The publication of Hutton's "Theory of the Earth" did not immediately awaken much sympathetic interest in his doctrine. This arose partly from the somewhat cumbrous style in which he wrote, but chiefly because he was so far in advance of his age, that men were unprepared to recognise in his teaching a wide induction from carefully observed facts, instead of the speculation of one of the visionary enthusiasts of whose productions the world was now getting weary. He met, eventually, with determined opposition from De Luc and Kirwan—the latter of whom even insinuated a charge of atheism and impiety against him. Kirwan's was a formidable name, for his reputation as a chemist and mineralogist stood high. His capacity for geological research, however, will now be placed in a very subordinate position by any one who can find time

* Playfair, *Trans. Roy. Soc. Edin.*, v., part iii., p. 68.

† Theory of the Earth, part i., chap. i., sect. 3 and 4; chap. v.

and patience to read his "Essays."* This work, and his previous memoir, entitled, "Examination of the Supposed Igneous Origin of Stony Substances," † have long since passed out of the familiar literature of Geology. They deserve, however, to be remembered, if only because it was the appearance of the memoir that stimulated Hutton to expand and republish his "Theory" in the form in which he left it.

Among Hutton's personal friends there were two who, while earnestly and loyally sympathising with his doctrine, had the ability to render it the most essential service. John Playfair, the genial Professor of Mathematics in the University of Edinburgh, from constant intercourse with Hutton, both in the city and among the hills, had thoroughly mastered his friend's teaching. After Hutton's death in 1797, finding that the Huttonian Theory still met with but little attention, Playfair prepared and published his classic "Illustrations."‡ Gifted with a pen as facile and graceful as that of his master was heavy and obscure, he unfolded the new doctrine with consummate skill, and produced a volume which will serve as a perpetual model of luminous and fascinating exposition. It was from the appearance of this work rather than of Hutton's ponderous chapters that the real influence of the Huttonian Theory began.

Sir James Hall of Dunglass was a man of a wholly different temperament. Quick, original, inventive; with an enthusiastic love of science, and a determination to take nothing on trust, but to subject every statement where possible to the test of experiment, he became a follower of Hutton, as it were against his will, and only by degrees, as he succeeded in disproving one by one the objections which at first the Huttonian Theory awakened in his vigorous mind. He had travelled abroad. In particular he had visited some of the volcanic districts of Italy, and had there seen the phenomena of volcanic action partly under the guidance of Dolomieu.§ Not long after the first publication of the

* Geological Essays, 1 vol. 8vo, London, 1799.

† Memoirs of the Royal Irish Academy, vol. v. (1793), p. 51.

‡ Illustrations of the Huttonian Theory of the Earth, 1 vol. 8vo, Edin., 1802.

§ *Trans. Roy. Soc. Edin.*, v., 56.

Huttonian Theory, Hall is found reflecting on the objections made to Hutton's views, that had granite, porphyry, and whinstone ever been in a fused condition, they would have resembled glass, instead of presenting the stony crystalline aspect in which they are now found. It occurred to him that their present structure might be due not merely to the effect of consolidation under pressure as Hutton supposed, but more especially to extremely slow cooling. The occurrence of an accident at the Leith Glass Works supplied him with an actual corroborative example—a large pot of glass having cooled down slowly into a mass which had completely assumed a stony structure. Convinced that this was a true cause of change in the internal constitution of fused masses he communicated his views to the Royal Society of Edinburgh in 1790,* and determined to pursue the subject by instituting a series of experiments. On making known his intention to Hutton, however, he received but little encouragement from him. Hutton judged that the degree of heat, and the scale on which it had been manifested in nature, were such that no experiments could be expected to bring any real elucidation of the subject. As he afterwards expressed the idea in his reply to the strictures of Kirwan, there are some "superficial reasoning men who judge of the great operations of the mineral kingdom from having kindled a fire and looked into the bottom of a little crucible."†

But, though unconvinced, Hall, out of deference to his master's feelings, forbore to put his design into execution. The year after Hutton's death, however, he gave to the Royal Society of Edinburgh his first great paper—an essay which must be regarded as one of the landmarks of science, for it really laid the foundations of experimental geology.‡ He proved by a series of ingeniously contrived and carefully executed experiments that the internal structure of igneous rocks has been in great measure determined by their rate of cooling; that where they congealed rapidly from a state of fusion they appear quite glassy, while, where they were

* *Op. cit.*, iii., part i., p. 10. † Theory of the Earth, i., p. 251.

‡ Experiments on Whinstone and Lava (read March 5 and June 18, 1798). *Trans. Roy. Soc. Edin.*, v., p. 43.

allowed to cool slowly they have acquired a stony structure. Out of the basalts of the neighbourhood of Edinburgh and the lavas of Sicily, Vesuvius, and Iceland, he thus produced at one time glass, at another, lithoid masses ("crystallites" as he called them) not unlike the original rocks.

It would be beyond the scope of my present slight sketch to enter more fully into these remarkable researches, or to trace the course of Hall's subsequent career as an experimental philosopher of a high order. Every one of his memoirs is replete with original observation, careful induction, and suggestive speculation. In particular his memorable essay on "The Effects of Compression in Modifying the Action of Heat,"* formed the starting point for the long succession of brilliant researches by which subsequent observers, notably Delesse and Daubrée, have thrown so much light on the still obscure subject of metamorphism.

The Scottish school of Geology, of which Hutton, Playfair, and Hall were the three great founders, dealt with the grand dynamical principles of the science rather than with questions of detail. Its range was necessarily much more restricted than that which is now open to us. It knew almost nothing of organic remains, and had no intimation of the extended vista into the past history of our planet which organic remains have since opened up. Its most strenuous admirers will not now contend for the accuracy of all its doctrines, nor for the validity of all the arguments by which principles true in themselves were sustained. As yet the facts of the science were comparatively few, and our wonder should be, not that these men fell into what we now know to be obvious errors, but that with such limited experience they should have erred so seldom, and should have attained to such breadth and clearness of perception. In the domain of igneous action, with which we are more specially concerned at present, they showed that granite, and the series of rocks which they included under the term "whinstone," have most certainly been erupted from beneath, and have in many cases hardened and otherwise altered the stratified masses through which they rose.

* *Trans. Roy. Soc. Edin.*, vi., p. 71 (read June 3, 1805).

While such was the state of inquiry here, the origin of such rocks as basalt was by no means a settled question on the Continent. For many years much controversy had been carried on, and scientific societies even offered prizes for the solution of the problem as to the volcanic or non-volcanic origin of basalt.* In France, indeed, the question had been answered confidently by independent observers, who found in the singularly interesting district of Auvergne streams of basalt connected with still perfect cones and craters, as well as isolated portions of similar basaltic sheets capping hill-tops, and separated from any cones. The writings of Desmarest,† Montlosier,‡ Dolomieu,§ and others, ought to have settled for ever the truly igneous origin of the basaltic rocks.

While this question was still in dispute, Werner began his career at Freiberg. Devoting himself with great industry and enthusiasm to mineralogy, he was thence naturally led to consider the formation of rocks. The hills of Saxony furnished him with material, out of which he constructed a system that was meant to explain the structure of the globe. He taught that instead of framing theories of the history of the planet, it was needful first of all to ascertain the nature and distribution of the strata composing the earth's crust. This investigation he termed "geognosy." But his own example serves to illustrate the fact that we cannot go on as mere machines, laboriously collecting facts, without consciously or unconsciously framing some hypothesis to give them a living connection. While disclaiming the theories of the cosmologists, Werner himself framed a theory not less crude and unfounded than the wildest of those which he opposed. Turning his extensive knowledge of mineralogy to the investigation

* In the year 1787 a natural history society at Berne proposed as a subject for investigation the question "What is basalt? is it volcanic or is it not?" and adjudged the prize to Widenmann's essay, in which non-volcanicity was maintained. In 1804 a similar subject was offered for a prize essay by the *Gesellschaft Naturforschender Freunde* at Berlin.—K. C. von Leonhard's "Basalt-Gebilde," vol. i., p. 2, *note*.

† Histoire de l'Academie Royale des Sciences Naturelles, ann. 1771, pp. 23, 705; ann. 1777, pp. 39, 599.

‡ Essai sur la Théorie des Volcans d'Auvergne. Clermont, 1789.

§ *Journal des Mines*, No. 41, p. 393; No. 42, p. 405.

of rock-masses, he introduced into their study a precision of nomenclature such as had never before been attempted. The rocks thus strictly defined were traced by him in what he believed to be a certain order throughout his little domain of Saxony; but, full of enthusiasm in his subject, he easily persuaded himself that what seemed to him to be the sequence in that territory was the normal sequence for the whole globe. His system of geognosy, being thus simple, and capable of ready application elsewhere, soon acquired notoriety. It saved labour in investigating the geological structure of a country, since it assumed that, when once the true nature of the rocks had been determined, a reference to Werner's table of sequence would show what must needs be their relative position. It was enforced, too, with such eloquence, that men from all parts of Europe came to listen to the Freiberg teacher, who had discovered a key to unlock the hitherto hidden history of the globe. Though Werner wrote almost nothing himself, yet his many illustrious pupils have fully expounded his teaching.*

The fundamental idea of the Wernerian doctrines was that the visible portion of the earth's crust consists of successive layers which were deposited universally, chiefly as chemical precipitates from an original ocean that overspread the whole globe. Werner assumed that there had always been inequalities of the earth's surface, and that on the retirement of the waters the first rock to emerge was the earliest that had been thrown down from solution, viz., granite. In this way he accounted for the position of this rock along mountain crests. Next in succession came deposits of gneiss, mica-schist, and clay-slate, with porphyry, quartz, and other crystalline masses. The highly inclined position of these strata, which had been adduced by Hutton as irrefragible proofs of disturbance and upheaval, were calmly regarded by the Freiberg school as the original form in which the material had been deposited, though the effect of subsidence in producing disturbance of the masses was sometimes admitted. In none of these higher and older rocks had any organic

* The best expositions in English of the Wernerian geognosy are those of Jameson, quoted in subsequent pages.

remains been found. It was accordingly inferred that they had been formed before the appearance of plants and animals. As the sea still retired and additional land came to be exposed, mechanical deposits were necessarily mingled with those of a chemical nature. These strata received the name of "transition" rocks, and were regarded by Werner as having been "deposited during the passage or transition of the earth from its chaotic to its habitable state"* and as marking the gradation from the primitive purely chemical depositions to the more recent mechanical accumulations of gravel, sand, and mud. It was at the epoch of their formation that plant and animal life made its entry upon the earth. The transition strata, necessarily occupying ground lower than the mountainous protuberances of the primitive masses, were by the continued subsidence of the ocean in part uncovered, and being consequently attacked by the waves, served to supply some of the detritus which was now spread over the sea floor to form what were called the "floetz" rocks. These, consisting partly of chemical, partly of mechanical deposits, extended over the whole globe as "universal formations." They included what were called the "Floetz-traps," "greenstones," basalts, porphyries, and other rocks which Hutton and his school in this country, and Desmarest, Montlosier, Voight, Dolomieu, and many others on the Continent had insisted were of igneous origin. These crystalline masses were regarded by the Wernerians as chemical depositions "formed by a deluge, that is, by a sudden rising and retiring of the waters of the globe."†

These crude notions taking their rise within the narrow confines of Saxony, bear witness to the limited experience of their founder, who with his keen powers of observation would assuredly have vastly modified them had it been his good fortune to enlarge his views by extended travel. His dicta, expressive of authoritative certainty, were implicitly accepted by his followers, not as mere hypothesis, but as indisputable fact. Seldom in modern times has there been such unconditional acceptance of a master's *ipse dixit* by his followers. The

* Jameson: "System of Mineralogy," vol. iii., 1808, p. 145.

† Jameson, *op. cit.*

fact that Werner had made a statement on any subject was cited as a sufficient answer to any objection or argument. At the same time it is amusing to read the ill-suppressed contempt which these writers express for theorists. "We should form," says one of them, "a very false conception of the Wernerian geognosy were we to believe it to have any resemblance to those monstrosities known under the name of Theories of the Earth." It seems never to have occurred to them that under the belief that they were making nature her own interpreter, they were themselves so blinded by theory as to be incapable of realising some of the most simple and obvious facts in geological structure.

Looking back from the present stand point of science we cannot but wonder on what chemical principles the Wernerians satisfied themselves that the rocks of the earth's crust could have been precipitated from aqueous solution, and by what physical principles they explained the retirement of the ocean. They would admit of no subterranean movement. They asserted that the original ocean must have reached at least as high as the highest mountain peak. Whither did the retiring waters escape? Some Wernerian writers supposed them to have found their way into subterranean cavities. This absurd notion was ridiculed by others who frankly confessed that they could not solve the difficulty. "But," says Jameson very näively, "although we cannot give any very satisfactory answer to the question" [he prudently gave no answer at all] "*it is evident that the theory of the diminution of the waters remains equally probable.* We may be fully convinced of its truth, and are so, although we may not be able to explain it. To know from observation that a great phenomenon took place is a very different thing from ascertaining how it happened." * A very different thing indeed! Yet one would suppose that the impossibility of explaining the "theory" might have suggested doubts whether the "observation" on which it was based could really be reliable.

But besides the difficulty of accounting for the progressive retirement of the ocean still greater complication was intro-

* *Op. cit.*, vol. iii., p. 82.

duced into the problem by the assertion that during the general subsidence there were occasional intervals when the level of the sea rose again. By what conceivable mechanism this rise took place is not explained.

The existence and influence of subterranean heat were quietly ignored by the Wernerians. They refused to recognise any proofs of general subterranean heat, and consequent volcanic action. They could not deny the existence of volcanoes, but they minimised their importance as much as possible, regarding them as merely local and superficial phenomena due to the inflammation of beds of subterranean coal. They asserted that volcanoes occur only in coal districts that have been covered with sheets of basalt, and that the coal, undergoing spontaneous combustion with access of water, gives out so much heat as to melt the overlying basalt, and cause it to flow into the hollows, whence it is expelled by the force of ascending aqueous vapour.*

If modern volcanoes, with their copious outflows of lava were thus explained, we need not wonder that the idea of the existence of ancient lavas all over the world, of diverse ages, and utterly independent of any coal deposits, was ridiculed as one of the "monstrosities" of speculation against which the sober, inductive spirit of Wernerianism had to wage unrelenting warfare. So prejudiced were the Wernerian geognosts that they refused to admit the igneous origin even of obsidian and pumice, rocks in which an illiterate peasantry had long recognised the traces of fire. They had even the boldness to assert that pumice had been "ascertained to be an aquatic product," because it alternates with basalt and porphyry, passes into obsidian and pearlstone, and "has never been observed to flow in streams from the crater and sides of a volcano," and because "no one ever saw it forming a stream in countries containing extinct volcanoes."†

The genius of Werner may be estimated, if not from his writings, certainly from the number of his followers and the enthusiasm with which they left Freiberg to apply his system to the elucidation of the geognosy of all parts of the

* Jameson, *op. cit.* iii., p. 219.

† Jameson, *op. cit.*, iii., p. 196.

world. It is noteworthy, however, that the most illustrious of them, after loyally striving to uphold their master's teaching about universal formations and the aqueous origin of the crystalline rocks, were compelled by the evidence of nature herself to abandon it. L. von Buch, Humboldt, and Daubuisson are memorable examples of this conversion.

The first Wernerian propagandist who appeared in this country was Robert Jameson. Having devoted himself more especially to mineralogy, he made a series of journeys through the Shetland, Orkney, and Western Islands, and published the results in two works. He adopted the system of Werner, and in his "Mineralogy of the Scottish Isles," published in the year 1800, gave the first account of that system which had yet appeared in England. In this essay he declares emphatically his dissent from the views of those who would maintain the volcanic origin of basalt. "I do not hesitate a moment in saying," he remarks, "that in my opinion there is not in all Scotland a vestige of a volcano."*

Attracted by the fame of the Freiberg school, Jameson went thither in the year 1800 and studied under Werner. In his absence, the "Illustrations of the Huttonian Theory" appeared in 1802. But that the leaven of Wernerianism introduced by him was already at work was shown a few months after the issue of Playfair's volume by the appearance of an anonymous answer to it, in which the respective merits of the Plutonist and Neptunist systems were contrasted greatly to the detriment of the former.†

In 1804, Jameson, fresh from Freiberg, was appointed to the Chair of Natural History in the Edinburgh University, vacant by the death of Dr Walker. Never did a more uncompromising disciple leave the Saxon school. Not only was

* Mineralogy of the Scottish Isles, vol. i., p. 5. This assertion was made in reference to the observations of Faujas St Fond, who, visiting Scotland in 1784, had been struck with the abundant traces of volcanic rocks, and had stated his views in his interesting "Voyage en Angleterre et en Ecosse, et aux Iles Hebrides," 2 vols. small 4to, Paris, 1797.

† This work, first published anonymously, but forming the fourth volume of Murray's "System of Chemistry," was afterwards translated into French by C. A. Basset, and published at Paris, together with a French edition of the "Illustrations" in 1815.

he imbued with Werner's doctrines, his writings now bristled with German words, and with English phrases built on a thoroughly German model.*

To Jameson's enthusiasm for science, and his great services, not only to his own favourite department, mineralogy, but to the cause of natural history, which he taught here for half a century, the best testimony is to be found in the crowd of distinguished naturalists who have been trained under him. With sincere veneration for his memory, and a grateful recognition of his eminent services, I must confess my own conviction that his éarly influence on the progress of geological science in this country was disastrous. He returned from Freiberg at a time when Hutton's views were beginning to attract general attention, and when Hall was in the full pursuit of his experimental researches. Had the university teaching of geology been in accord with the distinctively Scottish school, what might not have been achieved by the labours of the devoted band which the geniality and the energy of the new professor now gathered around him! But from the first he set himself stubbornly against Plutonist views in any shape; could scarcely, indeed, restrain some contemptuous expression when he had occasion to refer to them. It is true that the opposition which he raised to these views kept alive an interest in the subject, and indirectly advanced the science. But the advantage derived from this source cannot be regarded as having afforded more than a very slight compensation for the injury done by the arrest, and almost extinction, which Wernerianism under Jameson effected on the progress of true geology here.†

* Among the characters of minerals, for example, we find such definitions as "not particularly difficultly frangible," "not particularly heavy, approaching to light," "between hard and semi-hard," "saltly bitter," "metallic glimmering," etc.—these phrases being followed by the German terms of which they were translations.—(Treatise on the External, Chemical, and Physical Characters of Minerals.)

† It is interesting to read the judgment pronounced on Jameson's standing by one of his German contemporaries, K. C. von Leonhard, published in 1832: "Jameson wurde in Freiberg so fest und unerschütterlich für die anti-vulkanische Lehre eingenommen dass er sich von ihrer Unhaltbarkeit nicht überzeugen konnte. Sie galt ihm als feste und unveränderliche Grundlage. Von dieser Vorstellungs-Art hätte er allerdings um so mehr abkommen sollen

One of the first tasks undertaken by Jameson after his appointment as Professor of Natural History was the publication of a "Mineralogical Description of the County of Dumfries." This work was dedicated to Werner and Kirwan, a conjunction of names which must have been to the Huttonians ominous of the line to be taken by the new professor. The book was intended to be the first of a series of similar essays, in which the mineralogy of every part of Scotland should be described; but it remains the only one of the series ever completed. It may be taken, like Daubuisson's "Monograph on the Basalts of Saxony," as a typical example of the Wernerian geognostical method.

In introducing his volume to the notice of its readers, Jameson informed them that its plan, being that which he intended to follow in all his future labours in geognosy, was different from any hitherto proposed; but that, from its concordance with the principles of the Wernerian geognosy, he believed that it would be found to give a clear and comprehensive view of the external aspect and internal structure and materials of a region. He begins with a sketch of the physical geography of Dumfriesshire, which gives an opportunity for introducing the Wernerian cosmogony. He then proceeds to describe the distribution of the various kinds of rock or

da sein heimathliches Land ganz vorzüglich geeignet ist die Verhältnisse der Diuge zu durchschauen. Allein im Unglauben an vulkanische Wirkungen wurden die Beobachtungen einseitig aufgenommen und Erklärungs-Weisen gewählt welche die Schwierigkeiten nur weiter hinausschoben, ohne sie zu heben, ja im Gegentheile unauflösliche Zweifel enstehen liessen. So musste Jameson beim besten Willen und bei der grössten Wahrheits-Liebe in gewissen Irrthümern verharren; selbst bei manchen seiner neuern Schriften glaubt man in eine viel ältere Zeit hinüberzublicken." Full justice is then done by this writer to the value of Jameson's geognostical work.—(*Die Basalt-Gebilde.* Stuttgart, 1832. Band. i., 39.) In another passage of the same book, von Leonhard thus writes of the influence of Wernerianism in Scotland: "Obwohl Schottland die Heimath des berühmten Stifters der plutonischen Lehre, wo das schöne Licht vulkanischen Wissens, des freiern Denkens sich entzündete, seit den lezten Jahrzehnden viele und höchst wichtige Aufklärung geboten über den Gegenstand, welcher uns beschäftigt [*i-e.*, die Basalte], so bedarf es dennoch nur einiger Kenntniss der neuern dortländischen Litteratur, um zu wissen, das selbst auf diesem, für den Vulcanismus so musterhaften Boden, *die antineptunische Meinung keineswegs die herrschende* gewesen."—(*Op. cit.*, p. 21.) This was deliberately published even so late as a quarter of a century after the founding of the Wernerian Society.

formations. But beyond the fact that the greywacke and slate are the oldest formations over which come the "independent coal formation," and the "newest floetz-trap," he gives hardly any indication of the geological structure of the country. Each variety of rock is described with care, but with reference to the Wernerian sequence rather than to their relations to each other as constituents of the rocky crust. In particular, the interesting lava beds interstratified at the base of the Carboniferous series of the south of Scotland are dismissed in three pages, in which their position over the red sandstones and their trend from the Annan to the Esk are the most important circumstances narrated. In this and the other geognostical productions of the time the writers kept before them two main subjects of inquiry—the mineralogical nature and varieties of rocks and their superficial distribution. The Wernerian sequence of formations settled the order of succession among the rocks, and happily put out of sight those problems of geological structure which every field geologist must now grapple with at the outset.

In the course of his examination of Dumfriesshire, Jameson came upon the "pitchstone" which has been already referred to. He was disposed to consider his discovery of it as a matter of some importance, for he mentions it among the more notable results of his survey. As his description of the rock, besides its connection with the subject of the present communication, is a fair example of Wernerian geognosy, I give it here in full.

"At Todshaw Hill, and the hills called Castle Hill, Watch Craig, and Wat Carrick, near the manse of Eskdalemuir, which are composed of compact greywacke, there are several summits covered with greyish-black-coloured pitchstone. The pitchstone is unstratified, and lies over the much inclined strata of greywacke. In the same hills there is porphyry slate which, like the pitchstone, occurs in globular and columnar distinct concretions. Sometimes *contemporaneous* masses of pitchstone are to be seen enclosed in the porphyry-slate or basalt, and globular distinct concretions, whose centres are pitchstone, but the surfaces of a substance much resembling porphyry-slate. We can also observe the transition from pitchstone to porphyry-slate or basalt.*

"This pitchstone, from its occurring along with porphyry-slate, and lying over transition rocks, is to be referred to the newest floetz-trap formation.†

"*Observations.*

"Werner has hitherto described but one pitchstone formation, and it belongs to the primitive rocks. Several years ago I observed, in the highly interesting island of Arran, pitchstone alternating with floetz greenstone that lay over the independent coal formation.‡ Afterwards I saw it in veins traversing floetz-trap rocks in the Isle of Eigg§, and among similar rocks in the Isle of Mull.||

"Since that time Werner has examined the black pitchstone of Zwickau in Upper Saxony, which he considers to belong to a similar formation. Mr Humboldt, the celebrated and enterprising Prussian traveller, whilst on the summit of the Pic of Teneriffe, observed beds of pitchstone among floetz-trap rocks; and I have seen in the interesting collection of Captain-General von Charpentier specimens of a similar fossil that was found in the basaltic country of the Veronese. We have thus proofs that this pitchstone is subordinate to the floetz-trap formation, and that it is widely distributed." ¶

Three years after the appearance of the volume from which these extracts are taken, Jameson gathered his followers

* "This pitchstone like that of Glencloy, in the island of Arran, will probably be found to contain bituminous or carbonaceous matter. The pitchstone of Glencloy, when powdered, emits a bituminous smell, and colours the sulphuric acid slightly ('Mineralogy of the Scottish Isles,' vol. i., p. 48). Basalts and other rocks belonging to the same formation contain, according to Klaproth and Lampadius, bituminous or carbonaceous matter; and Mr Pepys has discovered carbonaceous matter in wood opal and wood stone.—Parkinson on Petrifactions, vol. i."

† "Dr Reuss, of Bilin, is of opinion that porphyry-slate occurs in older formations than the floetz-trap; and Captain-General von Charpentier says that basalt sometimes occurs in primitive mountains. Both these observations, as I have shown in my book on Mineralogy, are incorrect."

‡ "Mineralogy of the Scottish Isles," vol. i., p. 23.

§ *Ibid.*, vol. ii., p. 44.

|| *Ibid.*, vol. i., p. 213.

¶ Mineralogical Description of Dumfriesshire, pp. 115-117.

together and founded the Wernerian Society, of which he was first President, and, whilst it existed, its main buttress. At one of the earliest meetings of this institution he propounded a series of mineralogical queries, among which we find the following—"What are the extent and particular geognostic relations of the black pitchstone of Eskdalemuir, in Dumfriesshire?"

This query, so far as I have been able to discover, received no further elucidation from Jameson himself, and has not been regarded by any subsequent investigator. The answer which now can be given to it will be in some measure an indication of the progress of petrography during nearly three-quarters of a century.

Part II.—Stratigraphical.

The first point to be noticed refers to the name bestowed by Jameson upon the substance he described. The Wernerians, being especially proud of their mineralogy, seldom lost an opportunity of pointing out the defectiveness of that of their Vulcanist opponents. It is curious, however, to find that Jameson was himself in error when he identified this Eskdale rock as pitchstone. He states that the rock passes into basalt. But true pitchstone, such as that with which he was familiar in Arran and elsewhere, contains somewhere about 65 per cent. of silica, while in basalt the proportion of this oxide is not more than from 45 to 55 per cent. It is incredible, therefore, that crystalline basic basalt can pass in the same little hill into vitreous acid pitchstone. Some years ago, being confident that the rock could be no other than one of the vitreous conditions of basalt which I have found in many basalt dykes both on the mainland and among the Western Islands, I made an excursion into Eskdalemuir, and found that this was undoubtedly the case.

Another and more important mistake was committed by Jameson in his determination of the geological structure of the locality. He says that the hill-tops are covered with pitchstone, which overlies the much-inclined strata of greywacke. Now, in reality, the vitreous rock forms only a part of the black mass of these summits (which is in great measure crystalline dolerite), and, instead of lying upon the ends of the greywacke beds, rises through them as a massive dyke. This dyke has been carefully traced and mapped by my colleagues in the Geological Survey, Mr B. N. Peach and Mr H. M. Skae, from the Leadhills in Lanarkshire all the way to Liddesdale (a distance of fully forty-five miles), and Mr J. G. G. Wilson has followed it for some miles farther into England. It forms one of the vast series of basalt dykes which traverse the north of England and a great part of Scotland, in a general east and west or south-east and north-west direction. Many years ago I pointed out that these dykes may be traced westwards in ever-increasing numbers, till they reach the Miocene volcanic plateaux of the north of Ireland and the Inner Hebrides; that they cross rocks of different ages, including the chalk and the older parts of the Tertiary volcanic sheets; that they cross large faults without deflection or interruption.* From these facts I afterwards inferred that the dykes must be on the whole of Tertiary age, and that they form part of that remarkable series of volcanic eruptions which produced the terraced hills of Antrim, Mull, Morven, Eigg, and Skye.† Subsequent investigation has fully borne out this inference.

When the extraordinary number and the remarkable prevalence of these dykes are considered, together with the extensive area over which they may be traced, they are found to present problems of great difficulty. I have observed them among the Orkney Islands and in Caithness, and have followed them southwards along the whole length of Scotland into the north of England. In some districts, particularly as they approach the great basaltic plateaux of the west, they become so numerous as to form one of the most prominent features in the scenery as well as the geology of the districts. The remarkable dykes of the coast lines of Cumbrae, Ayrshire, Arran, Jura, Islay, Pabba, and Skye are familiar to all passing travellers. It seems hardly credible that such prodigious

* *Trans. Roy. Soc. Edin.*, 1860, xxii., p. 650.

† *Trans. Roy. Soc. Edin.*, 1866-67. British Association Report for 1867, Sect., p. 52.

quantities of molten rock should have ascended so many fissures over such an extended area without somewhere flowing out at the surface. Yet to the east of the line of great basalt plateaux there are no proofs of any such superficial outflow having occurred, unless certain erupted sheets in the Lanarkshire and Stirlingshire coalfields can be so regarded.

That an enormous amount of the general denudation of this country has taken place since the extravasation of the dykes is shown by innumerable instances in which the dykes run along the crests of hills and cross important valleys. It is manifest that the hills could not have had their present form and altitude, otherwise the basalt, if it reached the surface along their crests, would have poured down their sides. It is equally obvious that where a dyke runs as a bold prominent rib down either side of a valley, the valley, at least at its present depth and form, must have been eroded since the dyke was erupted. By evidence of this kind it can be shown that to a large extent the existing valleys of this country have been excavated since Miocene times.* In this vast denudation it is possible that sheets of basalt that were formerly spread over various parts of the country as outflows from the dykes, have been wholly removed. But when we consider the durability of this rock in massive sheets, we are led to doubt whether any extensive superficial outpourings ever took place except over the great western plateaux.†

During many years of exploration among the Tertiary volcanic rocks of this country, I have been often struck with the remarkable infrequence of traces of any true associated volcanic vents, such as those which occur so abundantly in connection with the Palæozoic igneous rocks. Over the wide area of the mainland of Scotland and northern England—an area thousands of square miles in extent—where the basalt dykes can now be traced at the surface, not a single

* See *Quart. Jour. Geol. Soc.*, 1871, p. 310., and *Trans. Roy. Soc. Edin.*, loc. cit.

† That veteran geologist, Dr Ami Boué (who still lives to take an interest in Scottish geology), realised the difficulties presented by the dykes, but conceived that the melted rock might have been supplied from above by superficial sheets of moving lava, though he admitted that this idea involves the necessity of enormous denudation.—*Esquisse Géologique sur l'Ecosse*, p. 272.

"neck" or pipe can be referred to the Tertiary period. Among the terraced basalt plateaux of Antrim and the Inner Hebrides one finds the same want of evidence of cones and craters from which these wide sheets of lava proceeded.* Mile after mile the beds of basalt may be followed in nearly horizontal position with wonderful persistence and uniformity of thickness. Very rarely, too, are they separated from each other by beds of tuff. Unlike the mingled sheets of lava and ashes constituting the materials ejected from such cones as Vesuvius or Etna, the Miocene basalts form nearly the whole of their great plateaux, with here and there thin bands of clay or coal full of the remains of the terrestrial vegetation covering the land which they overflowed. I am persuaded that the explanation of the origin of these widely extended sheets of basalt is to be sought not in the familiar or Vesuvius type of a volcano, but in those great fields of lava which cover such wide tracts in the Western States and territories of North America and in the Deccan. According to Whitney, the area covered by lavas between the Sierra Nevada and the Rocky Mountains fully equals the whole extent of France. As has been well shown by that geologist, by Richthofen, King, Hayden, and many other observers, these basaltic floods belong to the closing epochs of volcanic activity, after a long succession of earlier rhyolitic and trachytic eruptions. In a recent visit to the basalt plain of the Snake River, in Idaho, I was greatly impressed by the analogies presented by it to some of the more notable features of our Tertiary basalt plateaux. The basalt of that arid plain has flowed along the base of the hills, running in and out exactly as a lake of water does round the bays and promontories of its margin. Many of these hills are formed of trachyte which had been much eroded into hollows before the eruption of the basalt. The great Cañon of the Snake River has been excavated through the cake of basalt and partly in the under-

* Mr Judd (*Quart. Jour. Geol. Soc.*, vol. xxxii., p. 292) has described what he believes to have been some of the miocene vents of the West Highlands; but even on this view they are altogether inadequate to have supplied the immense volume of lava, while they leave unexplained the persistence, horizontality, and regularity of the basalt sheets and the absence of tuffs.

lying sheets of trachyte. Mr Clarence King states his belief that some single sheets of basalt have flowed at very gentle angles for 50 or 60 miles.* The sheets, however, are so flat and so like each other, that unless a given bed were followed without any breach of continuity in the observation, it could not, I fear, be certainly identified at distant points. Here and there small *puy*-like cones have been formed more recently upon the basalt floor of this region, but these are few in number, and do not much affect the extraordinary monotony of the apparently limitless desert plain. I could nowhere see any trace of tuff between the sheets of basalt, but here and there lay beds of sand and gravel, or a thin seam of red bole appeared, like those which occur in Antrim, Skye, and Mull.

The absence of any cone or cones which could have supplied such a vast flood of basalt and the remarkable horizontality and persistence of the successive sheets seem to me strongly to favour Richthofen's suggestion of fissure eruptions, by which the basalt welled out from many openings without the emission of accompanying ashes and scoriæ. The surface of the basalt plain likewise bears its evidence in the same direction. When looked at from above it seems nearly level, but on closer examination is found to be traversed by wave-like undulations of columnar compact basalt, many of which have split along the crest so as to show a trench with ranges of columns on either side.

That in Britain during Miocene times there were many thousands of fissure eruptions, without accompanying fragmentary discharges or the production of cones, is certain from the evidence of the innumerable east and west dykes. I am disposed to look upon the great basalt plateaux of the north of Ireland, the west of Scotland, and the Faroe Islands, as representing part of the subærial outflow from some of these fissures. From this point of view the dykes acquire a new interest, inasmuch as they reveal to us some of the features of a remarkable type of volcanic action, and stand to fissure eruptions in the same relation that "necks" do to eruptions from distinct cones.

* Geological Exploration of the 40th Parallel, vol. i., p. 593.

The Eskdale dyke has thus more than merely local interest. It forms one of a vast series of fissures up which, during Tertiary time, lava has risen, and its careful study may do something towards the elucidation of the mechanism of the eruptions to which it owes its origin.

The north-western limit to which this dyke has been traced may not be its actual termination in that quarter. A short way further north several similar dykes appear and continue in the same direction for many miles towards the north-west. It is not always possible to find continuous evidence of the presence of dykes at the surface, partly of course from the depth of soil or superficial drifts, but partly also, no doubt, because a dyke, though continuous at some depth below, did not everywhere rise equally near the surface. The remarkable series of dykes which runs through the high ground round the sources of the Tweed, Annan, and Clyde may therefore be parts of one subterranean mass of igneous material which, running on towards the north-west, reappears in great force at the surface along the shores of the Firth of Clyde. The coast-line from Ardrossan to Gourock is traversed by many large and small veins of basalt. The convergence of the dykes in the counties of Ayr, Renfrew, Dumbarton, Stirling, and Lanark towards the angle of the Clyde estuary, opposite the mouth of Loch Long, is remarkable.

From where it first appears among the high ground to the north of the village of Leadhills, the Eskdalemuir dyke runs in a tolerably straight course towards the south-east, across the range of the Lowther Hills, the valley of the Powtrail Water, and the high grounds surrounding the upper part of the valley of the Clyde, until it descends into the broad plain of Annandale below Moffat. Here it is lost under the alluvial floor of the valley, but it reappears immediately among the slopes on the east side, whence it pursues a persistent though somewhat tortuous course across hill and dale until it reaches the Esk, where Jameson's observations were made. Crossing this river, it keeps along the line of the valley as far as Langholm, where, mounting up into the moors drained by the Tinnis Water, it finds its way across into the dale of the Liddel, and passes thence into England. How much further it continues towards the south-east I have not yet ascertained.

Throughout this long course the breadth of the dyke varies considerably, averaging probably about forty feet. Where the edge of the dyke permits observations to be made, the basalt always appears to fill a fissure, either vertical or inclined at a high angle with the horizon. For most of its course the dyke runs through steeply-dipping, folded, and fractured Lower Silurian rocks; but the fissure up which it has risen has been opened in these rocks as a long persistent dislocation, that has been little, if at all, affected by the structure of the rocks through which it runs. In Eskdale the dyke enters the Upper Silurian belt, likewise without deflection, though it is observed to curve round with the trend of the valley of the Esk. Beyond Langholm it crosses the volcanic zone at the base of the Carboniferous Series, and then the overlying sandstone, shale, and limestone groups, with equal indifference and continuity.

Part III.—Petrographical.

Throughout most of its course this dyke consists of an ordinary crystalline-granular dolerite, weathering into the usual rudely spheroidal blocks which, scattered over the hills along its route, indicate its position. In Eskdale it presents a more complex structure. It there consists of three portions (Pl. V., fig. 1). On either side lies a zone of the usual dolerite, about eight feet broad. Between these two marginal zones comes a central band, sixteen to eighteen feet broad, of a very compact, vitreous basalt—Jameson's "pitchstone." In the two outer belts of rock there is no feature of special importance to be noted. Along their junction with the highly inclined greywacke and shale, they assume the normal fine-grained texture, but show no trace of a glassy character. The central vitreous band, on the other hand, presents several curious features which are readily visible in the field. The line of demarcation between this band and the marginal dolerite zones is quite sharp. The vitreous rock stands up prominently as a wall, on the outer surface of which a curious series of polygonal reticulations may be observed. These, as shown on Pl. V., fig. 2, consist of prominent ribs, each about a couple of inches broad, enclosing shallow, cup-shaped hollows. This external sculpturing arises from the internal prismatic structure of the vitreous band. The prisms are, of course, approximately horizontal, being directed from the nearly vertical walls of the band. Each consists of a central core of vitreous rock, with an external sheath of dull and, to the eye, apparently more crystalline and devitrified rock. It is the union of the sheaths of contiguous prisms which has formed these prominent ribs. Each rib is thus composed of the outer shell of two prisms, the dividing line between which is marked by a suture along the centre of the rib. Moreover, each rib is cut into small segments by a system of close joints, which are placed generally at a right angle to the course of the rib. (Plate V., figs. 2, 3, and 4.)

On breaking open the vitreous cores of the prisms, we perceive that the rock, deep iron-black in colour, has a peculiar vitreous glaze quite unlike that of an ordinary basalt; that here and there the black glass of the base is segregated into kernels or irregular patches, in which can generally be detected one or more amygdules of chalcedony, but some of which have a black empty internal cavity, and that throughout the rock devitrification has proceeded so far as to allow of the individualisation of the triclinic felspar (of which distinct facettes can be seen with a lens), and evidently also of other minerals. Occasionally rounded green grains may be observed, which recall the olivines of common basalt. The rock is remarkably close-grained, breaking with a splintery, sub-conchoidal fracture. It is tolerably homogeneous in texture, the most prominent feature being the patches of black glass of all sizes up to that of a small bean, and the occasional amygdules of dull white chalcedony.

The hard prominent ribs which divide the vitreous cores along the margin of the central band of the dyke, present to the naked eye a texture which recalls that of many somewhat decayed felsites. The rock, instead of the vitreous lustre of the central portions, has a dull aspect, with numerous minute glimmering points, and many dispersed crystals of triclinic felspar. A minutely crystalline structure is indicated by the abundant kaolinised felspars on its weathered surface. Yet, different though they are in outward aspect, there can be no doubt that these ribs, or rather sheaths, and the internal vitreous cores which they surround, were originally parts of the same molten mass, and that the present contrast of texture must be referred to some subsequent alteration. The real nature of the difference of texture, however, could only be satisfactorily examined by the aid of the microscope.

In nothing does the petrography of to-day stand out in greater contrast to that of Jameson's time, than in the employment of the microscope as one of the great instruments of research. In this connection it is interesting to remember that it was here, in Edinburgh, that William Nicol first devised the method of making sections of mineral substances, which, cemented with Canada balsam on glass, could be reduced to any desired degree of thinness and transparency. The applicability of this method to the study of rocks, was not perceived for many years. The late Mr Alexander Bryson, our fellow-townsman, had for some time employed it in the preparation of slices of quartz and other minerals in granite, showing cavities partially filled with fluid. It was the examination of his collection that suggested to Mr Sorby the important aid likely to be afforded by the microscope to some branches of geological inquiry.* Mr Sorby soon set to work on the subject, and produced in 1857 his great paper on the "Microscopical Structures of Crystals, indicating the origin of minerals and rocks." † With the appearance of this memoir a new era began in the study of rocks. Not long after its publication, the subject was taken up by Zirkel in Germany, where it has been since pursued with ever increasing interest and enthusiasm by a continually augmenting band of observers. The literature of microscopic petrography is already voluminous, and bids fair to go on in rapid multiplication, for geologists have now very generally recog-

* See Mr Sorby's paper, *Quart. Jour. Geol. Soc.*, xiv., p. 454.

† *Op cit.*, p. 453.

nised that the old methods of study are inadequate. They admit that a chemical analysis, on which they used implicitly to rest, can after all tell us only the chemical elements of a rock or mineral. What may be the combination of these elements must be a matter of inference, unless the actual internal structure of the rock can be scrutinised. But it is here that the microscope comes in to our aid, laying open to the eye the forms in which the chemical constituents have been combined, and the structure of the rocks which they compose. Hence as questions of structure necessarily involve questions of origin, the genesis of rock-masses can often be followed with singular clearness by microscopic research. Moreover, all rocks exposed to the influence of the atmosphere or of percolating water, are subject to more or less alteration. In the microscope we are furnished with an admirable implement for tracing these changes from their first beginning onward until the total obliteration of original structure and composition.

I offer here the results of a microscopic examination of the Eskdale dyke, first of the doleritic external band and then of the vitreous centre.

(1.) *Microscopic Structure of the Dolerite forming the marginal bands of the dyke.*

I have already remarked that the dolerite on either side of the Eskdale dyke shows the usual crystalline character, except towards the line of contact with the surrounding greywacke and shale, where, at the Shaw Burn and elsewhere, it presents the close-grained texture commonly to be observed in an intrusive mass along its contact with the rocks which it has invaded. The general character of this fine-grained, or chilled, edge of the dolerite, as seen under a magnifying power of forty diameters, is represented in fig. 1 of Pl. VI. There can be no doubt that the marginal portions of dykes and intrusive sheets represent earlier stages in the solidification of the once molten masses. Chilled by contact with the surrounding rocks, the basalt or dolerite was rapidly congealed; while further away, where cooling was more prolonged, the conditions were more favourable for crystallisation. The marginal portion, therefore, represents more nearly than the central part what was the condition of the rock at the time of emission from below.

The fine-grained outer layer of the Eskdale dyke shows under the microscope no glass. It has been entirely devitrified. Its most abundant mineral is the triclinic felspar (probably labradorite) which occurs in thin prisms, ranging from $\frac{1}{500}$ to less than $\frac{1}{1000}$ of an inch in diameter. In the specimens I have examined no large porphyritic prisms occur among these minute forms. The augite may be observed in its two common forms, minutely and irregularly granulated or drop-like, and also in well-defined crystals not unfrequently twinned. Among the granules sometimes crystalline faces and angles may be observed, and they always act on polarised light, so that they are not mere glass. The augite prisms, with well characterised forms, have sometimes a diameter of $\frac{1}{70}$ of an inch, and thus attain a considerably larger size than the felspar—a relation the reverse of that which I have usually found to obtain among the dykes and intrusive sheets in Scotland. The magnetite occurs in exceedingly minute octahedra, which may average perhaps $\frac{1}{5000}$ of an inch in diameter. They are found both singly and ranged in small rod-like aggregations. I observed no olivine. On rotating a slice of the rock between crossed Nicol prisms, no portion remains persistently dark, but between the recognisable crystals indefinite fibres and granules make their appearance, which no doubt represent the devitrification of an original glassy base. A slight alteration from weathering, which the rock has undergone, seems to have affected the indefinite ground-mass more than the crystalline constituents.

The central or more thoroughly crystalline portion of the dolerite presents, under a magnifying power of forty diameters, the general character represented in fig. 2 of Pl. VI. It is a dolerite of the normal type among the Tertiary and Carboniferous volcanic rocks of Scotland. At Shaw Burn this character is well exhibited. The large, clear, and striated prisms of labradorite are there the most conspicuous constituents of the rock, when examined under the microscope. The augite occurs in small prisms, which from their imperfection often assume the form of irregular crystalline granules. The magnetite occurs in abundant and tolerably well defined crystals. No olivine was observed. These minerals are dispersed through a base relatively small in quantity, and with distinct action on polarised light. This substance is crowded with minute clear microliths, which are often to be observed specially abundant round the augitic ingredients. There occur also curved, club-shaped, opaque microliths, which occasionally radiate in a tufted manner from a common centre. The rock has undergone some alteration, as is shown by filaments of calcite and a good deal of diffused "viridite" and "opacite." A specimen taken from Wat Carrick Hill, rather fresher in condition, shows a large proportion of base of a pale brown tint, dusty or granular, and crowded with fine curved dark-brown to black hairs and straight yellow rod-like microliths. The felspar contains in some of its prisms abundant yellow granules and rods which are probably augite. The augite is well crystallised, but its prisms are remarkably small. The magnetite occupies a less prominent place in the rock, both as to quantity and size of individuals, than at Shaw Burn, its octohedra ranging from $\frac{1}{500}$ of an inch to exceedingly minute form.

(2.) *Microscopic Structure of the Central Vitreous Band.*

The vitreous central band of the Eskdale dyke, or Jameson's "pitchstone," is full of interest when studied with the microscope. Examined with even a low magnifying power it is readily seen to consist of a clear glass through which are diffused abundant crystals of striated felspar, augite, magnetite, and many small microliths.

The Glass.—The abundance of this substance at once marks a strong contrast between the central band and the marginal zones of dolerite. Though black and opaque in thick fragments, the glass in extremely thin sections appears pale brown or almost colourless, and perfectly transparent. For the most part it is remarkably homogeneous, and remains absolutely inert in polarised light. But it is marked by the occurrence of clots and streaks of a rich dark-brown tint, which are also quite unindividualised. The clot-like patches, which may frequently be observed in interspaces between groups of felspar or augite crystals, vary in size from extremely minute, microscopic portions up to these prominent kernels already referred to as so conspicuous to the naked eye. Sometimes streaks may be noticed proceeding from the clots, and following a sinuous course among the crystals. In other cases the clots themselves are made up of confluent streams of dark-brown glass curving round and enclosing groups of crystals or microliths. Curdled patches and streaks of similar darker glass appear all through the rock, and by their current-like flow between the felspars and augites show with great beauty and distinctness the former extremely fluid condition of the mass.

The frequently observed bleaching of a volcanic glass round its enclosed crystals may be here observed in many examples; likewise the contrary effect where the glass attains its blackest opacity along the margins of crystals, especially of the felspars. The bleaching may be observed more particularly round the augite and magnetite, as if the colouring iron oxide had been drawn out of the still unsolidified glass by the attraction of these ferruginous minerals.

It is evident from the beautiful fluxion structure of this glass round its enclosed crystals of felspar, augite, and magnetite, that these minerals had already assumed crystalline forms while the rock still possessed great internal liquidity. Large enclosures of the glass may be noticed in many of the clear felspars. The devitrification of the rock occurs in its incipient stages even in the most glassy parts, and can be traced until the characteristic brown glass disappears among the crowded crystallites.

Crystallites.—Of these rudimentary forms of crystallisation the sections of the rock examined by me present, at least, three kinds—1st, Globulites. What appears under a low power to be a homogeneous, structureless, or sometimes slightly dusty glass can in some places be resolved into an aggregate of globules or granules so minute as just to be visible with a magnifying power of 400 diameters. There appears to be a tendency throughout the glass to assume this globulitic character. It is only here and there, however, that the globulites become large enough to attract notice with low powers of 30 to 50 diameters. In occasional eddies of the fluxion structure, or in interspaces between the crystals, the glass appears with a $1\frac{1}{2}$-inch objective to be somewhat dusty, the dust grains being drawn out into the fluxion streaks, accumulated in little centres between the currents, or massed into clot-like patches. With a higher power these portions are seen to consist of crowds of minute, pale-yellowish, clear, drop-like granules, distributed with considerable uniformity. Applying a magnifying power of 800 diameters, we find that while most of these granules are spherical, not a few are elongated and dichotomous at one or both ends (see fig. 5, Pl. V.). Whatever be their form they are invariably inert in polarised light. The largest do not exceed on an average about $\frac{1}{2000}$ of an inch in diameter, the ordinary spherical globulites averaging perhaps about $\frac{1}{20000}$. In the dusty areas where these globulites are most developed they are not only to be observed in patches and streaks through the glass, but are specially noticeable crowded upon the pale microliths to be immediately described.

2. Opaque Grains and Rods.—Round the augite and magnetite crystals some parts of the glass are rendered dark by a quantity of black dust formed of minute, black, opaque particles, and short, straight fibres. This black border is usually separated from the enclosed crystals by a very narrow interspace of clear glass. Its component grains and straight rods may be magnetite. They are often to be noticed round isolated magnetite crystals, and sometimes arranged in chief mass at two opposite ends of a crystal as if by a kind of magnetic polarity. They also encrust translucent microliths.

3. Microliths. — These are of two varieties—(*a.*) Pale-yellowish, clear, straight dart-shaped rods, ranging from less than $\frac{1}{1000}$ up to fully $\frac{1}{100}$ of an inch in length. In some cases I noticed them curved, and even spiral. They may be observed in all parts of the glass, but chiefly round the crystals and crystalline granular patches of augite. Solitary prisms of this mineral occur in the glass, bristling all round with an armature of these fine spines, and reminding the observer of some radiolarian and foraminiferal forms of life (fig. 5, Pl. VI.). These microliths, so constantly and abundantly divergent

from the augite, show such an affinity for that mineral as to suggest that they are themselves augitic; though it is remarkable to find such well-formed crystals, microliths, and globulites in this conjunction. (*b.*) In areas where the globulites are most developed, the dart-shaped microliths, as above mentioned, are crusted with these bodies. Owing to the irregular way in which this incrustation has taken place, endless variety may be noticed in the resulting club-like shape of the microliths. But through them all may be detected the original simple, dart-like rod, with its envelope of crowded globulites. The more elongated globulites have attached themselves usually by one end. (Fig. 5, Pl. V.)

3. Trichites.—Under this name may be grouped a series of straight, curved, or coiled hair-like opaque fibres, sometimes translucent and isotropic, and then varying in tint from a pale yellow, through shades of dirty green or brown, to black, and in length up to $\frac{1}{50}$ of an inch or more. Some of them consist of an internal pale yellow translucent hair, coated with black opaque matter. These so resemble the microliths that they may be only a form of these bodies. Curved fibre-like microliths, not crusted with globulites but sometimes coated with black opaque matter, occur in prodigious numbers in the Eskdale dyke at Kirkburn, above Langholm. Their general character in mass at that place is shown in fig. 6 of Pl. VI. The interspaces which, in the more vitreous parts of the rock are occupied with pale brown glass are there crowded with these microliths and with globulites, and are no longer inert in polarised light, but present a mottled glimmering from many points, but without any distinct crystalline forms. This is the most complete devitrification which I have met with in undecomposed parts of the Eskdale dyke. It presents not a little resemblance to portions of some of the intrusive basalt-rocks of Carboniferous age in central Scotland.

A remarkable devitrification of the rock is to be observed in those hard "ribs" which I have described as projecting from the wall of the vitreous centre of the dyke, and forming the outer envelope or crust of the vitreous columns. The specimens which I have examined were all obtained from the weathered face of the rock where the contrast between the core and the external sheath is to be seen. Their dull finely crystalline aspect is found to arise mainly from a change in the vitreous magma, whereby the enclosed crystalline constituents are allowed to stand out more prominently. In general arrangement and relative proportion of ingredients the rock does not differ in any marked degree from the glassy portion; but, unfortunately, it is considerably decayed. The felspars are somewhat dull and granular. The augite is plentifully surrounded with diffused "viridite," and the magnetite has no doubt furnished most of the limonite which gives a prevalent yellowish hue to the rock.

The most singular feature, however, in the internal structure of these ribs is the disappearance of the abundant and characteristic glassy base. At first, indeed, when a thin slice is examined under the microscope, the numerous pale brown interspaces which it presents are naturally taken by the observer for the usual glassy substance, though in a somewhat modified form. They even retain what evidently represents the fluxion structure as in the portion drawn in fig. 3 of Pl. VI. But they are no longer passive in polarised light. They have all acquired a crystalline structure, indicated by abundant points of light in the dark field of the crossed prisms. They show under a magnifying power of 400 diameters, traces of globulites and dart-like microliths, with amorphous granules and shred-like filaments.

How far this change in the base is an original one or due to subsequent weathering, the specimens in my possession do not enable me to decide. In ordinary columnar basalt the sutures between the prisms offer convenient channels for the passage of percolating water, and it is evident that where this percolation takes place, the outer parts of the prisms may be more altered than their inner parts. In such cases, however, the greater degree of alteration is usually evident in a more oxidised crumbling aspect. But in this Eskdale dyke it is these inter-columnar parts which stand up most prominently, while the vitreous cores are hollowed out.

The Felspars.—The great majority of the clear prisms so abundantly dispersed through the vitreous base are well striated triclinic felspars. Among them occur water-clear unstriated Carlsbad twins which are probably sanidine. The felspars seem to have been the first minerals to crystallise out of the original magma. They are remarkably sharply defined against the surrounding glass, and vary in size from less than $\frac{1}{1000}$ to fully $\frac{1}{50}$ of an inch in diameter. They frequently enclose portions of the glass, and drop-like granules of augite.

Though they commonly appear in the usual form of elongated strips, with abrupt or indefinite terminations, they also present examples of pyramidal endings, occasionally compound where different groups of twin lamellæ have their own crystallographic termination. Here and there one or more of these lamellæ may be observed projecting in a pectinate manner beyond the end of a strip-like prism.

The Augite occurs in well-defined forms. Seen with a low power these appear as pale greenish yellow granules, sometimes dispersed singly through the glass, but more frequently aggregated into groups. That the apparent granules have really definite crystalline contours, however, may be seen even with a weak magnifying power. More highly enlarged they are found to present abundantly the characteristic monoclinic prisms and terminations of the volcanic variety of augite. The smaller prisms project from the groups with clear sharply defined forms, while the inner portions of the groups have a fissured granulated character. The prisms average perhaps about $\frac{1}{500}$ of an inch in length. Very perfect isolated prisms occur, which, when cut perpendicular to the vertical axis, present the well-known eight-sided sections. Besides the small abundant prisms, there are also to be observed much larger and less perfect forms, having an internal flawed structure as if they were built up of an aggregation of granules, yet polarising uniformly and not with reference to the individual granules. These larger flawed crystals sometimes contain abundant and large glass cavities. There are likewise to be observed large macroscopic kernels or patches which to the unassisted eye appear like fragments of compact basalt, caught up in the dyke. These on being submitted to microscopic examination prove to be aggregations chiefly of crystalline grains and imperfect prisms of augite with very small triclinic felspars, and also scattered magnetite. They have no definite external contour. The crystals project from them into the surrounding glass, which can also be traced among interstices even in the midst of the kernels. These patches therefore are original aggregations of the components of the rock, and not extraneous included fragments.

The Magnetite presents no features requiring special remark. It is well crystallised in the forms usual in basalt, but on the whole is less abundant than in many of the basalts of central Scotland. Its smaller octohedra are crowded round the augite prisms, forming here and there a kind of black border. Its dust-like grains appear in the most globulitic parts of the glass, and it is probably they that encrust some of the minuter forms of microliths, which consequently appear as opaque rods or needles.

I have not succeeded in detecting olivine in any of the slices yet prepared. There occur indeed here and there rounded kernel-like aggregations of dull green serpentinous matter which may represent this mineral. But they are comparatively infrequent, so that even if olivine be present it must take but an insignificant part in the constitution of the rock.

(3.) *Chemical Composition of the Eskdale Rock.*

To complete this account of the so-called "pitchstone" of Eskdale, there remains for consideration the question of its chemical composition. It is evident that while the rock is not to be associated with the acid pitchstones, neither on the other hand are its affinities to be sought among the more basic basalts. It is well known that among the vitreous forms of the basalt-rocks varieties occur with a much more acid character than normal crystalline basalt. If we take the analyses recently collected by Roth * of the crystalline felspar-basalts, the proportion of silicic acid may be set down

* Beiträge zur Petrographie der Plutonischen Gesteine Abhandl. k. Akad. Wissensch. Berlin, 1869, p. 195.

as ranging between 50 and 55, though in some varieties it sinks below the lower limit, and in others rises above the higher. In the series of basalts collected during the Geological Exploration of the 40th Parallel in the Western States and Territories of the American Union, the percentage of silica varies from 48·4 to 54·8.*

But if we pass to the vitreous types associated with the basalt rocks we encounter a still higher proportion of silica. Thus in the pitchstone-like external crust (0·03 metre thick) of a dyke (0·2 metre broad) in Lamlash Island, Arran, Delesse found the composition to be: silica, 56·05; alumina, 17·13; peroxide of iron, 10·30; protoxide of manganese, a trace; lime, 6·66; magnesia, 1·52; potash, 0·98; soda, 3·29; water, 3·50 = 99·43.† He found the composition of the crystalline portion of the dyke to be nearly the same, but the specific gravity to be 2·649, while that of the glass was 2·714.

At my request my colleague, Mr J. S. Grant Wilson, has subjected the Eskdale dyke to chemical analysis. The specific gravity of a normal portion of the glassy rock is 2·7. An average sample of the same rock was reduced to powder, and allowed to remain in hydrochloric acid for ten days. It was thereafter boiled. At the end of this treatment the proportion of the rock dissolved in the acid was found to be only 16·8 per cent.

Another portion of the powdered rock submitted to quantative analysis gave the following results:

Silica, ...	58·67
Alumina, ...	14·37
Peroxide of Iron, ...	1·64
Protoxide of Iron, ...	6·94
Protoxide of Manganese, . . .	trace
Lime, ...	7·39
Magnesia, ...	4·65
Potash, ...	1·42
Soda,.	3·01
Water, ...	2·02
	100·11

* Explor. 40th Parallel, vol. i.; Table of Analysis, xii.

† Ann. des Mines, xiii. (1858), 369.

Some of the isolated kernels or particles of black glass dispersed through the rock were picked out and found by Mr Wilson to yield 65·49 per cent. of silica; with alumina, 14·66; protoxide of iron, 5·44; lime, 3·73; magnesia, 1·57; the alkalies, owing to the small quantity of the material available, were not determined.

In its specific gravity and high proportion of silica the Eskdale rock agrees with other known vitreous basalts. It is worthy of remark also that its glass kernels contain about 7 per cent. more of this acid than the general mass of the rock.

Comparing its characters with those of the various hyalomelans and tachylites which have been described by Zirkel, Möhl, Fischer, Rosenbusch, and others, we observe that it differs from all of them as they in turn differ from each other. If we follow the not very satisfactory classification which ranges as tachylite those glassy forms of basalt, which are more or less readily soluble in acid, and, as hyalomelan, those which resist the acid, we see that the Eskdale rock takes an intermediate position, rather inclining to hyalomelan. Yet its internal structure, abounding in microliths, but with no spherulitic concretions or gas-pores, links it rather with the described forms of tachylite. I have recently had sections prepared of other vitreous basalts from different parts of Scotland, and hope in another paper to bring forward additional information regarding this interesting and still imperfectly understood condition of our basalt-rocks. From what has now been laid before the Society, it will be seen how much more detailed must be the work of the geologist and the petrographer than was possible in the days of Jameson, and how vastly greater are now the facilities for this research. There can be no doubt that the rocks of Scotland present a marvellously rich field for the application of modern methods of petrography.

Explanation of Plates.

Plate V.

Fig. 1. Section of Eskdale dyke near Eskdalemuir Manse: *a*, *a*, Highly inclined Silurian greywacke and shale; *b*, *b*, Dolerite, *c*, vitreous basalt of

central band showing a prismatic structure, the prisms being directed inwards from the outer walls of the vitreous zone. (This and the three following figures have been drawn from his own observations by Mr B. N. Peach.)

Fig. 2. View of a square yard of the outer wall of the vitreous central band, showing the polygonal arrangement of the prisms and their investing sheaths or ribs.

Fig. 3. View of a smaller portion of the same wall to show the detailed structure of the ribs (*a*, *a*) and their vitreous cores (*b*, *b*).

Fig. 4. Profile of a part of the weathered face of the wall, showing the way in which the hard ribs or sheaths project at the surface.

Fig. 5. Microscopic structure of the vitreous core. This section shows a crystal of augite, enclosing magnetite and surrounded with microliths, each of which consists of a central rod of pale yellow glass crusted with pale yellow isotropic globulites. The glass around this aggregation is clear, but at a little distance globulites (many of them elongated and dichotomous) abound, with here and there scattered microliths, some of which are curved and spiral. (800 diameters.)

PLATE VI.—MICROSCOPIC SECTIONS OF ESKDALE DYKE.

Fig. 1. Portion of the outer or chilled edge of the outer dolerite band (*b* of fig. 1 in Pl. V.), Shaw Burn. (70 diameters.)

Fig. 2. From the more coarsely crystalline central part of the same marginal dolerite. (70 diameters.)

Fig. 3. Structure of the hard rib or sheath surrounding the vitreous core (*a*, *a*, in fig. 3 of Pl. V.), Shaw Burn. (70 diameters.)

Fig. 4. Structure of the vitreous core (*b*, *b*, in fig. 3 of Pl. V.), Shaw Burn. The colourless crystals are the felspars, the greenish are augite, the black are magnetite. The pale brown glass with its beautiful fluxion structure and crowded microliths forms the largest part of the rock.

Fig. 5. Structure of the vitreous central band, Wat Carrick. This section shows with a magnifying power of 250 diameters the fluxion structure of the glass, the aggregation of the globulites and darkening of the glass against the felspars, and the bleached unindividualised character of the glass round the augite and magnetite. The augites are seen to bristle with microliths usually straight and loaded with investing globulites. (See fig. 5, Pl. V.)

Fig. 6. From centre of vitreous part of dyke, Kirkburn above Langholm. The base is here crowded with pale yellow and greenish globulites and curved fibre-like microliths. (250 diameters.)

VI. *Obituary Notice of the late Dr James M'Bain.*

By DAVID GRIEVE, Esq., F.G.S.

(Read 17th December 1879.)

Dr M'Bain, on his deathbed, gave me some particulars of his early career, which with some additional matter I propose to read to the Society.

I need hardly remind those of our number who have for some years been connected with the Society, of the deep and lively interest which Dr M'Bain always took in its business. I have reason to know from himself that its prosperity was ever a source of anxiety to him, and that no other Society with which he was connected had such a place in his affections. It is only fitting therefore that some kind words *in memoriam* of our worthy departed friend should find a place in our *Proceedings.*

Dr James M'Bain was born at Logie, in the parish of Kirriemuir, Forfarshire, on the 30th November 1807. He received his elementary education at the Parish School of Kirriemuir. At the age of thirteen he became apprentice to Mr David Stewart, surgeon, Kirriemuir, and remained with him for three years. He thereafter went to Edinburgh, in the Session 1823-24, to prosecute the study of medicine, making two voyages to Davis Straits during the summer months (as was then the custom) as surgeon to the "Estudge" whale ship, Captain Deuchar. In March 1826, he passed his examination at Surgeons' Hall, Edinburgh, and received his Diploma when only a few months over nineteen.

In 1826, he graduated in Medicine at St Andrews University, and in August 1827, he passed the examination for Assistant Surgeon, Royal Navy, and shortly after received an appointment on board H.M.S. "Undaunted" just then commissioned at Chatham by Sir Augustus Clifford to take out Lord William Bentinck as Governor-General of India. The ship in due course arrived in the Hoogly at Diamond Harbour, and Dr M'Bain resided for three weeks at Calcutta as the guest of the Governor-General at Fort-William.

For several years Dr M'Bain remained attached to the "Undaunted," cruising among the Azores and Cape de Verde Islands on the outlook for pirates, and on other special service, during which period he had many opportunities for scientific observation, and of thus laying a good foundation for the working life of a naturalist.

In 1832, Dr M'Bain was appointed Assistant Surgeon to H.M.S. "Investigator," surveying vessel, commanded by Captain George Thomas, who was then employed in the

Survey of the Shetland Islands. This Survey was completed in 1834, and in the autumn of that year the "Investigator" proceeded to the Orkney Islands to commence the Survey of that group. Whilst thus employed, Dr M'Bain, along with Lieutenant F. W. L. Thomas, carried on a system of dredging round the shores of the Orkneys, and in deep water between the Orkney and Shetland Islands. The result was, that large and interesting collections of the Marine Invertebrata were made, the rarer specimens being handed over to Messrs Forbes and Hanley, then engaged in preparing their splendid work on the British Mollusca. Fine collections were also made of the British Marine Algæ, the rarer specimens of which were sent to Dr Harvey when engaged in bringing out his great work, the "Phytologia Britannica." In this work many of Dr M'Bain's discoveries will be found recorded.

At this time Dr M'Bain commenced a lifelong friendship with the late Dr Bowerbank, of London, whose constant correspondent he became, supplying him from time to time with many rare and unique specimens of Sponges found in Shetland and the Orcades, and which are mostly figured in Dr Bowerbank's "Monograph of the British Spongiadæ." On this subject, it may be here mentioned, Dr M'Bain contributed to our *Proceedings* an able paper, which will be found in Vol. II., p. 233.

In 1848, H.M.S. "Mastiff" which had superseded the "Investigator" in 1836, was paid off at Woolwich, having completed the Survey of the Orkneys, and Dr M'Bain did not again serve afloat.

In 1849, Dr M'Bain took up his residence at Elie, in Fife, where he remained four years. Here he was by no means inactive; Marine Zoology engaging much of his attention, and in the Rev. Mr Wood's work, "The East Neuk of Fife," will be found a most exhaustive list of the Mollusca and other Invertebrata of the Firth of Forth, which forms perhaps the "cream" of his work in that neighbourhood.

Having been appointed Naval Medical Agent at Leith, Dr M'Bain removed to Pirniefield there, where he became the intimate friend and constant companion of the late Professor John Fleming, who then resided at Seagrove in the same neighbourhood. They had frequent Natural History excursions together, in which they were often accompanied by another intimate friend, the late Mr Alexander Bryson, also a fellow of this Society, and who was always hailed as an acquisition of scientific strength by the exploring party.

In connection with Dr Fleming it may be here mentioned that at his death the celebrated Actinia "Granny," which originally belonged to the late Sir John Graham Dalyell, came into the possession of Dr M'Bain, it having been presented to him by Mr Fleming, and the life history of this remarkable Actinia was the last contribution made by him to the Royal Physical Society. "Granny" was handed over by the Doctor to Mr John Sadler, Curator of the Botanic Garden, Edinburgh, on the 1st March 1879, shortly before his death, with many earnest and pathetic injunctions relative to the care and treatment of this aged and historical zoophyte.

Dr M'Bain eventually took up his residence at Trinity, where he dwelt for many years, and where he died.

He joined this Society as a resident Fellow in 1857, having for some years previously been on the non-resident list of Members. During the time he was connected with the Society, not a session, I believe, elapsed without various interesting communications from his pen having been read at our meetings, and it may also be noticed that he was twice elected to fill, for the usual term of years, the Presidential Chair of the Society.

In 1861, Dr M'Bain was elected a Fellow of the Royal Society of Edinburgh, and was at one time a Member of the Council of that learned body. He was also a Member of the Botanical Society of Edinburgh, and took an active share in its business.

Dr M'Bain's tastes and studies were on the whole zoological, notwithstanding that other branches of science had a share of his attention. He was a good comparative anatomist, and had an excellent knowledge of osteology; which latter skill may be traced to his having been a pupil of the late celebrated anatomist, John Barclay, who very generally succeeded in imparting to his students a thorough acquaintance with that branch. Dr M'Bain subsequently supplemented his knowledge of bones by attending the lectures of the celebrated Professor Owen, of London. In this direction he studied very minutely various species of marine animals of such orders for instance as the *Pinnipedia* and *Cetacea,* and many of his papers on such osteological subjects are scattered throughout our printed *Proceedings.* Indeed, had it not been for the sake of brevity, I would willingly have here enumerated the more remarkable of Dr M'Bain's papers, but must for the reason given content myself with simply referring to the Society's published *Proceedings.*

Dr M'Bain, it may be said, in conjunction with the late Professors John Fleming, John Goodsir, and George Wilson, Dr Strethill Wright, Messrs Andrew Murray, Alexander Bryson, and other eminent naturalists, who, alas! with our friend, are all now departed from us, contributed much to the attraction of the meetings of our Society, and filled bright pages of its history, which will never be forgotten.

Dr M'Bain may be said to have been a lover of science for its own sake. He lived, moved, and had his being in science. He was in politics an advanced Liberal, but he seldom or ever thought or talked of politics, unless the subject was thrust upon him. His all absorbing topic, whether in the house with his microscope, or abroad in the fields with his pocket lens, was Natural History in some shape or form. In later years he gave a good deal of attention to Geology, and went much among the rocks, hammer in hand. He delighted in illustrating the wonderful works of Nature, as well in their atomical minuteness, as in the gigantic rock masses, which form the earth's crust; and such illustrations were always copious and lucid, displaying a complete mastery of the subject in hand. He was particularly fond of pedestrian excursions, in which he was a most enjoyable and instructive companion. As a geologist he was well acquainted with field work, and in many excursions in our own country, replete as it is with striking geological features, he would point out to the tyro the structure of the landscape, drawing at times on the roadside sand or dust with a borrowed walking-stick, diagrammatic sections in rough illustration of his descriptions. With the mature geologist again, he would quietly discuss the nature and course of apparent phenomena. Several important papers on geological subjects, notably one on strata of Lower Carboniferous age, underlying the basalt on the north-east portion of Arthur Seat, will be found in our *Proceedings*, and are worthy of attention.

Dr M'Bain was a good botanist, and rarely ever went on his walks without his vasculum—picking up here and there, by the way or hillside, or in the woods, weeds and wild flowers, discoursing thereon as he went along.

Our friend had antiquarian proclivities, but there was another branch of science to which he was very partial, viz., Geographical Science. This occupied much of his attention, and few men were better acquainted with the *ancient* writers on this subject than he was—no one could quote Strabo, "chapter and verse," more readily and aptly than he. He took great interest in modern geographical discovery, and more particularly so of the Arctic regions. His early voyages to these parts gave us a cue to his well-known enthusiasm on this subject, and his ever anxious sympathies on behalf of explorers. It may here be mentioned that his interest in this direction led his friend Dr Robert M'Cormick, R.N., to remember him, and to name a headland in Wellington Channel in his honour. In the parliamentary paper, "relative to the recent Arctic Expedition of 1854," will be found (p. 190) a woodcut of the headland named Cape M'Bain, and in illustration of M'Cormick's report of the boat voyage, which he commanded during the "North Star" Expedition in search of Sir John Franklin and his crews.

The bent of Dr M'Bain's mind was eminently utilitarian and practical; he dealt little in the hypothetical, so that in some respects he might be considered by some as being rather behind Science workers, according to the fashion of the present day as regards at least their plans of working. His writings were devoid of ornament; no word painting adorned his periods, and certainly it must be admitted, that he never would have excelled as a popular author. In fact Dr M'Bain was somewhat slow at composition; he thought a great deal over his subject, which was always well and thoroughly elaborated before being committed to writing. Facts and deductions from facts were alone valued by him; all else he considered absolutely superfluous.

After Dr M'Bain's death I received a letter from an old and valued friend of his,* in which there are some very apt critical remarks, which may be here appropriately quoted.

"Dr M'Bain," says this friend, "was not a man who formed opinions hastily. In science as in politics, as might be expected, he was a Liberal, and I may say shared most of the advanced views promulgated of late years, but having once formed an opinion on any subject he was singularly tenacious of it; it was only a perfect *tour de force* of facts that would compel him to quit his old anchorage, and either remove to another or set himself adrift on the world of doubt once more. It was the same with his friendships. He was slow to take to a new man, but having once formed a favourable opinion of him, his regard and attachment were firm and enduring. Hence Dr M'Bain's opinion went a long way with good men, and his influence was equally great with those who knew the perfect disinterestedness with which he took up any object dear to him, and the slowness but sureness with which he arrived at his conclusions.

"His knowledge of science was very extensive. As a naturalist he might not have been a great authority in any one department of science, for his range was great. But whatever point he took up he made it his own, and on that question at least he was *thorough*. He had little rhetoric, and the scientific use of the imagination was strange to him. One fact, as I have often heard him say, was worth all the poetry of Christendom."

"As regards the Doctor's personal character" (the same friend adds) "I need not speak. His contempt for anything mean or little was as thorough as that of any man of my acquaintance. Morally the words of an old epitaph I have somewhere seen might well be applied to our friend—'*He was a despiser of sorry persons and little actions.*'"

* Dr Robert Brown, formerly the respected secretary of this Society, now resident in London.

An amiable trait in our deceased friend was the encouragement he gave to young men studying at the University by inviting them to his house, and by giving them every assistance in his power in the prosecution of their scientific studies, bestowing on them the fruit of his experience, as well as the benefit of his advice. Frequently, indeed, he assumed to act *in loco parentis,* not even sparing his censure when he thought that was needed. Many of these students are now scattered in distant lands, and not a few in after-life continued to correspond with him.

It is needless to say how beloved Dr M'Bain was in the circle of his intimate friends. His unobtrusive sociality and genial suavity of disposition threw a charm into the bond of friendship, and for one to be able to look back on the many pleasant days of rational and social intercourse spent with our friend, not unfrequently in the green fields under the blue canopy of the heavens, is a melancholy joy to be cherished, and while memory has a place, is not likely to be easily obliterated.

Apart from this inner circle, Dr M'Bain's popularity was great in various quarters. He was well liked by his brethren of the Medical profession, with whom he always worked harmoniously, and then again from having spent a large portion of his life in the Royal Navy, a strong feeling of good fellowship always existed between him and the commissioned officers of that service. But his main and conspicuous popularity was with the crews of the Guard and Hospital ships, and Coastguard men, over whom, as Medical Agent, he had the professional health supervision. These crews looked up to him with truly filial affection. Irrespective of his functions of Medical Attendant, he may be considered as having been the permanent Father Confessor of the Firth of Forth Fleet; for not only did these honest fellows confess their peccadillos, but they poured their joys, their sorrows, and their secrets into the capacious bosom of our friend. We have his own authority for saying that these unsophisticated sailors received and acted on his advice on all sorts of miscellaneous matters with the faith and simplicity of children, often seeming to feel—by experiencing relief—as if they had actually received the rite of absolution.

For nearly two years before his death, Dr M'Bain was in delicate health; he never well recovered from the shock of his wife's sudden death, which greatly prostrated him. He was a man much domesticated, and Mrs M'Bain took a large share of the burden of life from his shoulders—her loss therefore greatly aggravated a painful disease to which he was subject, and which ultimately cut him off. For several months before his death he suffered much, and the cessation of life in his case could only be considered as a happy and blessed relief.

Dr M'Bain died at his residence at Logie Villa, Trinity, on the 24th March 1879.

VII. *On a Collection of Fossils from the Bowen River Coalfield and the Limestone of the Fanning River, North Queensland.* By R. ETHERIDGE, Jun., Esq., F.G.S., of the British Museum, President. [Plates VII.-XVII.]

(Read 18th February 1880.)

1. INTRODUCTION.—The collection described in the following pages was forwarded to me for investigation by my former colleague Mr R. L. Jack, F.R.G.S., F.G.S., etc., Government Geologist for North Queensland.

The specimens were collected either personally by Mr Jack, or under his direction, during a survey of the Bowen River coalfield and its neighbourhood, and may be looked upon as supplementary to those of the Daintree Collection described by my father,* and brought together through the exertions of my late lamented friend Richard Daintree, C.M.G., F.G.S., during the time he held the post now occupied by Mr R. L. Jack.

The present collection comprises fossils from three formations, viz., the Devonian of the Fanning River, the Carboniferous of the Bowen coalfield, and the Cretaceous series of the Tate River.

* Description of the Palæozoic and Mesozoic Fossils of Queensland. Quart. Jour. Geol. Soc., 1872, xxviii., pp. 317-360.

Before proceeding to describe the species of these three formations in their respective order, I purpose giving a brief outline of Queensland geology and palæontology, in so far as the districts from which the present collection was obtained are concerned. To this section will be added some additional notes forwarded by Mr Jack, and bearing on his collection. The description of the species will next occupy attention, followed by a few deductions drawn from a study of the species in general, and in conclusion will be found a tolerably full bibliographic list, bearing on the palæontology of Queensland generally. The corals, which are few in number, have, in conjunction with those collected in North Queensland by Mr Daintree, formed the subject of a separate paper by Prof. H. A. Nicholson, M.D., and myself.

The second part of the report will be occupied with a description of the plant remains which accompany the Mollusca now described. I have found it necessary to retain these for further consideration, as I believe I am in a position, from a study of them, to throw some additional light of an important nature on the much vexed question of the age of the Australian coal-beds.

2. Geological and Palæontological Notes on the Devonian, Carboniferous, and Cretaceous Beds of the Fanning River, Bowen River, and Tate River respectively.—(1.) *Devonian—Fanning River Limestone.*—Mr Jack writes* me that this limestone, from which a small packet of fossils has been obtained, is the equivalent of Daintree's Burdekin or Broken River limestone, and is probably the same as that of Red Gap and Double Barrel Hill, where a few obscure corals were met with; but the limestones and accompanying strata are so metamorphosed that it has been quite impossible to make much out of the specimens. Speaking of his Burdekin limestone at Terrible Creek, the late Mr Daintree observed that "the limestones, where little alteration has taken place, are a mass of aggregated corals."† These are the Lower Devonian or "Siluro-Devonian" beds of my father's classification. He says,‡ "There cannot now be

* Letter dated "Townsville," 12th Oct. 1878.

† *Loc. cit.*, p. 290. ‡ *Loc. cit.*, p. 324.

any doubt that the Broken River limestone beds, containing *Favosites*, etc., are the lowest fossiliferous deposits in the Queensland area, and their age is undoubtedly Lower Devonian or 'Siluro-Devonian.' These are succeeded by the Gympie group, a higher series, with the Star River and Mount Wyatt beds succeeding, rich in *Lepidodendra* and *Spiriferæ*. These Devonian rocks yield generally *Lepidodendron, Leptophlœum, Productus, Spirifera*, etc.—indeed possess a fauna and flora closely allied to that of Canada of the same age." The corals in question, contained in the Daintree Collection, were not described at the time the remainder of the collection was worked out; but, as before stated, they have, with those forwarded by Mr Jack from the Carboniferous beds of the Bowen coalfield, formed the subject of a separate paper by Prof. H. A. Nicholson and myself.

Mr Jack informs* me that the Broken or Burdekin limestone is perhaps 450 feet thick, and rests on granite. Its upper limit was not observed, but it was believed to dip under a series of brown and green sandstones seen at Dalrymple and Dotswood. Mr Jack's observations quite bear out the position assigned to these limestones by my father, as compared with the succeeding series. He says in the same letter, "The last-named beds I understand to be lower in position than those of the Star basin, although these are also seen resting on granite and mica-schist."

The fossils from the horizon of the Fanning limestone consist of five species of *Brachiopoda* from the limestone itself, and two species of the same class from the shale above it. The limestone at Red Gap and Double Barrel Hill, which Mr Jack thinks may be the same as that at the Fanning River, has yielded some corals; but, as before observed, they are undeterminable.

(2.) *Carboniferous—Bowen River Coal-Beds.*—The Bowen, according to Mr Daintree,† is one of the rivers draining the northern or palæozoic coalfield of Queensland, and from it and Roper Creek he mentions the following fossils: *Streptorhynchus crenistria* (Phill.), *Spirifera striata* (Martin), *S. con-*

* Letter dated "Townsville," 21st May 1878.

† *Loc. cit.*, p. 285, *et seq.*

voluta (Phill.), a Spirifer allied to *S. bisculcata* (Sow.), and *Productus Clarkei* (Eth.). In a small branch of the Bowen River, near the Nebo road-crossing, an interesting section was discovered by Mr Daintree, in which a Fresh-Water Series with three coal-seams, and containing *Glossopteris,* is overlaid by *Productus* and Spirifer beds.* At the Pelican Creek, a tributary of the Bowen, a coal-seam of the Fresh-Water Series was overlaid by a coarse-grained sandstone, with casts of shells, and an arenaceous limestone band containing *Streptorhynchus crenistria,* a shell common throughout all the Lower Marine series.

Mr Jack writes me † that he does not see any cause for alteration in the classification of this portion of the Queensland rocks, adopted by Messrs Daintree and Etheridge, viz., in descending order:

a. Bowen River Coalfield Series.

Unconformity.

b. Star River Series (= Mount Wyatt beds).

?

c. Devonian Sandstones (Keelbottom and Dalrymple).

Conformity.

d. Burdekin River Limestone (= Fanning River do.). "Siluro-Devonian" (*Etheridge*).

According to Mr Jack, the Bowen coalfield is divisible into an Upper or mainly Fresh-Water Series, and a Lower or Marine group, both with interstratified coal-seams, and the former with a few well-marked marine bands. Plant remains are common to both, but much more abundant in the Fresh-Water Series, plenty of *Glossopteris* but *no Lepidodendron.* The sandstones of both the Marine and Fresh-Water Groups have pockets and nests of pebbles, and sometimes large isolated boulders, highly suggestive of ice action, but perhaps to be accounted for by the presence of large silicified trees found lying horizontally, which may have had something to do with their transport. The silicified wood is present in quan-

* Daintree, *loc. cit.*, p. 286, fig. 9.

† Letter dated "Don River," 6th August 1878.

tity and of large size, some stumps possessing more than forty rings of growth.*

Mr R. B. Smyth, F.G.S., has, in the "First Sketch of a Geological Map of Australia," coloured the Bowen River coal-field Carbonaceous (Mesozoic), in a similar way to that of the great New South Wales coalfield, instead of Carboniferous. Setting aside any deductions to be drawn from the plant remains found in these fields as so much mere controversial matter, it is difficult to imagine how Mr Smyth can reconcile this mapping with the well-known occurrence of fossils of true Upper Palæozoic age in them, and about which there never has been any dispute.

The fossils from the Bowen coalfield forwarded by Mr Jack are numerous as to specimens, and tolerably so as to species. They form the bulk of the collection, and afford some valuable information, especially in relation to the previous investigations of Mr Daintree. Unfortunately for descriptive purposes, they are, as a rule, in a most miserable state of preservation. The *Brachiopoda* are well represented, and have proved a very troublesome series. Under this head I am much indebted to Mr T. Davidson, F.R.S., who, with his ever-ready kindness, has devoted time and trouble to several obscure and difficult points which have presented themselves. The *Polyzoa* are not in great force as to species, and have been anything but an easy group, from their always appearing as badly-preserved casts. The *Gasteropoda* are almost unrepresented, and the *Cephalopoda* only by one genus. The *Echinodermata* are quite absent, even to the usually ever-occurring fragments of Crinoid stems, whilst the Bivalves, although, as ever, an interesting group of fossils, are, like *Polyzoa*, rendered unsatisfactory by their state of preservation.

(3.) *Cretaceous—Tate River Series.*—The geology of the North Queensland Cretaceous Formation has only, so far as I am aware, been written on by the late Mr Richard Daintree.† Beds of Cretaceous age were first shown to exist in North

* Letters dated "Don River," August 6th, and "Townsville," October 12th, 1878.

† Quart. Jour. Geol. Soc., 1872, xxviii., p. 278.

Australia, on palæontological evidence, by Professor M'Coy, who, in 1865, described a small collection of fossils made by Messrs Sutherland and Carson on the Flinders River.* These were described in 1866 and subsequently,† and numbered in all eight species, three of *Reptilia*, three *Cephalopoda*—*Ammonites Flindersi* (M'Coy), *Belemnitella diptycha* (M'Coy); and *Ancyloceras Flindersi* (M'Coy)—and two Bivalves—*Inoceramus Carsoni* (M'Coy), and *I. Sutherlandi* (M'Coy). Notwithstanding that Professor M'Coy was the first to indicate the presence of cretaceous rocks in Australia, with any certainty, it is nevertheless certain that Mr F. T. Gregory was the first to collect cretaceous fossils, as we learn from Mr Charles Moore, F.G.S.‡ (who examined Mr Gregory's collection), that a chalk ammonite was present amongst the fossils from Western Australia, sent by Mr Gregory.

Mr Moore supplemented M'Coy's list by a new species of *Crioceras*, *C. Australe* (Moore),§ from the Upper Maranoa District in Queensland, and to these my father added ‖ a large and interesting series of cretaceous fossils collected by Mr Daintree from Maryborough, Hughenden Station, Marathon Station, and Flinders River. Another collection is referred to,¶ although not described, made by Mr W. Hann, and derived from the Bowen Downs, head of the Thompson and the Barcoo River beds.

The immense extent of the Queensland cretaceous rocks is well shown on Mr Daintree's map, attached to his paper previously quoted, extending as they do from lat. 18° S. to lat. 29° S.

In his "First Sketch of a Geological Map of Australia,"** Mr R. B. Smyth dismisses the cretaceous and other secondary formations of Australia and their fossils in a very unceremonious manner. After quoting the limited number of species, described at various times by Professor M'Coy, from

* Annals Nat. Hist., 1865, xvi., p. 333; Trans. Roy. Soc. Vict., 1866, vii., p. 49.

† For Bibliography see list of papers appended to this Report, and my "Catalogue of Australian Fossils."

‡ Quart. Jour. Geol. Soc., xxvi., p. 227.

§ *Loc. cit.*, p. 257.

‖ Quart. Jour. Geol. Soc., xxviii., pp. 338-346.

¶ *Loc. cit.*, p. 348.

** Geol. Survey Vict., Progress Report for the Year 1876, iii., pp. 45-67.

these beds, he tells us, "'Sections of Strata and a Description of the Cretaceous Rocks of Australia,' as given in the *Quarterly Journal*, etc., etc." Of the fossil contents of these rocks, or the information deducible from the study of them, nothing is said, so that we are obliged to conclude that Mr Smyth has overlooked the important papers by Mr Charles Moore, F.G.S.,* and Mr R. Etheridge, F.R.S.,† which is not saying much for the "First Sketch."

Mr Jack has forwarded to me a very well-marked, and what appears to be new, *Crioceras*, from the Tate River, North Queensland, which will be described further on.

3. Description of the Fossils.

Devonian Species—Brachiopoda.

Genus Spirifera—*J. Sowerby*, 1816.

(Min. Con. ii., p. 41.)

Spirifera curvata—Schlotheim (?).

Anomia Terebratulithes curvatus, Schl., Nachträge zur Petrefact, 1822, p. 68, t. 19, f. 2.

Spirifera curvata, Davidson, Mon. Brit. Dev. Brach., 1864, p. 39, t. 4, f. 29-32; t. 9, f. 22, 26, and 26*a*, 27 and 27*a-c* (*for synonomy*).

Obs.—Much doubt must of necessity attach itself to the shell referred to this species, from its crushed and partly decorticated condition, but on one portion of its surface there are visible traces of the characteristic concentric imbrications with the peculiar vertical serrations crossing them. Mr Davidson considers that it strongly resembles Schlotheim's species.

Loc. and Horizon.—Fanning River Limestone, North Queensland.

Collector.—R. L. Jack, Esq., F.G.S., etc.

Spirifera, sp. ind.—Pl. VII., fig. 1.

(Compare *Sp. euryglossus* (Schnur), Palæontographica, iii, p. 209, t. 36, f. 5, *a-d*.)

Obs.—Another Spirifer occurs in the Fanning Limestone,

* Quart. Jour. Geol. Soc., xxvi., pp. 226-261.
† *Ibid.*, xxviii. pp. 37-50.

of which we at present have only one specimen. It is quite decorticated, much smaller than the preceding, with a deep well pronounced sulcus in the ventral valve extending well up into the beak, and bounded by strong ridge-like margins. In the dorsal valve there is a corresponding medial fold although not relatively so prominent as the sulcus. The hinge line was less in length than the width of the shell. It appears to resemble some of the *Spirifera glabra* group, but the loss of the shelly matter renders identification difficult, especially as we have only one specimen. A close resemblance exists between *Spirifer euryglossus* (Schnur), and the present species.

Loc. and Horizon.—Fanning River Limestone.

Collector.—R. L. Jack, Esq.

Genus Atrypa—*Dalman*, 1828.

(Kongl. Vet. Acad. Handl. för år 1827, p. 102.)

Atrypa reticularis—Linnæus.—Pl. VII., fig. 2.

Anomia reticularis, Linn., Syst. Nat., 1776, 12th Ed., i., pt. 2, p. 1152.
Atrypa ,, Davidson, Mon. Brit. Dev. Brachiopoda, 1864, p. 53, t. 10, f. 3 and 4.

Obs.—One very well marked example of this cosmopolitan species has been forwarded by Mr Jack, and it affords me much satisfaction to be able to introduce it from Queensland rocks of Devonian age. The ventral valve is much better preserved than the dorsal, and although the characteristic decussating frills or laminæ are preserved on both, they are seen to much greater advantage on the ventral.

Loc. and Horizon.—Limestone of the Fanning River.

Collector.—R. L. Jack, Esq.

Atrypa desquamata—J. de. C. Sowerby.—Pl. VII., figs. 3, 4.

Atrypa desquamata, J. de. C. Sow., Trans. Geol. Soc., 1840, 2d. ser. v., Expl. of t. 56—t. 56, f. 19, 20.
,, ,, Davidson, Mon. Brit. Dev. Brach., 1864, p. 58, t. 10, f. 9-13, t. 11, f. 1-9 (*for synonomy*).

Obs.—From the series of figures of *Atrypa desquamata* given by Mr Davidson, it is quite clear that the species is one of considerable variation, both in the relative dimensions of the shell, from the hinge line or beak to the front margin, and also laterally, from side to side, the result being that the length of the hinge line is also variable, short in some varieties, longer in others.

We possess three shells from the Fanning River beds, which I think are more than probably this species. If we take the best preserved of the three, we find that it is very much more transverse than those represented by Mr Davidson on Pl. X. of his Devonian Monograph, but not more so than some of the figures of Pl. XI. of the same work. Again, the relative convexity of the valves when in apposition is very much less than Mr Davidson's fig. 1*b* of Pl. XI., but is a little more pronounced than the fig. 3*a* of the same plate. Even among the three Queensland examples the shape varies somewhat. The ribbing of the valves corresponds with that seen in *A. desquamata,* and there are also traces of concentric laminæ. Mr Davidson lays stress on the exposure of the foraminal aperture and presence of an area. Both are to a certain extent visible in one of the Queensland specimens, and of the former I give an enlarged figure.

Professor M'Coy appears to have been the first to describe* the spiral appendages in *A. desquamata,* and they have since been figured in their entirety by Mr Davidson.† It is interesting to note that two of the specimens under description (Pl. VII., fig. 4) exhibit traces of these arms from the shell having been removed by weathering.

Loc. and Horizon.—Limestone of the Fanning River, and shale above the Fanning Limestone, at Fanning Old Station.

Collector.—R. L. Jack, Esq.

Genus Rhynchonella—*Fischer,* 1809.

(Notice Foss. Gouv. Moscou, p. 35.)

Rhynchonella, sp. ind.—Pl. VII., fig. 5.

(Compare *R. primipilaris* (Von Buch), Davidson, Mon. Brit. Dev. Brachiopoda, 1865, p. 66, t. 14, f. 4-6.)

Obs.—We have five specimens of a *Rhynchonella,* which appear to be very close to if not quite identical with this

* Brit. Pal. Foss., p. 379.

† *Loc. cit.*, t. 11, f. 7, 8.

species. Like the Spirifers, previously described, their preservation is unsatisfactory, but they appear to correspond better with the characters assigned by Mr Davidson to Von Buch's species than to any other. The shape of the shell appears to be much the same, and there is the bending down of the front margin of the dorsal valve quite apparent in all the specimens. On submitting the specimens to Mr Davidson he replied that "the *Rhynchonellæ* seem to be very close to the *R. primipilaris* of the Devonian."

Loc. and Horizon.—Fanning Old Station, in shale above the Fanning Limestone.

Collector.—R. L. Jack, Esq.

Genus Orthotetes—*Fischer*, 1829.

(Bull. Soc. Imp. Nat. Moscou, p. 375.)

Orthotetes crenistria, Phillips, var.

Spirifera crenistria, Phillips, Geol. York, 1836, ii., p. 216, t. 9, f. 6.
Streptorhynchus crenistria, Davidson, Mon. Brit. Dev. Brach., 1865, p. 81, t. 18, f. 4-7.
Orthotetes crenistria, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 212, t. 10, f. 8.

Obs.—A very well marked and clear specimen of this variable shell was forwarded with the other specimens, but unfortunately through a mishap to the parcel containing it, when passing through the post, the specimen was lost.

Loc. and Horizon.—Limestone of the Fanning River.

Collector.—R. L. Jack, Esq.

CARBONIFEROUS SPECIES.

Class Actinozoa.

This class is represented by two species of Lonsdale's genus *Stenopora* from the fossiliferous and decomposed nodular ironstone of Coral Creek, Bowen River coalfield, and there is one specimen of a rugose coral from a similar bed on Parrot Creek, four and a half miles up. These corals have been described in a separate communication by Professor H. A. Nicholson, M.D., and myself.*

* Annals Nat. Hist., Sept. and Oct. 1879.

At the present moment it may simply be stated that the two species of *Stenopora*, are *S. ovata* (Lonsdale), and an undoubtedly undescribed and peculiar form, which we have distinguished as *S. Jackii.*

Class Polyzoa.

The Polyzoa from the Bowen River coalfield are few in species, and their state of preservation is exceedingly bad; and in this resembling to a great extent most other examples I have been accustomed to see from the Australasian Palæozoic rocks. The geological collection of the British Museum contains some very fine slabs from various localities, chiefly Tasmanian, but all of them, almost without exception, are, like the Queensland examples, in the state of casts. In such specimens the whole of the substance of the polyzoarium has been removed, leaving usually not the slightest trace of the cells, but is merely represented by the hollow spaces from which the stems and branches have disappeared, and the casts of the mesh-like fenestrules. This state of preservation has rendered identification very difficult, a difficulty not decreased by the obviously perplexing manner in which the characters of the species appear to run into one another.

The principal forms which have been described from the Australian Carboniferous rocks are *Fenestella ampla* (Lonsd.), *F. internata* (Lonsd.), and *F. fossula* (Lonsd.), and according to the descriptions and figures given by Mr Lonsdale in Mr Darwin's and Count Strzelecki's works appear well established and distinct species. When, however, I came to examine a suite of specimens in the British Museum from typical Tasmanian localities, in conjunction with the Queensland specimens, I found that, in the absence of definite information concerning the nature of the cells, it became very difficult to distinguish between them, so little reliance can be placed upon the size and relative distance apart of the meshes of the polyzoarium. The number of intermediate forms which appear to exist between any two hitherto considered species is so great as to almost preclude any satisfactory conclusion being arrived at.

With the view of assisting in the correct determination of these specimens, I have endeavoured to obtain access to the types of Lonsdale's species of *Fenestella*, forming a portion of the collection formed by Dr Darwin, F.R.S., and described in his work on "Volcanic Islands." Unfortunately these are not now forthcoming, and appear to have been altogether lost, so that for the future the determination of these species must always remain on an unsatisfactory basis. An exception to the unsatisfactory state of things amongst the Queensland Polyzoa exists in the form of a much crumpled, contorted, and curled polyzoarium of large extent, easily recognisable by its strongly marked characters, when seen in the form of casts. In this particular it is clearly allied to the typical condition of *Fenestella ampla* (Lonsdale), but differs essentially in the perfectly circular form of the casts of the fenestrules, their quincuncial arrangement, and wide separation from one another, thus denoting a large extent of interstitial surface on the stems and branches.

The next example in regard to the size of its constituent parts is what at first sight might be taken for Lonsdale's *F. ampla*, but on a critical comparison with the figures given in Count Strzelecki's work, it will be observed that the casts of the fenestrules are smaller and very much closer together than in the latter. The difference between the size of the fenestrules as represented by their casts and the distance of one from the other in the two specimens will become apparent at once. So far they are distinct, but there are in the British Museum Collection intermediate forms so intimately uniting these by insensible gradations that I hesitate to separate them, notwithstanding the noteworthy points of difference between the two extremes. It may not be out of place to mention that the smaller form agrees very much better with Professor De Koninck's representation of *Fenestella ampla* than with the late Mr Lonsdale's, from which De Koninck's figure differs in many particulars.

The third and last form we have to deal with possessed a frond still finer in the mesh than the preceding, the fenestrules being very much closer together and almost round. As it stands by itself, it is quite separable from any of the others, yet there are here, as in the former case, a number of specimens intermediate between it and the supposed *F. ampla* referred to above. In point of texture the one now under consideration compares most favourably with Lonsdale's *F. fossula.*

That one and all of these are a single variable species it is difficult to believe, and I do not for one moment so assert it; but it is nevertheless quite clear that, taking certain well-marked forms amongst these Australian Carboniferous *Polyzoa* as fixed points, we then have a series of intermediate examples so varied and so numerous that it is exceedingly difficult, and at times I believe quite impossible, to draw a line of demarcation where one species begins and the other ends—what is one and what is another. Some observers would doubtless endeavour to make every slight variation a specific difference; but with this I do not agree, and were they to do so in the present instance, a difficult and much obscured subject would become still more complex.

Genus Protoretepora—*De Koninck*, 1877.

(Foss. Pal. Nouv-Galles du Sud., pt. 3, p. 178.)

Obs.—This genus was established by Professor De Koninck for the reception of certain species hitherto placed in *Fenestella*, *Polypora*, and other genera. According to the original definition of *Fenestella*, as laid down by Lonsdale, the celluliferous face of the polyzoarium is external.* He says, "One row of pores on each side of the branches externally;" and again M'Coy, in describing the genus, adds, "two rows of prominent pores on the external carinated face of each interstice."† By the redefinition of M'Coy, and again of King,‡ the original *Fenestella* of Lonsdale became restricted to those fan-like or infundibuliform reticulate Palæozoic *Polyzoa* in which the vertical or radiating ribs (interstices) are alone poriferous, and the connecting bars (dissepiments) not so. By this judicious restriction there were eliminated from *Fenestella* (Lonsd.), such colonies as *Polypora* (M'Coy), *Ptylopora* (Scoular), *Phyllopora* (King), and the like. *Polypora* (M'Coy), includes those

* Murchison's "Silurian Syst.," 1839, p. 677.

† Synop. Carb. Limestone Foss. Ireland, 1844, p. 200.

‡ Mon. Perm. Foss. England, 1850, p. 35.

reticulate colonies in which both the interstices and dissepiments are cell-bearing, in contradistinction to *Fenestella.** *Phyllopora* (King), on the other hand, contains those forms in which there is no definite separation into interstices and dissepiments, but the whole of one surface of the colony, the outer or external, is celluliferous,† having a general and outward resemblance to the recent *Retepora.* It appears, however, that the names *Fenestella* and *Polypora* had been indiscriminately used by some writers for colonies which really possessed the characters of *Phyllopora,* except that the cell-bearing face or aspect of the polyzoarium was internal instead of external, as expressly stated is the case by Professor W. King in his genus. It is for these infundibuliform and intermediate *Phyllopora*-like forms that Professor L. G. de Koninck has proposed his genus *Protoretepora.* In a few words, it may be said to differ from the allied genera as follows: from *Fenestella,* by having the whole of one face of the polyzoarium cell-bearing, and that the internal instead of the external, and the cells limited to the interstices only; from *Polypora,* by the absence of a well-defined separation of the polyzoarium into interstices and dissepiments, and the disposition of the apertures of the cells on the internal instead of the external face, although, like *Phyllopora,* the whole of the cell-bearing face is celluliferous; lastly, from *Phyllopora,* simply by the fact that the celluliferous aspect is internal, and not external, the arrangement and disposition of the cells being exactly the same.

Protoretepora would at first sight appear to have close relations to the recent *Retepora,* and it appears to me that the only reason assigned for their separation by Professor De Koninck scarcely seems sufficient. He says that "in *Retepora* properly speaking the branches are arranged (*contournées*) in such a way as to form meshes, and not regular rows of 'oscules' or fenestrules" (*i.e.* as in *Protoretepora*). I must confess that after examining carefully a specimen of the recent *Retepora Beaniana* (King), I cannot see that the difference pointed out by Professor De Koninck is of sufficient importance in itself to base a generic separation on. On the

* M'Coy, *loc. cit.*, p. 206.

† King, *loc. cit.*, p. 389.

other hand, if we look a little more minutely into the subject, we shall, I think, find a much more satisfactory reason for the separation of the two forms.

Lonsdale long ago pointed out, in describing* his *Fenestella ampla,* that the polyzoarium was bilamellar, the outer layer or back of the branches being "composed of a uniform crust," upon which are seated the tubular cells, at right angles, or a little obliquely to the former. This structure is exceedingly well shown in Mr Lonsdale's figure given in Count Strzelecki's work;† but we are indebted for a further and fuller exposition of it to Professor W. King. This author showed‡ that in his genus *Phyllopora,* and some other Palæozoic genera, the frond was bilamellar or bistructural, consisting of a lamina of capillary tubes, called the basal plate, and an outer lamina of cellules, arranged more or less at right angles to and on this. On the other hand, he states that in the *Elasmoporidæ* (= *Reteporidæ,* auct.) the frond is unilamello-celluliferous, "composed of one lamina, consisting simply of cellules or polypidoms." As before stated, this bilamellar structure has been shown to exist in *Protoretepora ampla* by Lonsdale, and it appears to me a character of much more generic value than the mere arrangement only of the fenestrules.

Two forms of *Protoretepora* occur amongst Mr Jack's fossils—one, a bold and distinctly marked form, which I propose to call *P. Koninckii;* the other possessing all the character of *P. ampla,* the type of the genus, except that it is of a much smaller habit.

Protoretepora Koninckii, sp. nov.

Sp. char.—Polyzoarium infundibuliform, curled and much crumpled, of large extent. Fenestrules, small round, separated by wide interspaces (interstitial), and arranged in quincunx. Interstitial surface occupied by from five to ten rows of cell apertures between contiguous fenestrules. Cells with hexagonal or polygonal bases. Basal plate thin and striated.

* Darwin's "Volcanic Islands," pp. 163, 164.

† *Ibid.*, t. 9, f. 3*d*.

‡ Annals Nat. Hist., 1849, pp. 388-90; Mon. Perm. Foss., p. 42.

Obs.—The above imperfect characters are derived from numerous casts occurring in the fossiliferous and feruginous sandstone nodules of Coral Creek, and notwithstanding their brevity, will, I think, enable the form to be recognised, its characters are so prominent and marked.

The fenestrules are smaller than in typical specimens of *P. ampla* (Lonsdale), but the increased interstitial surface separating the circular fenestrules gives to *P. Koninckii* a very marked appearance, which is still further increased by the large extent of the curled and crumpled infundibuliform frond, with its numerous ramifications displayed to great advantage in the nodular matrix in which it is entombed.

Unfortunately for a proper illustration of the species, I am at present only acquainted with casts, and whenever any trace of the cells is left, it is always the hexagonal or polygonal bases, with the basal plate worn off.

From amongst the other species which Professor De Koninck indicates as belonging to *Protoretepora*, the present one may be distinguished thus: From *P.* (*Polypora*) *Halliana* (Prout)* by identically the same points which separate it from *P. ampla* (Lonsdale), only in a more marked degree, and from *P.* (*Polypora*) *Hamiltonensis*† by the generally enlarged condition of all the characters in *P. Koninckii*, as compared with those of the last named.

Loc. and Horizon.—Coral Creek, below Sonoma road-crossing, Bowen River coalfield, in a decomposed nodular ironstone, associated with *Stenopora* and numerous other fossils (Marine Series, Nos. 77, 80, 85, 98, 123, etc.).

Collector.—R. L. Jack, Esq.

Protoretepora, sp. ind.

(Compare *P.* (*Fenestella*) *ampla* (Lonsdale), in Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 268, t. 9, f. 3-3*d*, and more particularly De Koninck's figs., Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, t. 8, f. 5-5*c*.)

Obs.—Of equal frequency with the last is another form, the second referred to in the introductory remarks on the Polyzoa, having more or less the character and appearance of

* Illinois Geol. Survey Report, ii., t. 21, f. 4 and 4*a*, *b*.

† *Ibid.*, ii., f. 6 and 6*a*.

P. ampla (Lonsdale), the type of the genus *Protoretepora*, but with this exception, that the entire habit of the polyzoarium is on a smaller scale. Whether to consider this as a variety only of *P. ampla*, or as a distinct form I am at a loss to decide, a state of uncertainty which is not diminished by the regular gradation traceable through a series of specimens previously referred to, as in the British Museum Collection. Careful measurements of the number of fenestrules in the space of an inch vertical on the surface of these examples shows that, from the typical *P. ampla*, where there are pretty constantly 9 or 10, we pass through such gradations as polyzoaria with 14 or 15, another with 16 or 17, and an extreme of 18 to 20, and this it must be borne in mind without any material change in the other features, beyond such as would of course be caused by increased or decreased growth. I have investigated this matter somewhat fully in company with my colleague, Dr Woodward, F.R.S., who agrees with me as to the difficulties attending specific separation amongst these Australian *Polyzoa*. Of course it is just possible that, had we the perfect fronds to deal with, matters might be simplified, but as they are at present only known to me as casts, little more can be said just now.

The non-celluliferous face of the present Queensland specimens is minutely striated, the fenestrules are oval and of medium size. The cellules are arranged in quincunx, and in from three to six oblique rows on the interstitial surface, but more commonly the rows are four.

Loc. and Horizon.—Identical with the preceding species (Nos. 64, 81, 93, 109, etc.).

Genus Fenestella—*Miller and Lonsdale*, 1839.

(Murchison's "Silurian System," p. 677.)

Fenestella, sp. ind.

(Compare *F. fossula* (Lonsdale), in Strzelecki's "Phys. Descrip. N. S. Wales," 1845, p. 269, t. 9, f. 1 and 1*a*.)

Obs.—This is a dense probably infundibuliform species, in which the number of rows of cells on the interstices varies from two to five, the increase taking place a short distance before the bifurcations of each branch, the normal number however appears to be five. The specimens, like those just described, exhibit none of the true substance of the polyzoarium, but consist of mere casts in various states of preservation. The fenestrules are very closely set and almost round. The state of preservation does not permit of any definite description being given.

Loc. and Horizon.—Identical with the preceding species (Nos. 84, 112, and 130, etc.).

CLASS BRACHIOPODA.

Genus Spirifera—*J. Sowerby.*

Spirifera glabra—Martin.

Conch. (*Anomites*) *glaber*, Martin, Pet. Derb., 1809, t. 48, f. 9, 10.
Spirifera glabra, Davidson, Mon. Brit. Carb. Brachiopoda, pp. 59 and 264, t. 11, f. 1-9, t. 12, f. 1-5, 11 and 12 (*for general synonomy*).
,, ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 56 (*for Australian synonomy*).

Obs.—I refer to this species a portion of a single specimen of a ventral valve, showing the umbo, visceral region, area, and part of the sinus. There are also traces of the broad concentric laminæ which make a prominent feature in the Australian forms of this species. It is of frequent occurrence in the Carboniferous rocks of this Continent.

Loc. and Horizon.—Stonelumpy Creek, Bowen River coalfield (Marine Series, No. 164).

Collector.—R. L. Jack, Esq.

Spirifera convoluta—Phillips.—Pl. VII., fig. 6.

Spirifera convoluta, Phill., Geol. York., 1836, ii., p. 217, t. 9, f. 7.
,, ,, Davidson, Mon. Brit. Carb. Brachiopoda, p. 35, t. 5, f. 2-15 (*for general synonomy*).
,, ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 55 (*for Australian synonomy*).

Obs.—A small cast in a friable micaceous sandstone appears to possess all the chief characters of this species—elongated hinge line, acute alar angles, and bifurcated ribs, which gradually disappear on the wings.

Loc. and Horizon.—Parrot Creek, four and a quarter miles up (Marine Series, No. 140).

Spirifera Darwinii—Morris (?).—Pl. VII., figs. 7-10; Pl. VIII., fig. 11.

S. Darwinii, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 279.
S. subradiatus, Morris (*non* Sow.), *loc. cit.*, t. 15, f. 5*a* (fig. *cæt. exclusis*).
S. Darwinii, Dana, Geol. U.S. Exploring Exped., p. 684; atlas, t. 1, f. 7.
,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 230; Atlas, t. 10, f. 11, t. 11, f. 10, t. 16, f. 1.
,, Etheridge, jun., Cat. Australian Foss., 1878, p. 55.

Obs.—I have referred to this species a few small Spirifers from Coral Creek and other localities, with a deep wide sinus in the ventral valve, bordered on each side by three prominent ribs, and the rudiment of a fourth. In the dorsal valve the fold is broad and well marked, and there are the same number of ribs as in the ventral. There are indications of the divided mesial lobe or fold in one of the specimens, but in the other dorsal valve the fold is too much pinched up to show this distinctly. The characteristic concentric laminæ are also visible in another of the specimens. I have compared the Queensland examples with the type contained in the Strzelecki Collection, and also with a very typical specimen from the cliffs at Woollongong, New South Wales, for which I am indebted to my friend Professor A. Liversidge, F.C.S., F.G.S., etc., of Sydney University, and I find that, allowing for difference of age and state of preservation, it may safely be concluded that the specimens collected by Mr Jack belong to this species.

I am quite in accord with Professor De Koninck in referring one of the shells figured by Professor Morris as *Spirifer subradiatus* (G. Sowerby) to the present species. I have compared this particular specimen with Morris's type of the latter.* In justice to Professor Morris, it must be borne in mind that he himself hinted at this union. Again, I think it not at all improbable that Professor Dana is correct in placing *S. paucicostata* (G. Sow.) as a synonym of *S. Darwinii* (Morris).

Loc. and Horizon.—Coral Creek, below Sonoma road-cross-

* Strzelecki's "Phys. Descrip. N. S. Wales," p. 279.

ing (No. 83); Parrot Creek, four and a quarter miles up (No. 148); both in Marine Series.

Collector.—R. L. Jack, Esq.

Genus Orthotetes—*Fischer.*

Orthotetes crenistria, var. *senilis*—Phillips.—Pl. VIII., figs. 12-15.

Spirifer senilis, Phill., Geol. Yorksh., 1836, ii., p. 216, t. 9, f. 5.
Streptorhynchus crenistria, var. *senilis*, Davidson, Mon. Brit. Carb. Brach., t. 27, f. 2-2*a*, 3-3*a*, and 4.
Leptæna senilis, M'Coy, Brit. Pal. Foss., 1853, fas. 3, p. 45*a*.

Obs.—There can be no mistaking this semi-conical, irregular, and gnarled-looking variety of the widely spread *Orthotetes crenistria*. The ordinary form of the species has been before recorded from Australian Carboniferous rocks,* but, so far as I am aware, the variety *senilis* has not previously been met with.

The Queensland specimens have, in common with British examples, the semi-conic ventral valve, with step-like interruptions, "produced by two or three very large and irregular concentric undulations," the elevated but not incurved beak, and the wide area with its convex deltidium. Similarly, the dorsal valve exhibits the straight hinge line, evenly convex surface, and much less marked undulations. The striation of the valves likewise appears to be identical, and there are also the same concentric laminations of the area and deltidium as seen in some British examples. In these shells from Queensland the shelly matter is decidedly and distinctly punctate, and when the surface is at all worn the punctæ are everywhere visible, and more especially on the area. I believe the punctate structure of the shell in *Orthotetes* (= *Streptorhynchus*) has not been generally recognised, for in the generic descriptions of it given by all the best authors, the shell is said to be impunctate. However, that most accurate observer, Professor W. King, has not omitted to notice this peculiarity in a Permian species of the genus, *O. pelargonatus* (Schlotheim).† On mentioning the existence of these perforations in the Australian shells to Mr Davidson, he informed me

* De Koninck: "Foss. Pal. Nouv-Galles du Sud.," 1877, pt. 3, p. 213.
† Mon. Permian Foss. England, p. 109.

that he had recently seen the same structure in some British *Orthotetes.*

The punctæ on the exterior of the shells appear as small rugosities scattered at random over the surface of the ribs or striæ and intervening valleys ornamenting these shells, but when worn to any extent their perforate character at once becomes apparent. They are in particular very numerous on the area and deltidium.

These prominent examples of *Orthotetes senilis* to some extent resemble the variety *robusta* (Hall), figured by Mr Davidson from Indian Carboniferous rocks,* only, in the latter, the ventral valve appears wider across the hinge; the umbo, however, projects upwards and backwards, as in the Queensland examples.

Loc. and Horizon.—Pelican Creek, three-quarters of a mile above Sonoma road-crossing (Marine Series, Nos. 54 to 57 inclusive). Havilah-Byerwin Road, one mile south of Rosella Creek crossing. The geological position of this species in the Bowen River coalfield is both interesting and peculiar. According to Mr Jack's notes, it is found at a second locality in a marine band, in his Fresh-Water Series, which is characterised by the predominance of the much-disputed genus *Glossopteris*, and other so-called Oolitic plants (Nos. 190, 194, 212).

Collector.—R. L. Jack, Esq.

Genus Productus—*J. Sowerby*, 1814.

(Min. Con., i., p. 153.)

Productus subquadratus—Morris (?).

P. subquadratus, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 284.
,, De Koninck, Mon. Productus et Chonetes, 1847, p. 100, t. 14, f. 1.
,, Etheridge, jun., Cat. Australian Fossils, 1878, p. 53.

Obs.—A single, large, quadrate, and gibbous cast of the exterior of the united valves of an individual appears from the arrangement of the spines and general appearance to be

* Quart. Jour. Geol. Soc., xviii., p. 30, t. 1, f. 16.

referable to this species, if species it be, and not, as Professor De Koninck has pointed out, only a form of *P. brachythærus* (G. Sow.). The ventral valve of the Queensland example, judging from the cast, was very much vaulted and covered with the elongated tear-like bases of spines disposed irregularly, but in the greatest number over the visceral portion of the valve, and on the ears.

The form of the dorsal valve is peculiar, on account of the marked concavity, following closely the curvature of the ventral valve, and uniting with the latter in its front prolongation, which is almost at right angles to the body of the shell. Besides the tear-like spines, the shell appears to have been covered with delicate vertical striæ.

In the only specimen which has come under my notice, the spine bases are finer and more numerous than represented in the figure given by De Koninck.

Loc. and Horizon.—Pelican Creek, two and a half miles above Sonoma road-crossing (Marine Series, No. 59).

Collector.—R. L. Jack, Esq.

Productus brachythærus—G. Sowerby.—Pl. VIII., fig. 16; Pl. IX., figs. 17, 18.

P. brachythærus, G. Sow., Darwin's "Geol. Obs. Volcanic Is.," 1844, p. 158.
,, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," 1845, p. 284, t. 14, f. 4*c* (non 4*b*).
,, De Koninck, Mon. Productus et Chonetes, 1847, p. 102, t. 16, f. 1*a* and *b* (non 1*c* and *d*).
P. undulatus, M'Coy, Annals Nat. Hist., 1847, xx., p. 236, t. 13, f. 2.
P. brachythærus, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 198, t. 10, f. 4 and 4*a*, t. 11, f. 1.
,, Etheridge, jun., Cat. Australian Foss., 1878, p. 51 (*for synonomy*).

Obs.—This characteristic Australian species is represented in Mr Jack's collection by specimens from two localities. All who have written on *P. brachythærus* lay stress on the shortness of the hinge line, as compared with the width of the front. This, with the elongated decurrent bases of the spines, forming channels in the shell, are particularly characteristic points in G. Sowerby's species. The channelling of the shell by the spine bases is seen in many species of *Pro-*

ductus, but it appears to be peculiarly distinctive of *P. brachythœrus.* The length of the hinge line varies according to age, in large and old individuals it becomes longer, and the shell, which is very convex and geniculate, loses some of its convexity, and widens out likewise.

In describing this species Professor Morris, F.G.S., referred to it two shells of very different aspect and state of preservation. One of these is a cast in sandstone, showing the general form, and more particularly the channels formed by the decurrent bases of the spines. The other specimen is a decorticated silicious cast, and displays the internal characters of both valves to great perfection. On the ventral valve are exposed the node-like prominences of the cardinal muscles, the scars of the more elongated adductor muscles, and the internal cast of the beak. The dorsal valve shows the scars of the adductors, and the cast of the septum, which in this individual reaches almost to the front margin of the valve, an unusual length in the genus *Productus.* The vascular impressions are also preserved and come very far forward like the septum. These details are important as will be seen from the sequel.

In his recently published work on the "New South Wales Fossils of the Clarke Collection," Professor De Koninck has expressed an opinion that the two shells in question referred by Morris to *P. brachythœrus* are different, and do not belong to the same species, one being possessed of a short septum in the dorsal valve, and less marked muscular scars, the other on the contrary with a very long septum, and strongly marked scars. In working out Mr Jack's *Producti* it became essential, for anything like a correct determination of the specimens, that some more satisfactory solution of this subject than mere opinion should be arrived at.

In the first place I endeavoured to obtain access to Mr G. Sowerby's type specimen, contained in the collection made by Dr C. Darwin, F.R.S., but although the latter most courteously informed me of the supposed whereabouts of his collection, it cannot, after a thorough search, be found, so that I am afraid this, and the other specimens, all of them of great interest, must be accounted lost. Next in order of importance, from a typical point of view, are the specimens used by Professor Morris, and forming a part of the Strzelecki Collection, now in the British Museum. In the absence of Mr G. Sowerby's type these specimens must be so accepted, and to their structure all future appeals must be made in determining the identity of *P. brachythærus* (G. Sow.), Morris. Now, as stated above, Professor De Koninck regards the silicified cast* with the long septum, described by Morris as *P. brachythærus*, to be specifically distinct from the true *P. brachythærus*,† a name which he considers should be retained for a form with a short septum, amongst other characters. Now the silicified cast figured by Morris in Strzelecki's work (Pl. XIV., f. 4*a* and *b*) has for one of its most distinctive characters a long septum in the dorsal valve, as previously pointed out, and on looking this matter up it became a question with Dr H. Woodward and myself whether the view advanced by De Koninck was not the correct one, especially as the example of *P. brachythærus* represented by the sandstone cast accorded much better with Sowerby's description of his species, than did the silicious example. The specimen in question,‡ as then exposed, was that of a ventral valve backed up with matrix, so that it became a nice point, whether, on the removal of this, in itself a very delicate operation with so fragile a specimen, the cast of the dorsal valve would be visible and the septum exposed, long or short as the case might be. After due consideration we determined that an effort should be made, and the specimen was accordingly handed over to Mr Barlow, the Departmental Lapidary at the British Museum, for manipulation. Extreme care enabled Mr Barlow to remove the whole of the matrix without very much damage to the specimen, considering the delicacy of the operation, and with this result, that it was found to possess, so far as we are able to judge, a short septum, so probably confirming in a remarkable manner Professor De Koninck's surmise. The matter then stands thus—the figure given by Morris in Strzelecki's work on "New South Wales," Pl. XIV., f. 4*c*, is the true *P. brachythærus*,

* Strzelecki, pl. 14, f. 4*a* and *b*.

† *Loc. cit.*, f. 4*a* and *b*.

‡ Strzelecki, *loc. cit.*, pl. 14, f. 4*c*.

characterised by the presence of a short septum and a little developed muscular system. On the other hand (Pl. XIV., f. 4*a* and *b* of the same work), the silicious cast, with a very long septum and great muscular development, is a distinct and separate species; its identity will be considered further on.

I am indebted to the kindness of Professor T. M'K. Hughes, M.A., for the loan of the specimen of *P. brachythœrus* from the W. B. Clarke Collection of the Woodwardian Museum, referred to by Professor M'Coy in his celebrated paper on the New South Wales Fossils,* and also for the type of *Productus undulatus* (M'Coy), from the same collection. The Cambridge specimens of *P. brachythœrus* do not call for any particular notice beyond the fact that they show the species to be in outward appearance not unlike the variety *pugilis* (Phill.) of the European species, *P. semireticulatus* (Martin)—a peculiar streaky appearance is given to the exterior of the shell by the decurrent bases of the spines. With regard to M'Coy's *P. undulatus*, Professor De Koninck † refers it to *P. brachythœrus;* but a careful examination of the type forwarded to me from the Woodwardian Museum has not so thoroughly convinced me of the advisability of this step as I could wish. I have not seen such peculiar undulating striæ upon any specimen of *P. brachythœrus* I have examined.

Finally, a few words must be said on the subject of *Productus fragilis* (Dana). My own impression, taken merely from the description and figures of the species by Professor Dana, is that *P. fragilis* is nothing more than a condition of *P. brachythœrus.* Professor De Koninck is of a contrary opinion, and has furnished an elaborate description of it in his recent work. ‡ With all due respect, however, I would venture to suggest that Professor Dana's description and figures are totally inadequate for any palæontologist to determine, with anything like certainty, what is, or is not, *Productus fragilis* (Dana). I looked forward to being able to throw some light on this subject by means of a direct comparison of authenticated specimens of *P. fragilis*, with the Morrisian type of *P. brachythœrus.* Unfortunately, however,

* Annals Nat. Hist., 1847, xx., p. 235.

† Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 198. ‡ *Loc. cit.*, p. 201.

Professor J. D. Dana, in a very kind letter lately received,* informs me that the specimens of his *P. fragilis* are supposed to have been destroyed in the disastrous fire which took place some years ago at the Smithsonian Institution, where the "Expedition Collection" was deposited. Here, again, we shall, in all probability, be for ever left in doubt as to the correct identity of a species.

To return to the Queensland shells once more—their identification with *P. brachythærus* is fully borne out by the shortness of the hinge, tendency to expand towards the front, concavity of the dorsal valve, geniculate or bowed character of the ventral, and the exposure in one of the specimens of the short septum.

Loc. and Horizon.—Stonelumpy Creek—Marine Series (No. 165); Havilah-Byerwin Road, one mile south of Rosella Creek crossing, associated with *Streptorhynchus crenistria* var. *senilis*, in a marine band in the Upper or Fresh-Water Series of the Bowen River coalfield (No. 193).

Collector.—R. L. Jack, Esq.

Genus Strophalosia—*King*, 1844.

(Annals Nat. Hist., 1844, xiv. p. 313; Mon. Permian Foss. England, 1850, p. 93.)

Obs.—The presence of the genus *Strophalosia* in the Palæozoic rocks of Australia has already been satisfactorily indicated by Professor L. G. de Koninck,† who has described *S. productoides* from the Devonian beds of Kempsey, New South Wales. In a collection made by Mr A. C. Gregory on the Mantua Downs in 1856, and submitted by the late Rev. W. B. Clarke, F.R.S., to Professor M'Coy in 1861, the latter recognised certain forms which he considered indicative of Permian rocks, viz.: a shell resembling *Productus horridus*, and another near *Aulosteges* or *Strophalosia*.‡ Lastly, my father, although he considered the existence of a Permian fauna in these regions required confirmation,§ noticed the

* Letter, dated "New Haven," Feb. 17, 1879.

† Foss. Pal. Nouv-Galles du Sud., 1876, pt. 1, p. 83.

‡ Trans. R. Soc. Vict., 1865, vi., p. 46.

§ Quart. Jour. Geol. Soc., 1872, xxviii., p. 32.

occurrence of a shell on the Noyoa River, which was probably a *Strophalosia*, but may have been only a *Productus*.*

It now affords me much satisfaction to be able to definitely announce the occurrence of the genus *Strophalosia* in the Upper Palæozoic rocks of Queensland, for, through Mr Jack's exertions, numerous specimens of this genus have been collected. These I have provisionally separated into two species. On the one hand there is the shell called by my father *Productus Clarkei*, which, on a more complete investigation, turns out to be a *Strophalosia*. On the other hand are certain other examples, perhaps only a variety of the foregoing, and which may have ultimately to be united with it, but, through the absence of intermediate forms, I have thought it better to keep distinct from *S. Clarkei* for the present. With the concurrence of Mr T. Davidson, these have been referred to *Strophalosia Gerardi* (King).

The British Museum Collection contains another form of *Strophalosia* from New South Wales and Tasmania. The specimens were presented by the late Professor Jukes and Dr J. Milligan, and Mr Davidson also possesses a few. This form is, in many ways, a remarkable one, agreeing with both the preceding species in some respects, and differing in others. Pending the arrival of further material, I have adopted a similar course in this case, and have provisionally applied to them a name.

Strophalosia Clarkei—Etheridge.—Pl. IX., figs. 18*a*-21; Pl. X., figs. 22-28; Pl. XI., figs. 29-31; Pl. XII., figs. 32, 33.

Productus Clarkei, Etheridge, Quart. Jour. Geol. Soc., 1872, xxviii., p. 334, t. 17, f. 2 and 2 *a*, *b*.
,, ,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 203, t. 10, f. 5, t. 11, f. 2.
,, ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 51.

Sp. Char.—Ventral valve strongly gibbous, or inflated; very prominent and convex about the visceral region, sloping gradually off to the front, but non-geniculate and unproduced. Hinge line straight, but not equal to the width of the shell. Ears flattened, small when compared with the general pro-

* *Loc. cit.*, p. 334.

portions of the valve. Beak large, short, and blunt, but not overhanging the hinge line; immediately under it are two large obliquely-placed teeth, which fit into the sockets of the dorsal valve. In the umbonal region of the shell, proceeding from the beak towards the front, is a fine ridge or septum (a groove in casts), with, on each side of it, the dendritic adductor muscular impressions, each bounded on its outer margin by a well-defined groove (ridges in the cast). Immediately in front of these adductor impressions is a large, blunt prominence (in the cast becomes a hole or fossa of varying depth, and of a very marked character), with the outer edge much less precipitous than the inner. On each side this prominence are the depressed scars of the cardinal muscles, much deeper and more impressed on their inner or umbonal margins, and gradually dying out laterally towards the sides of the valve; they are vertically grooved and ridged. (In the cast these impressions become ridged prominences, projecting or scarp-like along their upper edges, and they impinge somewhat on each side over the deep fossa just described.) The interior surface of the valve is pitted and ridged, producing in the cast granules and grooves; the former are continued over the surface of the blunt prominence (fossa in the cast): the ridges seen on the interior represent the decurrent bases of spines. The exterior surface of the valve is unknown to me, but is described by Mr Etheridge, F.R.S., as "covered with fine, vertical, wavy lines, projecting from which are numerous slender spines."

The dorsal valve is oval, flat, and very thick, bevelled outwardly from the interior on the front margin. The latter is apparently continuous, and not indented in any way. Hinge line with rounded alar angles; area well marked, but not broad. Cardinal boss thick, strong, and prominent, projecting from the hinge line at an angle of 119°, with the exterior plane of the valve centrally divided by a groove, which is flanked on each side by a kind of shoulder. Sockets for the reception of the teeth of the ventral valve deep, broad, and so far surrounding the boss as to produce an appearance of isolation in the latter from the remainder of the valve. The cardinal boss is supported on each side by indistinct, oblique alar ridges. Septum strong and ridge-like, extending for more than two-thirds the distance between the cardinal boss and the front margin, terminating in a small button. Immediately under the boss is a deep depression, divided in the middle line by the septum, and in which are situated the dendritic adductor muscular impressions. This depression is separated by a transverse ridge running across the valve from a second depression similarly divided by the septum. The reniform impressions are narrow, semilunar, much incurved and abrupt at their front termination, and bounded outwardly by a deep groove or linear depression following their course. The internal bevelled edge is marked with very fine granules or pustules and small veinings, being the indications of the vascular system. The shell has a silky appearance, and when weathered or decorticated, the shell-substance is marked by a series of fine, wavy, vertical lines. The valve is externally ornamented with a number of close, concentric, scaly laminæ, and similar spines to the ventral. A series of spines are also placed along the hinge of the ventral valve (fig. 33), erect, and graduating outwards from the umbo.

Obs.—This interesting species is known to us under two conditions—internal casts of the ventral valve in sandy-mudstone, and dorsal valves retaining more or less of their shelly matter. Examples with the valves united, retaining the true shell, I have not seen; but that both conditions I have placed under the name *Strophalosia Clarkei* belong to one species, will, I think, be self-evident, after a careful study of the figures given. Further, the specimens occur together at the same locality.

The history of *Strophalosia Clarkei* is a brief one. It was originally described by my father as a *Productus*, from indifferent material in the Daintree Collection, and the external characters defined. Subsequently Professor De Koninck placed under this name a shell in the W. B. Clarke Collection, and described it in his New South Wales work. In my "Catalogue" I follow both these authors in placing the species under the genus *Productus*. I had not then enjoyed an opportunity of examining specimens.

To return to the fossils. Let us first examine the internal casts of the ventral valve, and compare the casts from Australia with the fine interior of *S. Goldfussi* (Münster), figured by Mr Davidson.* It will be observed that in Mr Davidson's fig. 9, representing a cast in a similar state of preservation to our specimens, there is, as in the latter, the correspondingly blunt and gradually attenuated but prominent beak (figs. 29 and 30, *i*, *i*), and deep pits left by the teeth of the ventral valve (fig. 30, *a*). Again, compare in fig. 10 of the "Permian Monograph" the concave or grooved back of the umbo with that of the Queensland cast (figs. 27-30, *b*). Thirdly, the position of the adductor scars in the same Permian figure is quite comparable with that of the Australian specimens (figs. 26-30, *c*, *c*, *c*, *c*), and more particularly with fig. 27. In Mr Davidson's figure the deep pit or fossa in front of these impressions is not so marked as in our fig. 29; but this is itself a variable point in the Australian shells. It is not as deep in fig. 26, and still less so in fig. 27 or 33. With regard to the cardinal muscular scars, we observe a perfectly similar arrangement—the position identically the same, similar ridging and grooving, the only apparent difference being that in the Permian *S. Goldfussi* the abrupt or scarp-like side appears to be towards the front, whereas in *S. Clarkei* it is towards the umbo or hinge-line (figs. 27 and 29, *e*, *e*, *e*, *e*).

Having, I hope, at least shown the resemblance of the sandstone casts to the genus *Strophalosia*, it may perhaps be well to say a few words on their relation one to the other, chiefly on account of the great disproportion in the development of the central eminence, causing the deep pit in casts, and from the less marked appearance of the muscular scars and internal portions generally. I find the central eminence to be a very variable character amongst these shells. We have one extreme in fig. 29, and the other in fig. 33. Between these two there is every gradation (figs. 26, 27, 28, *d*, *d*, *d*) in depth, and the same may be said of the muscular impressions, although they appear to be less open to variation than other parts.

We may now pass on to a consideration of the dorsal valves of *S. Clarkei*, and for this purpose the material we

* Mon. Permian Brach., Pal. Soc., t. 3, figs. 9 and 10.

possess consists of examples with the shell preserved, and in a few cases retaining their internal characters in a fine state of preservation.

It is strange that out of the large series forwarded by Mr Jack so few specimens should retain traces of the septum, reniform impressions, and other anatomical details. The usual condition under which the dorsal valves of *S. Clarkei* are presented to us in the Queensland Collection is shown by figs. 18*a*, 19, and 20, a flat, bevel-edged, more or less oval silky shell, and although viewed from the interior in each case, no trace of the marked characters of figs. 21 and 23 are visible, but on the contrary there is, in the place of the strong cardinal boss and septum, an oval gap in the shell substance. This discrepancy between such examples as figs. 18*a* and 21 I believe can be accounted for simply by decortication, because on several specimens before me I find traces of much shelly matter remaining, and which, if wholly preserved, would bring the shell up to the thickness required to make it correspond with fig. 21 or 23. A more complete demonstration may be made by means of figs. 20, 24, and 25. In fig. 25 we have a young example, in which the septum, alar ridges, and dental sockets are clearly visible. In fig. 20 these are all absent, but we have left the front termination of the right reniform impression (fig. 20), and again, in fig. 24, we have a further advance in traces of the great central depressions and the actual presence of the reniform scars, clearly leading up to figs. 21 and 23. I think that, putting together the information deducible from these several specimens, all the examples similar to figs. 18*a* and 19 may be fairly said to have intimate connection with the more perfect figs. 21, etc. On the receipt of Mr Jack's collection, I was at once struck with the appearance of fig. 23, and sought the opinion of Mr Davidson on the subject. In reply he sent me two corresponding valves (fig. 21) forwarded to him some time ago from New South Wales by the Rev. J. E. T. Woods, F.G.S., and which had been placed by Mr Davidson in his cabinet under the name of *Strophalosia Woodsi* (m. s.). On working through the Queensland Collection, it became apparent from the form, structure of the shell, and general characters of the specimens in question, that they could be no other than my father's *Productus Clarkei,* and identical with the well-marked fig. 23. Holding this in view, I forwarded my notes and specimens to Mr Davidson, and after a lengthened correspondence, and the production of satisfactory evidence, I was able to convince him of the identity of his *Strophalosia Woodsi* (m. s.) and *S. Clarkei* (Etheridge).

It is hardly necessary to compare *S. Clarkei* with other described species, except *S. Gerardi* (King). This will be done in connection with the description of that species, and there will then be discussed the possibility, first suggested by Professor W. King, and concurred in by Mr Davidson, of the latter's *S. Woodsi* being identical with *S. Gerardi* (King).

Loc. and Horizon.—Pelican Creek, five miles north of Sonoma Station; Pelican Creek, opposite Palmer's Old Station; Parrot Creek, four and a half miles up (Marine Series, Nos. 3, 10, 21, 36, 135, 138, etc., etc.).

Collector.—R. L. Jack, Esq.

Strophalosia Gerardi—King (?).—Pl. XII., figs. 34-37; Pl. XIII., fig. 38.

S. Gerardi, King, Annals Nat. Hist., 1846, xviii., p. 93.
,, De Koninck, Mon. Productus et Chonetes, 1847, p. 137.
,, Mon. Permian Foss. England, 1850, p. 96, t. 19, f. 6 and 7.
,, Davidson, Mon. Brit. Foss. Brachiopoda, Introduction, t. 8, f. 211.

Sp. Char.—Shell large, ovato-rotund, at times becoming almost deltoid, strongly concavo-convex; ventral valve convex, most so about the umbonal and visceral regions; umbone prominent, rounded, and overhanging the area to some extent; dorsal valve very concave, following closely the contour of the ventral, assuming a more or less deltoid form, usually much longer than wide; hinge line short, not as wide as the shell; area broad and well marked, elongately triangular; deltidium conspicuous, convex; surface of the ventral valve concentrically laminated, and giving rise to numerous adpressed tapering spines, which, when worn off, leave the valve covered by a series of short, blunt, somewhat projecting tubercles; surface of the dorsal valve similarly ornamented, but the concentric laminæ appear to be closer, the spines more numerous, closer together, and longer than on the ventral valve; near the front edge of the valve the lamellæ become very close and numerous, and assume a strongly imbricated appearance. The greatest concavity of the dorsal valve is just below or in front of the hinge line, where it appears to become much pressed in. The shell at times assumes a slightly irregular aspect, with an inclination or oblique tendency towards one side or the other; the front margin is rounded and continuous, and shows no indication of an indentation or sinuosity.

Obs.—After much consideration of the subject in all its bearings, and a long correspondence with my friend Mr Davidson, I have provisionally kept apart from the previous *S. Clarkei* certain Queensland *Strophalosiæ* with very concave dorsal valves, and have referred them to Professor King's *S. Gerardi.* On this subject Mr Davidson wrote me as follows: "The dorsal valves are so very concave that I should hardly like to consider *S. Clarkei* and *S. Gerardi* as one, and to place your father's species as a synonym of *S. Gerardi.* We have not as yet, so far as I can see, any reliable interiors of the ventral valve of *S. Gerardi*, and I think it would be safer to keep it and *S. Clarkei* separate, unless you have some specimens to lead you to positively combine the two in one."

To the courtesy of Professor W. King of Galway I am indebted for the loan of the type of his *S. Gerardi*, which has enabled me to make the closest of comparisons with the Queensland shells I have here provisionally placed under that species, and the only essential difference that I can point out is, that in the type of *S. Gerardi*, the form of the shell is much more transverse than in the Queensland examples now under notice, the general form of the latter being decidedly inclined to the deltoid. I, however, presume that in such a variable genus as *Strophalosia* this would, in the absence of other characters, count for very little.

Notwithstanding the flat valve of typical specimens of *S. Clarkei*, it is just possible that it and the shells now referred to *S. Gerardi,* with the concave dorsal valves, may, after all, be one and the same. I am led to this impression by the otherwise general resemblance of the shell structure, habit, and co-occurrence. At present I am in this difficulty—on the one hand we have a series of dorsal valves all *flat,* and no ventral valves attached (= *S. Clarkei*); on the other hand a number of bivalve examples, with very *concave* dorsal valves (? = *S. Gerardi*), but all from the same localities, and with many points of minute structure the same—Are they identical? I am afraid the question must remain at present an open one, as the material to hand is not sufficient to solve the problem. The more deltoid form of *S. Gerardi,* in particular the dorsal valve, would hardly be sufficient to found a separation on, more especially as it is not constant, but a gradation in outline exists, which would, in all probability, in a series of specimens, gradually lead up to the oval or transversely elongated outline of *S. Gerardi.* The same remarks apply to the ventral valve, for the limited number of specimens of *S. Gerardi* known renders it difficult to assert what would be the average form of this valve. It may be oval, as in the type specimen, or there may be a gradation towards the less regular outline of the Australian shells I have referred to it.

Should my surmise as to the identity of *S. Gerardi* and *S. Clarkei* ultimately prove correct, my father's specific name will of course have to be abandoned, that is to say, presuming the identity of the Queensland shells with King's *S. Gerardi* to be correct.

In his description of *S. Gerardi* Professor King does not mention the existence of spines on the dorsal, but I find, on a close examination of his typical specimen, what appears to be the bases of insertion of the spines.

Loc. and Horizon.—Pelican Creek, five miles north of Sonoma Station; Pelican Creek, opposite Palmer's Old Station; Bowen River, between Traverse Stations 25 and 26; Parrot Creek, eight miles up (Marine Series of Bowen River Coalfield, Nos. 12, 23, 25, 26, 29, 31, 34, 68, and 157, etc.).

Collector.—R. L. Jack, Esq.

CLASS PELECYPODA.

Genus Aviculopecten—*M'Coy,* 1851.

(Annals Nat. Hist., 1851, vi., p. 171.)

Aviculopecten subquinquelineatus—M'Coy.—Pl. XV., fig. 52.

Pecten comptus, Dana (*non* M'Coy), American Jour. Sc., 1847, iv., p. 160.
,, *subquinquelineatus,* M'Coy, Annals Nat. Hist., November 1847, xx., p. 298, t. 17, f. 1.
,, *comptus,* Dana, Geol. U.S. Explor. Exped., p. 704, Atlas, t. 9, f. 5.
,, *subquinquelineatus,* M'Coy, Proc. Roy. Soc. V. D. Land, 1851, l., p. 322, t. 17, f. 1.
Aviculopecten ,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 295, t. 22, f. 2.
,, ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 66.

Obs.—This is a large, strong, and distinctly marked species, at first sight resembling *A. Fittoni* (Morris),* but easily distinguishable from it by the plain and unsubdivided condition of the radiating costæ, whereas in *A. Fittoni* the latter are composed of a series of smaller radii. In both species the concavities between the ribs are filled with subordinate costæ. In Morris's species there is only one between each pair of ribs, but in M'Coy's there are from three to five. In *A. subquinquelineatus* the ears are large and radiately striated, and the whole shell must have grown to some considerable size. It appears Professor Dana's name of *P. comptus* has precedence of M'Coy's by a short time, and would be the accepted one for this species, were it not that the name *comptus* had already been used by Professor M'Coy† for an Irish carboniferous limestone shell. Professor Dana's name has therefore to give way to the subsequently described *P. subquinquelineatus.*

Loc. and Horizon.—Bowen River, at No. 25 Traverse Station, in a hard flinty micaceous sandstone of the Marine Series.

Collector.—R. L. Jack, Esq., F.G.S.

* Strzelecki's "Phys. Descrip. N. S. Wales," t. 14, f. 2.

† Synop. Carb. Limestone Foss. Ireland, 1844, p. 90, t. 15, f. 14.

Aviculopecten, sp. ind.

Obs.—There is a single specimen of a large species of *Aviculopecten*, with portions of the valves in apposition. It is a mere cast with remains of shelly matter here and there, but appears to correspond to a great extent with *A. limæformis* (Morris).* The shell is very inequivalve, one valve being moderately convex, the other almost flat, or even towards the ventral margin a little concave. These features are also to be seen in *A. limæformis*, but the surface of the cast of the convex and larger valve retains traces of almost too many radiating ribs for the species.

Loc. and Horizon.—Coral Creek, below Sonoma road-crossing, in a decomposed nodular ironstone of the Marine Series (No. 121).

Collector.—R. L. Jack, Esq., F.G.S.

GENUS PTERINEA—*Goldfuss*, 1832.

(Naturg. Atlasses, Th. iv., p. 73.)

Pterinea macroptera—Morris.

P. macroptera, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 276, t. 13, f. 2 and 3.
,, M'Coy, Annals Nat. Hist., 1847, xx., p. 299.
,, Dana, Geol. U.S. Explor. Exped., p. 704.
,, Grange, Dumont-d'Urville's "Voy. au Pole Sud., Géol.," 1854, ii., p. 96.
,, Clarke, Southern Goldfields of N. S. Wales, 1860, p. 287.
,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 305, t. 16, f. 12.
,, Etheridge, jun., Cat. Australian Foss., 1878, p. 77.
,, Clarke, Sed. Formations, N. S. Wales, 1878, 4th edit., pp. 122, 125, 141, etc.

Obs.—Mr Jack has forwarded a *Pterinea*, clearly this species, but only one specimen, and that without a part of the posterior wing. The small anterior lobe is only partially preserved, the hinge line was clearly somewhat less than the width of the shell, and there are distinct remains of concentric laminæ, although the specimen is only a cast. The cast of one of the characteristic teeth is also preserved.

Loc. and Horizon.—Coral Creek, below Sonoma road-

* Strzelecki's "Phys. Descrip. N. S. Wales," etc., p. 277, t. 13, f. 1.

crossing, in decomposed nodular ironstone of the Marine Series, associated with *Stenopora*, *Protoretepora*, *Fenestella*, etc. (No. 111).

Collector.—R. L. Jack, Esq., F.G.S.

Genus Notomya—*M'Coy*, 1847.

(Annals Nat. Hist., 1847, xx., p. 303.)

Section Mœonia—Dana, 1847.*

(American Jour. Sc., 1847, iv., p. 158. *Emended*, U.S. Explor. Exped., Geology, p. 694.)

Obs.—In my recently published "Catalogue of Australian Fossils"† I have called attention to the difficulties attending a proper subdivision of the species of Dana's genera *Mœonia* (vel. *Myonia*), *Pyramia* (vel. *Pyramus*), and *Cleobis* as pointed out by the late Dr Stolitzka.‡ In Professor Dana's first paper on Australian Palæontology contributed to the pages of the *American Journal of Science*, the three were described as separate and distinct genera, but in the more extended account of the geology of the Wilke's Exploring Expedition they were united under the one name *Mœonia*. Dana at the same time stated that his *Cleobis* was identical with *Notomya* (M'Coy). The arrangement adopted in my Catalogue was a purely provisional one, proposed more as a temporary or provisional arrangement than as an accurate solution of a difficult and obscure subject, and such it must remain until this group of Palæozoic Bivalves can be examined and studied as a whole. At the same time I gave my reasons for adopting the name *Notomya* (M'Coy), in preference to any of the others.

Notomya (*Mœonia*) *recta*—Dana.

Cleobis recta, Dana, American Jour. Sc., 1847, iv., p. 154.
Mœonia(?),, ,, Geol. U.S. Explor. Exped., p. 698, Atlas, t. 7, f. 2.
Mœonia ,, Clarke, S. Goldfield's "N. S. Wales," 1860, p. 287.
Notomya ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 73.

Obs.—The chief characters of this species are its very inequilateral and oblong form with the parallel dorsal and

* Non *Myonia*, Adams, 1860.

† *Ibid.*, pp. 71 and 72.

‡ Pal. Indica., iii., p. 83.

ventral margins. Professor Dana's specimen measured three and a half inches in length, but the shell I refer to *N. recta* measures seven and a quarter inches in the same direction. Like all the bivalves in Mr Jack's collection the state of preservation is very bad, but there appears to be the remains of an obscure posterior slope, a character which I do not find mentioned in Dana's description.

Loc. and Horizon.—Coral Creek, below Sonoma road-crossing, in a yellow, micaceous, decomposed ironstone (No. 116).

Collector.—R. L. Jack, Esq., F.G.S.

GENUS PACHYDOMUS—*Morris*, 1845.

(Strzelecki's "Physical Descrip. N. S. Wales," etc., p. 271.)

Pachydomus (?) *carinatus*—Morris.—Pl. XVI., fig. 53.

P. carinatus, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," 1845, p. 273, t. 11, f. 3 and 4.
Cypricardia rugulosa, Dana, American Jour. Sc., 1847, iv., p. 157.
P. carinatus, M'Coy, Annals Nat. Hist., 1847, xx., p. 301.
Mœonia (?) *carinata*, Dana, Geology U.S. Expl. Exped., p. 696, Atlas, t. 6, f. 1 *a* and *b*.
Pleurophorus (?) *carinatus*, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 283, t. 19, f. 8.
Pachydomus carinatus, Etheridge, jun., Cat. Australian Foss., 1878, p. 74.

Obs.—The strongly marked umbonal ridge and the slightly concave posterior slope at once mark this species as peculiar. Two specimens in a moderately good state of preservation have been forwarded; both have the entire shell removed, and are therefore in the form of casts, but with the exception of some slight displacement of the valves, the general outline is retained. I am inclined to doubt the reference of this species to the genus *Pleurophorus* made by Professor De Koninck, although no doubt it departs considerably from the true Pachydomoid type as exemplified by *P. antiquatus* and *P. globosus*, the typical species.

Loc. and Horizon.—Coral Creek, as before—(No. 102); Bowen River, at No. 25 Traverse Station (No. 136); Marine Series.

Collector.—R. L. Jack, Esq.

Pachydomus globosus—J. de C. Sowerby.

Megadesmus globosus, J. de C. Sow., Mitchell's "Three Exped. Int. E. Australia," 1838, i., p. 15, t. 3, f. 1 and 2.
Pachydomus ,, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 272, t. 10, f. 2 and 3.
(?) ,, ,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 272, t. 18, f. 5.
,, ,, Etheridge, jun., Cat. Australian Foss., 1878, p. 75.

Obs.—The fossiliferous rock of Pelican Creek has furnished a ponderous example of this species, but in a wretched state of preservation, without any trace of shelly matter remaining, and the whole substance of the cast having assumed the form of a decomposed feruginous ironstone nodule. The specimen measures roughly about eight inches by five and a half without the shelly matter. Across the dorsal region, from the one rounded diagonal ridge to the other, the shell measures at least five inches. This will give some idea of the great breadth attained by this species, and its general globose or gibbous outline. The umbones are very large, incurved, and quite anterior. Judging by the space occupied by matrix between the cardinal edges of the two valves, the external ligament must have been of great dimensions and strength. The collection contains two examples of this species, that from which the foregoing notes are taken, and a smaller one, which I believe to represent the young condition of the species. The latter, when held in certain lights, shows indistinct traces of radiating striæ in the cast. Upon examining the remarkably fine specimen figured by my friend Professor Morris, F.G.S., in the late Count Strzelecki's work, I find that it also, where the shelly matter is worn off, exhibits similar radiating ridges. The latter specimen might almost stand for the original of the figure, by Professor J. D. Dana, of his *Mæonia grandis*,* so close is the resemblance. To avoid any cause of error in this matter, I sought the kind assistance of Professor Morris, who at once pronounced the specimen in question, in the Strzelecki Collection, to be his type of James de Carle Sowerby's species *Megadesmus globosus*, and it was then unquestionably apparent both to Professor Morris and Dr H.

* Geol. U.S. Exploring Exped., p, 696, t. 6, f. 7 and 7*a*, 8 and 8*a*.

Woodward, F.R.S., who also entered into the question, that *Mœonia grandis* (Dana), can only be regarded as a synonym of *Pachydomus globosus* (J. de C. Sowerby).

Loc. and Horizon.—Pelican Creek, half a mile above Sonoma road-crossing, in a highly fossiliferous concretionary and feruginous mudstone. Pelican Creek, in a sandstone above the Garrick coal seam, both horizons in the Marine Series (Nos. 58 and 63).

Collector.—R. L. Jack, Esq.

Genus Sanguinolites—*M'Coy*, 1844.

(Synop. Carb. Limestone Foss. Ireland, p. 47; Brit. Pal. Foss., 1852, fas. 2, p. 276.)

Sanguinolites, sp. ind.—Pl. XVI., fig. 54.

Compare *Sanguinolites clava* (M'Coy), Brit. Pal. Foss., 1853, fas. 3, p, 504, t. 3F, f. 12.)

Obs.—With the exception of a somewhat shorter and more gibbous form, I am unable to distinguish this species from Professor M'Coy's *S. clava.* The specimen is, I believe, a cast of the exterior, as there are no traces of muscular impressions left, and the valves have by pressure been slightly displaced. Notwithstanding this, it is easily seen that the shell possessed a much more gibbous and rotund habit than *S. clava*, the relative convexity of the valves immediately below the beaks being greater. The rapid attenuation of the flanks towards the ventral margin and the thinning-off of the posterior end are as in *S. clava*, and there also existed a well-marked lunette and escutcheon, although the latter was much shorter than in M'Coy's species. Lastly, the posterior slope is more defined in the Australian form, and the valves were closed posteriorly. Taking all these characters together, it must be conceded that, in all probability, the two species are distinct. A useful comparison might be made between Mr Jack's shell and two Australian species described by Dana, did we only know more about them, viz., *Edmondia* (?) (*Pholadomya*) *Glendonensis*,* and *Sanguinolites* or *Edmondia* (?) (*Pholadomya*) *undata*.† The first, as figured by Dana, is a crushed-down

* Geol. U.S. Exploring Exped. Atlas, t. 2, f. 12. † *Loc. cit.*, f. 11.

shell, without form or character, and is simply unrecognisable; all one can say is, that it appears to be a shorter form than that now under discussion. The second is a very *Sanguinolites*-like shell, and is clearly separated from the latter by the position of the beaks, more than subcentral in position, and the consequently larger anterior end.

A glance at the species of *Sanguinolites* lately described* from the Carboniferous beds of N. S. Wales by Professor De Koninck (*S. Etheridgei, S. Mitchellii, S. M'Coyi,* and *S. Tenisoni*) will show how little resemblance they bear to the Queensland fossil. Of them, *S. M'Coyi* is certainly more nearly allied to the latter than any of the others.

Loc. and Horizon.—Coral creek, below Sonoma road-crossing, in decomposed concretionary and highly fossiliferous ironstone (No. 126).

Collector.—R. L. Jack, Esq.

In addition to the bivalves just described, there are three others which it is quite impossible to determine with any degree of accuracy. One of them (No. 118) is a shell allied to *Sanguinolites undata* (Dana),† or *S. Mitchellii* (De Koninck),‡ but it is much crushed. The two remaining shells (Nos. 60 and 205) are both *Pachydomi* or *Astartilæ*, and are perhaps nearer to *A. cyprina* (Dana)§ or *A. cytherea* (Dana)‖ than to any other of the described forms. Neither of them show any trace of the supplementary anterior muscular scars, although both internal casts.

Loc. and Horizon.—No. 118 is from the fossiliferous beds of Coral Creek, below Sonoma road-crossing (Marine Series); No. 60 was found in similar beds on Pelican Creek in the same neighbourhood (Marine Series); No. 205 is of considerable interest on account of its occurrence with *Orthotetes crenistria* var. *senilis*, in a marine bed in the Fresh-Water Series, at Havilah-Byerwin Road, one mile south of Rosella Creek crossing.

* Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, pp. 261-265, t. 16 and 17.

† *Pholadomya*, Geol. U.S. Explor. Exped. Atlas, t. 2, f. 11, *a* and *b*.

‡ Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, t. 16, f. 3.

§ *Loc. cit.*, t. 3, f. 6, *a-f*.

‖ *Ibid.*, t. 4, f. 1, *a-g*.

GASTEROPODA.

The remains of Gasteropoda are of rare occurrence amongst the fossils from the Bowen River coalfield, and are confined to the fragmentary remains of one or two indeterminable specimens. They are of interest only because of their occurrence in marine bands in Mr Jack's "Fresh-Water Series;" and it is to be the more regretted on this account that there is such a paucity of remains.

The fragments in question were found at Rosella Creek, two miles above Havilah Paddock, and at the Havilah-Byerwin Road, one mile south of Rosella Creek crossing.

CEPHALOPODA.

Genus Goniatites—*De Haan,* 1825.

(Mon. Ammonites et Goniatites, p. 39.)

Goniatites micromphalus—Morris.

Bellerophon micromphalus, Morris, Strzelecki's "Phys. Descrip. N. S. Wales," etc., 1845, p. 288, t. 18, f. 7.

,, ,, Dana, Geology, U.S. Explor. Exped., p. 708; Atlas, t. 10, f. 6.

Goniatites ,, De Koninck, Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, p. 339, t. 24, f. 5.

,, ,, Etheridge, Jun., Cat. Australian Foss., 1878, p. 89.

Obs.—Two specimens of this species have been collected by Mr Jack, both of them casts, without any trace of shelly matter remaining. The form of the shell and character of the umbilicus in the Bowen River coalfield specimens correspond quite well with Professor Morris's description and figures, but the depth of the body whorl near the mouth is not so great, although the disparity is greater in one of our specimens than in the other. However, this need be dwelt on less, since I find Professor Dana has given such a figure * of *G. micromphalus,* and on examining those in the Strzelecki Collection I see the same aperture is presented by some of the specimens there.

* Geol. U.S. Expl. Exped. Atlas, t. 10, f. 6*a*.

Loc. and Horizon.—Head of Pelican Creek, near Mount Diolin (Marine Series, Nos. 1 and 2).

Goniatites, sp. ind.

A second species is present differing from *G. micromphalus* in having a very much sharper back. It appears to be nearer to *G. striatus* (Dana)* than to Morris's species.

Loc. and Horizon.—Rosella Creek, two miles above Havilah Paddock. This is an important fossil, as it is another of those occurring in a marine band in the Fresh-Water Series (No. 187).

Collector.—R. L. Jack, Esq., etc.

CRETACEOUS SPECIES.

Cephalopoda.

Genus Crioceras—*L'Eveillé*, 1837.

(Mem. Soc. Géol. de France, ii., p. 313.)

Crioceras Jackii, sp. nov.—Pl. XVII., figs. 55-58.

Sp. Char.—Shell non-involute, with the whorls close but not touching; round or slightly flattened at the sides; tubercles blunt and node-like, arranged in six rows, two on each side or flank of the whorl, and two on the back or dorsal edge; those on the sides become less apparent and entirely disappear ultimately as the end of the last volution is approached, but those on the dorsal edge remain. The costæ are of two sizes, the non-tuberculate ribs being all of one size, whilst those bearing the tubercles are larger and separated one from the other sometimes by two, sometimes three, of the former; they are all entire and scarcely at all curved.

Obs.—Doubts existed on the first examination of the two specimens before me as to their identity with the genus *Crioceras* owing to the contiguity and close approximation of the whorls; the length and size, however, of the dorsal tubercles on the inner volutions clearly demonstrated that the whorls were separate from one another.

* *Loc. cit.*, f. 5, *a* and *b*.

Careful examination into the history and literature of this genus of *Cephalopoda* has failed to discover any species to which I can refer the Australian form, but the nearest species appears to be the Neocomion, *Crioceras Duvalleii* (L'Éveillé). The whorls in the latter are more open and not so contiguous as in *C. Jackii*, and the tubercles or spines are finer and much more slender in the French and British species.

The Cretaceous rocks of Australia have as yet only yielded one species of *Crioceras*, described by Mr C. Moore, F.G.S., as *C. Australe*, from the Upper Maranoa district.* The deep sulci separating the costæ or ribs will at once distinguish this from our *C. Jackii*, in which the former are very much reduced in their dimensions from the contiguity of the latter; neither are the ridges acute but well rounded in *C. Jackii;* and lastly, Mr Moore describes only two bosses in his species on each side.

The allied genus *Ancyloceras* is also represented in the Cretaceous beds of Queensland by one species, *A. Flindersi* (M'Coy), and briefly described † by Professor M'Coy as long ago as 1867. It is stated to be allied to the French Cretaceous species *A. Tabarelli* (Astier); and even supposing the form now under discussion to be an *Ancyloceras* rather than a *Crioceras*, as has been suggested to me by Dr Woodward, it cannot be this species. The British Museum Collection contains the "Astier Collection," and having compared it with the type of *A. Tabarelli*, I can safely affirm that it has not the slightest connection with the latter. Under the name of *Crioceras Jackii* I have included two shells, which at first sight appear to differ from one another in certain particulars; but I think they are merely forms of the same species. In the more robust of the two (fig. 55) the six rows of tubercles are continuous along the greater part of the largest whorl, the dorsal pair being quite so. In the second specimen (fig. 58), on the other hand, there are no tubercles at all visible on the body whorl, and they are only perceptible on the inner whorls when separated. The other characters of the two

* Quart. Jour. Geol. Soc., xxvi., p. 257.

† Annals Nat. Hist., 1867, xix., p. 356.

specimens are identical, and in the face of this I do not think the above difference is of sufficient importance to base a separation on.

Loc. and Horizon.—Tate River, N. Queensland, from beds of Cretaceous age.

Collector.—R. L. Jack, Esq.

Appendix.

I take this opportunity of describing a *Strophalosia* in the collection of the British Museum, and in that of Mr T. Davidson from New South Wales and Tasmania respectively. I first observed this form in a collection of fossils made by the late Professor J. B. Jukes, F.R.S., in Australia, and now in the British Museum. I provisionally apply to them the name of *Strophalosia Jukesii,* as they may be only a variety of the species just described, *S. Gerardi* (?), but as explained further on, the want of intermediate forms has induced me to consider them as at present distinct.

Strophalosia Jukesii, sp. nov. (?).—Pl. XIII., figs. 39-43.

Sp. Char.—Shell subquadrate, sometimes contorted, oval, or approaching the deltoid, almost plano-convex when the valves are in apposition. Ventral valve very convex and gibbous, most so about half-way between the umbo and the front of the valve, with a shallow but distinct mesial sinus, lateral angles rounded; front margin rounded, and sometimes a little indented, or occasionally a constriction, or slit, occurs either in the centre of the front, or to one side of it. Hinge line much shorter than the width of shell; umbo depressed, projecting a little over the hinge line, but not at all prominent. Area elongately-triangular, a little concave, longitudinally striated; fissure narrow and badly defined, covered by a small convex deltidium. Dorsal valve quadrate to deltoid, flat or very slightly concave, the concavity having no comparison to the convexity of the ventral valve; area small and triangular. Internal characters strongly marked; cardinal boss prominent, projecting at an angle of about 119°

with the plane of the exterior of the valve, continued forwards on the interior surface of the valve for nearly two-thirds of the distance between the boss and the front margin. Immediately in front of the base of the boss is a depression in which are placed the adductor muscles; the oblique dental sockets on each side of the boss are deep, large, and a little triangular. The reniform impressions are a marked feature, being very large and strongly auriform, and occupying the greater part of the interior of the valve from close under the hinge line to the front. They are bounded on their external margins by grooves between them and the bevelled edges. The latter bear granules and small elevations, indicating the vascular system.

Obs.—The characters of this very remarkable shell are wholly and entirely different from the Devonian *S. productoides,* which, according to Professor De Koninck, has been found in Australia. In the first place *S. Jukesii* is an exceedingly convex and gibbous shell, with a flat, or nearly flat, dorsal valve, without any trace of the concavo-convex outline of Murchison's species. The latter, speaking generally, assumes a much more transversely elongated appearance than *S. Jukesii.*

The alliance with the Permian forms *S. Goldfussi* and *S. lamellosa* is closer, both in the form of the shell, and relative convexity of the valves. Were we dealing only with the external characters I should have felt much inclined to refer, provisionally at least, the Tasmanian and New South Wales shells to one or other of the species just mentioned. The Australian form has the shape, rounded angles, occasional indented front margin, short hinge line, convex ventral valve with its shallow sinus, concentric lamellæ of growth, and characteristic spines of one or other of the above species. When, however, we compare the internal characters of the respective shells many points of divergence may be noticed. Thus, in the great disproportion of the reniform impressions appears to lie a well-marked difference. Their larger size, different shape, and much greater development in *S. Jukesii* will be at once apparent if the figures now given be compared with those of *S. Goldfussi* and *S. lamellosa* in the monographs of Messrs King, Davidson, and Geinitz. Again, if I mistake not, the septum has in *S. Jukesii* a much greater extension towards the front.

The chief point to be borne in mind when reviewing the specific relations of the present shells is, their connection with those previously described under the name of *S. Gerardi* and *S. Clarkei.* At first sight the difference in outline between the deltoid or quadrate form of *S. Jukesii,* and the oval *S. Clarkei,* would induce separation, but when we take into consideration the extreme variability of species of *Strophalosia,* and the very close correspondence between the massive internal characters of figs. 21 and 23 and those displayed by figs. 41 and 42, I think it is just an open question, whether the presence of a series of intermediate forms would not necessitate the union of all in one variable species? The view here hinted at receives some support from the flat exterior of the dorsal valve in both, and the remarkable condition of the concentric laminæ which constitute the surface of the valves. Finally, as regards *S. Gerardi* (?), the ventral valves both of it and *S. Jukesii* are alike, very convex, but in the former the dorsal valve is very concave, in the latter quite flat, except in one example, which is a little inclined to the concave condition.

It would not surprise me if eventually we have to unite the shells now described as *Strophalosia Clarkei* (Etheridge), *S. Gerardi* (King ?) and *S. Jukesii* (Etheridge, jun.), in one variable species, although, as I have before said, such a proceeding would be premature, as the material to hand is not sufficient in itself. In the meantime the subdivision now made will serve for the illustration of the specimen, and can be altered if occasion should arise.

Localities.—New South Wales, Jukes Collection, Brit. Mus., (?) Carboniferous, or Permian; Tasmania, Coll. of T. Davidson, Esq., F.R.S., to whom I am indebted for the loan of specimens, (?) Carboniferous or Permian.

The following is a description of the silicified *Productus* (?), figured by Professor Morris under the name of *Productus brachythærus* (G. Sow.).

Productus (?), sp. ind.—Pl. XIV., figs. 44-49.

Sp. char.—Ventral valve convex, gibbous, with a slight mesial sinus; umbo large, projecting a good deal beyond the hinge line, and a little curved downwards; hinge line straight, scarcely as broad as the shell. Adductor impressions elongated, divided by a groove (ridge in the cast), and placed on a central prominence between the two deep depressions forming the scars of the adductors. The latter are strongly marked with vertical ridges and grooves. The dorsal valve is flat, or nearly so, and of considerable thickness. In the interior the cardinal process is strong and prominent, projecting vertically above the hinge line; the alar ridges at the base of the cardinal process are strong and thick; alar angles apparently rounded; the cardinal process is continued towards the front of the valve into a very well-marked entire septum, extending to within a very short distance of the margin, and terminating in a slight enlargement or button (in the cast this is seen as a groove, and the alar ridges as broad depressions). Adductor impressions rather posterior, dendritic, and extending outwards laterally. Reniform or vascular impressions apparently well marked, their upper margins cutting the septum at about a third from the umbo; the expanded or terminal portion almost circular, and not large for the size of the valve. In the cast the surface of both valves is grooved and pitted, the pits (representing granules in the true shell) are very plentiful in the dorsal valve towards the front margin. External surface of shell not preserved.

Obs.—I have already explained (p. 286) the grounds upon which this form has been separated from *Prod. brachythærus.* Professor De Koninck has suggested that it may be referable to *Productus fragilis* (Dana). Pleased as I am to be able to confirm Professor De Koninck's views on the separation of the two specimens referred by Morris to *P. brachythærus,* I most emphatically dissent from his suggestion that the silicified example may be *P. fragilis* (Dana), for the following reasons: *Productus fragilis* (Dana), of which De Koninck gives a long description, was so very generally described, and illustrated with such unsatisfactory figures, that I consider any identification made by means of these to be in the highest degree problematical. As previously pointed out, a direct comparison with the type or types of *P. fragilis* cannot now be made, and I think it not improbable that it is only a form or variety of *P. brachythærus* (G. Sow.).

On comparing the figures of the present *Productus* with those of *Strophalosia Clarkei* (figs. 26 and 27), one would at first sight be inclined to think them identical; but on a close examination this is not so clear. It is quite true that in the ventral valves of the two (figs. 26 and 46) we observe the same large beak, elongated adductor scars, deep ridged cardinal scars, and convex gibbous form. In the dorsal valve both have a long septum, extending nearly to the front margin, and the adductor scars occupy the same position. In the ventral valve of *S. Clarkei* the thick prominent beak occasionally overhangs the hinge line; but in the silicified cast, on the contrary, it projects some distance beyond it, even allowing for the specimen being a cast (fig. 44). In the dorsal valve of *S. Clarkei* the boss, or cardinal process, projects from the hinge line at an angle of about 119°; but in *Productus* sp. it assumes the regular Productoid type, and is vertical to or at right angles with the hinge line. In Strzelecki's silicified *Productus* (?) we observe the reniform impressions, with the laterally elongated, and oval or circular extremities usually met with in the genus (fig. 44); but in *S. Clarkei* (figs. 21 and 23) these impressions assume very much more the semilunar, vertically elongated scars seen in some species of *Strophalosia*. Figs. 21 and 23 represent the interior of the dorsal valves of *S. Clarkei*, and at *f, f*, are distinctly visible the dental sockets for the reception of the teeth of the ventral valve. Fig. 48 is a wax cast taken from the ventral valve of the silicified specimen (fig. 44), and on it no sockets are visible. I believe this does not arise from the absence of teeth, but from their non-preservation. Figs. 44 and 45 may be those of a *Strophalosia* rather than a *Productus*, perhaps identical with *S. Clarkei*. I hope to return to this subject, as I now have additional material from Point Puer, Tasmania, whence probably the Strzelecki specimen came, and by means of which I hope to place these Australasian *Strophalosiæ* on a more satisfactory basis.

If a *Productus,* it evidently comes very close to the Permian *P. horridus.* The less perfect state of preservation of the Australian shells does not permit an opinion to be passed on the lateral wings; but so far as the mesial sinus of the ventral valve is concerned, it is decidedly less in the latter than in typical examples of *P. horridus* (figs. 50 and 51). Internally, however, the two forms very closely resemble one another. There are the same strongly developed cardinal muscular impressions in the ventral valve, similar prominent overhanging beak, and long septum in the ventral valve; indeed, the whole habit strongly reminds us of the well-marked Permian form alluded to.

Loc.—Tasmania. (Strzelecki and Jukes Collections, Brit. Museum.)

4. Stratigraphical Notes on the preceding Species.

Having in previous pages given a description of the fossils, it now only remains to be seen how far the grouping of the species in localities will assist in the consideration of the stratigraphy of the districts collected from.

A. Devonian.

1. *Fanning River.*—A limestone at this locality has yielded to Mr Jack's researches a small parcel of fossils, which appear to have a strong Devonian facies. They are—two species of *Spirifer,* one close to *S. curvata* (Schlotheim), and another after the *S. glabra* type ; two species of *Atrypa, A. reticularis* (Linn.), and *A. desquamata* (Sow.), or at any rate a shell so close to the latter that it is difficult to make a separation between them; and lastly, *Orthotetes crenistria.*

2. *Fanning Old Station.*—The shale above the Fanning Limestone has yielded, at this locality, the *Atrypa desquamata* and several specimens of a *Rhynchonella,* which are as similarly near to *R. primipilaris* (Von Buch) as the large *Atrypa* is to Sowerby's species.

Looking upon the fossils from the Fanning River Limestone and its accompanying shale as a whole, the first fact which strikes us is the co-occurrence of two such typically distinctive fossils as *Atrypa reticularis* and *Orthotetes crenistria.* If we take either of these fossils alone, we are not assisted in any very great degree. *A. reticularis* ranges from the Upper Silurian to Devonian, although it may be taken to be essentially a representative Upper Silurian species. Similarly *Orthotetes crenistria* ranges from Upper Devonian to the Uppermost Carboniferous, but, like the former species, it has its accumulative horizon, the Carboniferous Limestone. Had we met with either of these species alone, their stratigraphical indication of Upper Silurian or Carboniferous Limestone, as the case may be, would not have been so strong, but in company their strictly individual bearing becomes lost, and we have to accept their combined testimony, which certainly indicates a Devonian age for the beds in question.

Spirifera curvata appears to be a Middle Devonian fossil; so does *Atrypa desquamata* and *Rhyn. primipilaris.* On the other hand, *Orthotetes crenistria* is an Upper Devonian and passage form, whilst *Atrypa reticularis* is a Lower and Middle Devonian species. On the whole, the Middle Devonian appears to put in a strong claim, but, pending further researches into this subject, I shall content myself by simply calling the beds in question Devonian.

Mr T. Davidson, F.R.S., was kind enough to examine the above fossils, and expressed the following opinion on them: "The small lot of specimens you forward for me to look at are, as you say, all Devonian, and can, with a little research, be identified, I think, with known species." * Any additional evidence bearing on the Devonian beds of Queensland is of great interest to me. The presence of rocks of this age was first shown in the colony in question by my father, who refers to this period the Star River and Gympie Series,† and has described a copious fauna.‡

This determination has, however, been objected to by several authors. For instance, Professor M'Coy believes that there is "no reason for considering the Gympie beds Devonian,

* Letter dated "Brighton," February 13, 1879.

† Quart. Jour. Geol. Soc., xxviii., p. 325.

‡ *Loc. cit.*, pp. 326-333.

the great balance of palæontological evidence, in my opinion, indicating rather the Lower Carboniferous age." *

In the description of "The First Sketch of a Geological Map of Australia," by Mr R. Brough Smyth, we are told that the Carboniferous beds "extend from the south part of Victoria to the northern parts of Queensland. . . . Professor M'Coy has examined the fossils from these beds, and, after giving careful consideration to all the evidence which is available, he has come to the conclusion that the so-called Devonian rocks of Queensland are in reality of Carboniferous age." †

Lastly, Professor L. G. de Koninck considers Mr Etheridge wrong in referring *Productus cora,* and "several other Carboniferous species," from Queensland to Devonian beds. ‡

Upon the relative value of the determinations on which my father based his conclusions, I am unable to pass an opinion, as I have not examined the specimens. Be this as it may, however, it gives me infinite pleasure to be able to bring forward further facts tending to show the general correctness of his conclusions.

B. Carboniferous (?)

Only the more important localities under this heading will be referred to at present:

1. *Pelican Creek,* five miles north of Sonoma Station.—This is a very interesting locality from the exclusive occurrence of *Strophalosia Clarkei* and the specimens referred to *S. Gerardi* (King ?). Of the former there are no less than forty-one specimens in various degrees of preservation, and seven of the latter.

2. *Pelican Creek,* three-quarters of a mile above Sonoma road-crossing.—At this locality a hard feruginous grit contains *Orthotetes crenistria,* var. *senilis.* This characteristic shell was noticed by the late Mr Daintree as occurring in an arenaceous limestone-band on the Pelican Creek, and overlying a coal-seam.§

* Prodromus Pal. Vict., Decade I., 1874, p. 38.

† Geol. Survey Vict., Report of Progress for Year 1875, No. iii., p. 61, Melbourne, 1876.

‡ Foss. Pal. Nouv-Galles du Sud., 1877, pt. 3, pp. 185 and 235.

§ Quart. Jour. Geol. Soc., xxviii., p. 288.

3. *Pelican Creek*, half a mile above Sonoma road-crossing.—*Pachydomus globosus* occurs here in company with *Prod. subquadratus*, bivalves, either *Pachydomus* or *Astartila*, and another shell which may be either a *Productus* or *Strophalosia*.

4. *Pelican Creek*, opposite Palmer's Old Station.—Like the first locality mentioned, we have here again a profusion of *Strophalosia Clarkei*, accompanied by *S. Gerardi* (?), and casts of *Polyzoa* referable to the genus *Protoretepora*.

5. *Coral Creek*, below Sonoma road-crossing.—As the *Strophalosiæ* were predominant at several of the preceding localities, we have their place taken here, so far as regards the number of individuals, by two species of *Protoretepora*, two well-marked *Stenoporæ*, and numerous Mollusca, such as *Spirifera Darwinii* (Morris), *Pterinea macroptera* (Morris), *Pachydomus carinatus* (Morris), *Mæonia recta* (Dana), *Aviculopecten limæformis* (Morris ?), a shell allied to *Allorisma* (?) *curvatum* (Morris), a *Sanguinolites* (near *S. clava*, M'Coy), and a badly-preserved form which may be either *Productus* or *Strophalosia*.

6. *Parrot Creek*, four and a quarter miles up.—The fauna of localities 1 and 4 is here repeated, except that there are no *Polyzoa*, but, on the other hand, two species of *Spirifera*, *S. convoluta* and *S. Darwinii* (Morris).

7. *Stonelumpy Creek*.—Here occur *Spirifera glabra* and *Productus brachythærus*.

The prevalence of *Strophalosia Clarkei* in at least two of these localities, and a similar preponderance of *Fenestella*, *Protoretepora*, and *Stenopora* at a third appear to be the most striking facts brought out by this grouping of the species in their localities. These data will probably be of some use to us in considering to what position in the Upper Palæozoic scale the beds yielding them should be assigned. It must be borne in mind that much difference of opinion has existed in the grouping of the Australian and Tasmanian coal-bearing rocks. One party, led by the late Rev. W. B. Clarke, F.R.S., etc., considered the whole series as continuous and of Palæozoic age.* The other party, led by Professor M'Coy, have

* It must, however, be borne in mind that Mr Clarke modified his views considerably, as regards the upper part of this series, some time before his death.

always maintained that the rocks in question were divisible into two great sections—one, the upper, characterised by the presence of certain plant and a few fish remains, they considered to be of oolitic, or at any rate of secondary age; the other, the lower, containing a copious Palæozoic fauna, was admitted by them to be a part of the Upper Palæozoic Series. Indeed, so far as the actual presence of the old fauna in this portion of the Australian sedimentary deposits is concerned, little or no diversity of views has existed, but there has been merely an expression of opinion as to the precise horizon to which the fauna should be referred in the Upper Palæozoic Series.

The Rev. W. B. Clarke assigned to the fossils in question a position analogous to the European, or perhaps more properly speaking, the British Lower Carboniferous rocks. Professor J. Morris, in a very able summary of the results of his examination of Count Strzelecki's Collection, said that, omitting two localities, the deposits containing these fossils "probably belong to that division of the Palæozoic Series usually termed Carboniferous."*

Professor M'Coy's examination of the collection deposited in the Woodwardian Museum led him to a similar conclusion, for he remarks, "so that the age, even if *we only look to the genera of the fossils,* is clearly limited to the Carboniferous period." An examination of the species led to a still more definite opinion, for he states that they place the deposits yielding them nearly on a parallel with the base of the Carboniferous system in Ireland.†

The summing up of this question by Professor J. D. Dana is also one of much importance. After discussing the question in an able manner, he assigns a Lower Carboniferous age to the fossils lying immediately below the great coal seams of New South Wales; or taking the whole series (including the upper or debatable plant section) as one continuous and conformable series of beds, which he evidently believed them to be, they are assigned to the "Upper Carboniferous, or partly the Lower Permian era."‡

* Strzelecki's "Phy. Descriptions," p. 296.

† Annals Nat. Hist., 1847, xx., pp. 310, 311.

‡ Geology, U.S. Exploring Exped., Capt. Wilkes, p. 495.

I shall conclude this portion of my subject by simply quoting the view of the late Professor Jukes. Like Professor Dana, Mr Jukes had the advantage of studying these beds *in situ*, in company with the Rev. W. B. Clarke, and his opinion is therefore one of much importance. He regarded them as the representatives of the British Silurian, Devonian, and Carboniferous periods, or to use his own words, "I should for the present hold the rocks of Australia now under consideration simply as *Palæozoic*, and only assert that their age was included within that of our Silurian, Devonian, and Carboniferous periods." *

It is now necessary to investigate the evidence afforded by the Queensland fossils, and find what influence has the frequent occurrence of *Strophalosia* on the question? According to Mr Davidson this genus ranges in time from the Devonian to the Permian inclusive and there dies out.† A species has been described by the same author from beds containing a copious carboniferous fauna in the Salt Range of the Punjaub, but so far as represented in the collection examined by Mr Davidson, of rare occurrence.‡ Mr J. S. Miller § gives two American carboniferous *Strophalosiæ*, *S. horrescens* (Geinitz, non de Vern. and Keys.), and *S. subaculeata* (Murchison), from the Coal Measures. The first of these is not a *Strophalosia* at all, according to the researches of the late Mr Meek, || but is identical with *Productus nebrascensis* (D. D. Owen), at any rate the second clearly indicates that there is at least one species of American carboniferous *Strophalosia*.

The above quotations show that *Strophalosia* to a limited extent occurs in rocks of Carboniferous age, but there is no doubt that the genus "attained its greatest numerical development in the Permian age, above which no authenticated example has yet been discovered."¶ The preponderance of so typically Permian a genus as *Strophalosia* in the Bowen

* Phys. Structure of Austr., p. 22.

† Geol. Mag., 1877, iv., p. 260.

‡ *St. Morrisiana* (King), Quart. Jour. Geol. Soc., xviii., p. 32, t. 2, f. 8.

§ American Pal. Foss., p. 135.

|| Pal. E. Nebraska, p. 165.

¶ Davidson, Introduction, p. 116.

River Series insensibly leads us to the questions, What claim have these deposits to be considered as of Permian age? or as containing a mixed Carboniferous and Permian fauna? To answer these questions we must go a little deeper into the subject, and pass in review the other species occurring in them. In the first place as to *Stenopora.* The recent researches of Professor H. A. Nicholson and myself show this genus to be a sound one, and not identical either with *Chætetes* or *Monticulipora,* as has been so stated by numerous authors. Further, the genus is, we believe, characteristically a Permian one, although it may be represented in carboniferous and lower rocks to some small extent, in other words, the long array of species of the latter age which have been tacked on to *Stenopora* from time to time, will, in all probability, be found wanting in its most characteristic features. Typical *Stenoporæ* have been described by Lonsdale from the Permian rocks of Russia,* and from Geinitz's description, his *S. Macrothi*† would appear to be another, although in his later work on the "Dyas," the species is merged in *Stenopora columnaris* (Schlotheim).

With regard to the *Polyzoa.* Although *Protoretepora* is a form which may very well find an analogue in true carboniferous rocks, it may nevertheless be more strictly likened to the Permian genus *Phyllopora* (King), rather than to the *Fenestella* or *Polypora* forms met with in the lower horizon.

So far therefore as the fauna found at two points on Pelican Creek (localities 1 and 4) and on Parrot Creek (locality 6) are concerned, I do not see how we can come to any other conclusion, than that very strong evidence exists of the marked Permian character of the fossils.

At the 3d, 5th, and 7th localities, we meet with an assemblage of forms, which, omitting one or two dubious ones, have usually been looked upon in New South Wales as of Carboniferous age, and are there undoubtedly associated with others, especially *Brachiopoda,* of a marked Carboniferous facies.

Unfortunately I am not in possession of any information as to the stratigraphical relation of the beds at the above localities, one with the other, except in the broad sense of

* Murchison's "Geol. Russia," 1845, i., p. 632.

† Veostein deut-hech Steinze, p. 17.

the two great divisions of Marine and Fresh-Water as stated by Mr Jack; but I feel little hesitation in saying that they form portions of one continuous series. I am led to this opinion by the lithological character of the specimens, and the general distribution of the species.

In conclusion, I may state that the examination of these Bowen Rock fossils, so far as it has gone, leads me to regard them as occupying a high position in the Palæozoic Series, and that all purposes would best be served by regarding them as of Permo-Carboniferous age.

The distribution of the *Strophalosia Clarkei*, a form on which I have laid considerable stress, is not confined to Queensland, as we have before us the example (fig. 21) obtained by the Rev. J. E. T. Woods from the Upper Palæozoic rocks of New South Wales, and forwarded by him to Mr Davidson. How far the discovery of such shells in New South Wales and Tasmania (figs. 41 and 42)* will have an influence in determining the age of the beds in which they occur, it is at present idle to speculate.

There is one point more which appears to me to be worthy of consideration in conjunction with these facts, viz., the strong resemblance borne by the *Productus* or *Strophalosia* last described, and found in New South Wales and Tasmania (figs. 44 and 45) † with the typical Permian species of the genus *Productus horridus* (figs. 50 and 51).

5. List of Localities from which Fossils have been collected in the Bowen River Coalfield by R. L. Jack, Esq.

"The specimens are numbered in red wax—*M* (Marine Series), *F* (Fresh-Water Series)."

"*M.* Nos. 1 and 2. Pelican Creek, head of, near Mount Diolin.
„ „ 3 to 5 (incl.). Pelican Creek, 5 miles north of Sonoma Station.
„ „ 54 to 57 (incl.). Pelican Creek, ¾ mile above Sonoma road-crossing.

* Milligan Collection, Brit. Mus.

† Strzelecki Collection, Brit. Mus., Milligan Collection, *id.*

"*M.* Nos. 58 to 61 (incl.). Pelican Creek, ½ mile above Sonoma road-crossing.

„ „ 62. Coral Creek, 3 miles above Sonoma Station.

„ „ 63. Sandstone above Garrick coal seam.

„ „ 64 to 75 (incl.). Pelican Creek, opposite Palmer's Old Station.

„ „ 76 to 132 (incl.). Coral Creek below Sonoma road-crossing.

„ „ 133. Bowen River, ½ mile above Stonelumpy Creek.

„ „ 134, 135, and 137. Bowen River, between Traverse Stations 25 and 26.

„ „ 136. Bowen River, at mouth of Creek at No. 25 Traverse Station.

„ „ 138 to 154 (incl.). Parrot Creek, 4¼ miles up.

„ „ 155 to 162 (incl.). Parrot Creek, 8 miles up.

„ „ 163. Twelve Mile Plain, above Stonelumpy Creek.

„ „ 164, 165. Stonelumpy Creek.

„ „ 166. Bowen River, at No. 25 Traverse Station.

F. „ 167 and 168. Macarthur Creek, below Macarthur coal seam.

„ „ 169 to 171 (incl.). Jack's Creek (all from one slab).

„ „ 173. Jack's Creek.

„ „ 175 to 182 (incl.). Cockatoo Creek, 12 miles up.

„ „ 183. Cockatoo Creek 3¼ miles up.

„ „ 184 and 185. Cockatoo Creek, 11 miles up.

„ „ 186. Cockatoo Creek, 3¼ miles up.

„ „ 187 to 189 (incl.). Rosella Creek, 2 miles above Havilah Paddock (a marine bed in the Fresh-Water Series).

„ „ 190 to 213 (incl.). Havilah-Byerwin Road, 1 mile south of Rosella Creek crossing (a marine bed in the Fresh-Water Series).

„ „ 214 to 221 (incl.). Cockatoo Creek."

6. List of Papers, Etc., relating to the Palæontology of Queensland.

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Bowerbank, Dr J. S.—A Monograph of the Silico-fibrous Sponges (*Proc. Zool. Soc.*, 1869, pp. 323-351; *Purisiphonia Clarkei*, Bow.).

Carruthers, W.—Notes on Fossil Plants from Queensland, Australia (*Quart. Jour. Geol. Soc.*, 1872, xxviii., pp. 350-360, Pl. XXVI. and XXVII.).

Carter, H. J.—Emendatory Description of *Purisiphonia Clarkei* (Bk.), a Hexactinellid Fossil Sponge from N. W. Australia (*Annals and Mag. Nat. Hist.*, 1878, i., pp. 376-379).

Clarke, Rev. W. B.—On the Genera and Distribution of Plants in the Carboniferous System of New South Wales (*Quart. Jour. Geol. Soc.*, 1848, iv., pp. 60-63).

Clarke, Rev. W. B.—On the Relative Positions of certain Plants in the Coal-bearing Beds of Australia (*Quart. Jour. Geol. Soc.*, 1861, xvii., pp. 354-362).

Clarke, Rev. W. B.—On the Occurrence of Mesozoic and Permian Faunæ in Eastern Australia (*Quart. Jour. Geol. Soc.*, 1862, xviii., pp. 244-247).

Clarke, Rev. W. B.—On the Age of the New South Wales Coalfields (*Annals and Mag. Nat. Hist.*, 1862, x., pp. 81-86).

Clarke, Rev. W. B.—On the Carboniferous and other Geological Relations of the Maranoa District in Queensland in reference to a discovery of Zoological Fossils at Wollumbilla Creek and Stony Creek, West Maitland (*Trans. R. Soc. Vict.*, 1865, vi., pp. 32-42).

Clarke, Rev. W. B.—On Marine Fossiliferous Secondary Formations in Australia (*Quart. Jour. Geol. Soc.*, 1867, xxiii., pp. 7-12).

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Daintree, R.—Notes on the Geology of the Colony of Queensland (*Quart. Jour. Geol. Soc.*, 1872, xxviii., pp. 271-317).

Etheridge, R.—Description of the Palæozoic and Mesozoic Fossils of Queensland (*Quart. Jour. Geol. Soc.*, 1872, xxviii., pp. 317-350, Pl. XIII. and XXV.).

Etheridge, R., jun.—Notes on some Upper Palæozoic Polyzoa from Queensland (*Trans. R. Soc. Vict.*, 1876, xii., pp. 66-68).

Etheridge, R., jun.—A Catalogue of Australian Fossils, etc., 1878, Cambridge, 8vo.

Etheridge, R., jun.—On the History of Palæozoic Actinology in Australia (*Trans. R. Soc. Vict.*, 1878, xiv., pp. 102-108).

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Leichhardt, L.—Journal of an Overland Expedition in Australia, from Moreton Bay to Port Essington, etc., 8vo. London, 1847.

M'Coy, Professor F.—Remarks on a Series of Fossils collected at Wollumbilla, and transmitted by Rev. W. B. Clarke of Sydney (*Trans. R. Soc. Vict.*, 1865, vi., pp. 42-46).

M'Coy, Professor F.—Note on the Cretaceous Deposits of Australia (*Annals and Mag. Nat. Hist.*, 1865, xvi., pp. 333, 334).

M'Coy, Professor F.—On the Discovery of Cretaceous Fossils in Australia (*Trans. R. Soc. Vict.*, 1866, vii.).

M'Coy, Professor F.—On the Occurrence of *Plesiosaurus* and *Ichthyosaurus* in Australia (*Annals and Mag. Nat. Hist.*, 1867, xix., pp. 355, 356).

M'Coy, Professor F.—On the Discovery of *Enaliosauria* and other Cretaceous Fossils in Australia (*Trans. R. Soc. Vict.*, 1868, viii., p. 41).

M'Coy, Professor F.—On the Teeth and Fossil-eye of *Ichthyosaurus Australis* (*Trans. R. Soc. Vict.*, 1869, ix., pt. 2, pp. 77, 78).

Moore, C.—Australian Mesozoic Geology and Palæontology (*Quart. Jour. Geol. Soc.*, 1870, xxvi., pp. 226-261, Pl. XVI.-XVIII.).

Stutchbury, S.—On the Geology of the Dividing Range between the Gwydir and the Namoi, Liverpool Plains District (*Parl. Blue Book*, Dec. 1854, pp. 14-20).

Stutchbury, S.—On the Country bordering the Coast between the Rivers Brisbane and Boyne (*Parl. Blue Book*, July 1866, pp. 6-14).

Wilkinson, C. S.—Notes on a Collection of Geological Specimens from the Coasts of New Guinea, Cape York, and neighbouring Islands, collected by William Macleay, Esq., etc. (*Annals and Mag. Nat. Hist.*, 1876, xviii., p. 190; *Geol. Mag.*, dec. 2, iii., p. 428; *Canadian Nat. and Geol.*, N. Ser., viii., pp. 156-160).

N.B.—I have not included in the above list the titles of the numerous papers by Professor Owen, C.B., F.R.S., in the *Philosophical Transactions*, on the remains of the extinct *Post Pliocene Vertebrata* found in Queensland.

Description of Plates VII.-XVII.

Fig. 1. *Spirifera*, sp. (compare *Spirifera curyglossus*, Sch. ("Palæontographica," iii., t. 36, f. 5*a-d*). A ventral valve, natural size, showing the umbo channelled by the deep median sinus. Fanning Limestone.

Fig. 2. *Atrypa reticularis* (Linn.). View of the convex dorsal valve, showing portions of the characteristic reticulo-imbricated surface. Fanning Limestone.

Figs. 3 and 4. *Atrypa desquamata* (J. de C. Sowerby)? Natural size. Fanning Limestone. Fig. 3. Ventral valve, with remains of radiating striæ. Fig. 4. With remains of spiral appendages.

Fig. 5. *Rhynchonella*, sp. (compare *R. primipilaris* (V. Buch) in Davidson's "Mon. Brit. Sil. Brach.," 1865, t. 14, f. 4-6). Ventral valve. Shale above Fanning Limestone.

Fig. 6. *Spirifera convoluta* (Phillips). View of valve, natural size; *a*, bifurcated ribs.

Figs. 7 and 8. *Spirifera Darwinii* (Morris)? An internal cast of a young example, natural size; Coral Creek. Fig. 7. View of the ventral valve, with the mesial sinus and part of the beak broken away. Fig. 8. Dorsal valve; *a*, pinched up mesial fold.

Fig. 9. Another specimen of the same, showing the mesial sinus and broad concentric laminæ of growth; natural size. Parrot Creek.

Figs. 10 and 11. A typical example of the same species, from the cliffs at Wollongong, New South Wales, showing the characteristic concentric laminæ and three ribs on each side the shell; natural size. *Collector*—Professor A. Liversidge.

Figs. 12-15. *Orthotetes crenistria,* var. *senilis* (Phillips), natural size; Havilah-Byerwin Road, from a Marine Band in the Fresh-Water Series. Fig. 12. View of the dorsal valve and area of the ventral. Fig. 12*a*. Portion of the surface magnified, showing punctæ. Fig. 13. Ventral valve of the same specimen, showing the conical form and gnarled appearance. Fig. 14. Side view of the same specimen, both valves in apposition. Fig. 15. Side view of another specimen.

Figs. 16-18. *Productus brachythærus* (G. Sowerby), natural size. Fig. 16. View of the ventral valve, with channels formed by the decurrent bases of the spines. Fig. 18. Side view of the same specimen, showing the geniculated form; both from Stonelumpy Creek. Fig. 17. Dorsal valve, with the short median septum *a*, and short hinge line *bb;* Havilah-Byerwin Road, in a Marine Band of the Fresh-Water Series, associated with *Orthotetes crenistria.*

Figs. 18*a*-25. *Strophalosia Clarkei* (Etheridge), natural size; various localities. Figs. 18*a*, 19, and 20. Interiors of the dorsal valve; Pelican and Parrot Creeks. Figs. 21 and 22 the same. (= *S. Woodsi.* T. Davidson, m. s.; *Collection*—T. Davidson, from New South Wales.) Figs. 23, 24, 25 the same. Pelican Creek.

N.B.—The following letters refer to the same parts in the figures 18*a*-25: —*a*, space left by the removal of the cardinal boss, septum, etc.; *b*, bevelled front margin; *c*, lump of shelly matter showing thickness of valve; *d*, rounded alar angles; *e*, cardinal boss; *f*, sockets for teeth of the ventral valve; *g*, elongated septum; *h*, *h*, oblique alar ridges; *i*, *i*, depressions in which are situated the adductor muscles; *k*, *k*, semilunar and narrow reniform impressions, additional or front depression; *n*, *n*, transverse septum between these depressions.

Figs. 26-32. *Strophalosia Clarkei* (Etheridge). Interior casts of the ventral valve, natural size. Parrot Creek:—*a*, teeth; *b*, ridge or septum (groove in casts) separating the adductor impressions; *c*, ridges in the cast bounding the latter; *d*, blunt prominence (deep pit in casts); *e*, *e*, depression for cardinal muscles, with grooves and ridges, forming scarp-like prominences in the cast; *f*, hinge spines; *h*, open channels left by spine bases; *i*, blunt umbo.

Fig. 33. *Strophalosia Clarkei* (Eth.), with portion of the true shelly matter adhering. Ventral valve natural size. Bowen River.

Figs. 34-38. *Strophalosia Gerardi,* King? (See Perm. Foss. England, t. 19, f. 6 and 7). Natural size. Pelican Creek. Figs. 34 and 35, exterior of the ventral valve, convex and round. Figs. 36 and 37, concave dorsal valve, with the area and umbo of the ventral valve. Fig, 38, portion of surface of another individual, showing spines—*a*, *a*, hinge line and area; *b*, concave dorsal valve; *c*, remains of spines on surface of ventral valve; *d*, blunt but not incurved umbo of ventral valve.

Figs. 39-43. *Strophalosia Jukesii,* sp. nov.? New South Wales and Tasmania. Coll. Brit. Museum. Natural size. Figs. 39 and 40, ventral and dorsal valve of the most complete and concave species we have. Figs. 41 and 42, interior of the dorsal valve. (Compare the form of the reniform impressions with those of figs. 21 and 23.) Fig. 43, side view of ventral valve of another specimen—*a*, *a*, hinge and area; *b*, spines on ventral valve; *c*, close concentric laminæ of dorsal valve; *d*, cardinal boss; *e*, septum; *f*, exterior boundary of reniform impressions; *g*, remains of alar ridge; *h*, bevelled front edge.

Figs. 44-49. *Productus* (?), sp. ind. (Compare *P. brachythærus* (Morris), in Strzelecki's "Phys. Descrip. New South Wales," etc., 1845, t. 14, f. 4 *a* and *b*.) New South Wales. Strzelecki Collection, British Museum—*a*, long septum, reaching to front margin; *b*, reniform impressions; *c*, beak of ventral valve; *d*, dendritic adductor impressions; *e*, beak removed, showing cardinal process; *f*, alar ridges; *g*, scarp-like casts of the depression for the cardinal muscles; *h*, septum dividing the adductors of the ventral valve; *i*, cardinal process; *k*, channels of spine bases.

Figs. 50 and 51. *Productus horridus* (Sowerby). Permian, Humbleton Hill. Coll. British Museum. Natural size. The same lettering applies here.

Fig. 52. *Aviculopecten subquinquelineatus* (M'Coy). Natural size. Bowen River, Marine Series.

Fig. 53. *Pachydomus ? carinatus* (Morris). Natural size. Coral Creek, Marine Series.

Fig. 54. *Sanguinolites*, sp. ind. (Compare *S. clava* (M'Coy), Brit. Pal. Foss., t. 3F, f. 12.) Natural size. Coral Creek, Marine Series.

Figs. 55-57. *Crioceras Jackii*, sp. nov. Natural size. Tate River. Cretaceous.

Fig. 58. *Crioceras Jackii*, var. Natural size. Tate River. Cretaceous—*a*, large ribs with tubercles; *b*, small plain ribs; *c*, tubercles; *d*, continuation of body whorl remaining attached to other portions of shell.

PLANTS.

Mr Carruthers has very kindly undertaken to afford me a few notes on the fossil plants collected by Mr Jack in the Bowen River coalfield. In connection with this branch of the subject the following remarks may not be found out of place. As before stated, in the introductory remarks, Mr Jack's memoranda accompanying the collection inform us that the latter is from two series of beds, a Marine (fossils numbered 1 to 166 inclusive) and a Fresh-Water Series (fossils numbered 167-221 inclusive).

From the first, or Marine Series, the remains of plants are only met with amongst the fossils collected from the concretionary ironstone of Coral Creek, below the Sonoma road-crossing, and were obtained personally by Mr Jack. The specimens are four in number, two of them being *Glossopteris*, and the others doubtful.

From the beds forming the second or Fresh-Water Series the remains are almost wholly those of plants, chiefly consisting of *Glossopteris* and *Phyllotheca*, which will be described in detail by Mr Carruthers. The point I wish to call attention to is the occurrence in this series of a bed at two different localities containing not only Marine fossils, but fossils of an undoubtedly Upper Palæozoic facies.

As before stated, Mr Jack has not supplied me with details of the stratigraphical relations of these beds one with the other, but with the view of showing that no mistake can exist, I quote from his list of localities as follows:

"Nos. 187 to 189 (incl.) Rosella Creek, two miles above Havilah Paddock, collected by R. L. J. (a Marine bed in the Fresh-Water Series)."

"Nos. 190 to 213 (incl.) Havilah-Byerwin Road, one mile south of Rosella Creek crossing, collected by R. L. J. (a Marine bed in the Fresh-Water Series)."

Now the importance of these facts must not be overlooked. In the case of the Coral Creek deposit we have an assemblage of fossils most carefully collected, and all presenting traces of one and the same matrix. An undoubted *Glossopteris* occurs here, near *G. ampla* (Dana)* (No. 115) in company with Polyzoa of an Upper Palæozoic type, such as *Fenestella*, *Protoretepora*, two species of *Stenopora*, a specimen which is either a *Productus* or a *Strophalosia* (No. 99), probably the latter; bivalves of the genera *Pachydomus* and *Mæonia*, another which I cannot distinguish from *Aviculopecten limæformis* (Morris), and certainly *Pterinea macroptera* (Morris).† An assemblage of fossils such as this would have been considered by all those who have in previous years written on the subject, Professors Morris, M'Coy, Dana, Jukes, Mr Daintree and others, as representing the Upper Palæozoic Series of New South Wales, etc.

* Geol. U.S. Expl. Exped., under Capt. Wilkes, Atlas, t. 13, f. 1.

† The remains of the *Glossopteris* actually occur in the same block of matrix with certain of these fossils.

In a Presidential address delivered to the Royal Society of Victoria on the 25th of April 1864,* Professor M'Coy tells us that in a discussion which took place at the reading of a paper by Mr Daintree, the latter mentioned, "in the course of the discussion a fact of the highest importance, and which may be found in some measure to reconcile the view of Mr Clarke and myself, namely, that Mr Clarke in making his original collections for determination had mixed together the fossils of the upper and lower beds. Now, as a portion of the fossils could be identified with European species, and there were among them two species of Trilobites (*Phillipsia* and *Brachymetopus*), characteristic of the Mountain Limestone as found in Ireland and Russia, the clearly marked age of these would have determined the age of the whole, if, as was supposed, they came from the same beds; and in this indirect way the *Pachydomi* and other new generic and specific forms, which from their novelty could not afford any indication of age of themselves, came to be considered as Palæozoic forms from their supposed associations with those which certainly were of that age. It is obviously, therefore, necessary to collect and investigate the evidence afresh from each bed by itself with care. . . . etc." These remarks, although undoubtedly sound in principle, will not apply in this case, for we have here careful collecting, showing that *Glossopteris* does actually exist in a deposit with a Marine fauna, amongst which is at least one specimen of *Productus* or *Strophalosia*.

Further, the same species of *Polyzoa*, which are found in abundance in the Coral Creek deposit with the *Glossopteris*, are also met with at Pelican Creek, where the characteristic fossil is *Strophalosia Clarkei*.

Taking all these facts into careful and unbiassed consideration, it appears to me impossible, if the Coral Creek fauna is admitted to be of Permio-Carboniferous age, or at any rate of Upper Palæozoic age, equally must it be admitted that we now have a tangible demonstration of the occurrence of *Glossopteris* in actual company with such a fauna.†

* Trans. R. Soc., Victoria, 1865, vi., p. lxvi.

† On this head, see Dr O. Feistmantel, "Palæontographica," 1878, suppl. iii., Lieferung. iii., Heft. 2, p. 67.

Next, as to the marine bands in the Plant or Fresh-Water Series, I have the following remarks to make. The Marine bed at Rosella Creek contains *Goniatites micromphalus* (Morris) and some indeterminable fragments of other Mollusca. The similar bed at the Havilah-Byerwin Road contains magnificent specimens of a particularly characteristic Carboniferous Brachiopod, *Orthotetes* (*Streptorhynchus*) *crenistria*, var. *senilis* (Phillips), in company with *Productus brachythœrus* (G. Sowerby), No. 193, and a bivalve, either a *Pachydomus* or *Astartila.*

Striking confirmation is again afforded by yet another locality, Cockatoo Creek, where we have *Glossopteris* and *Phyllotheca* actually in company with *Strophalosia Clarkei* (No. 176).

The plants which characterise this Fresh-Water Series I must now leave Mr Carruthers to describe. Beyond placing these facts on record, I cannot at the present time go further, pending the publication of Mr Jack's detailed report on the Bowen River coalfield.

(Unforeseen circumstances have prevented Mr Carruthers from carrying out his intention. The following is, however, a list of his determinations):

1. Macarthur Creek, below Macarthur coal seam—
   Glossopteris Browniana (Brong.) in great quantity.
2. Jack's Creek—
   Araucaryoxylon Nicoli (Carruthers, *sp. nov.*).
3. Cockatoo Creek, 12 miles up—
   Phyllotheca Australis (Brong.).
   Glossopteris Browniana (Brong.).
4. Cockatoo Creek, 3¼ miles up—
   Phyllotheca Australis (Brong.).
   Glossopteris Browniana (Brong.).
5. Cockatoo Creek, 11 miles up—
   Glossopteris Browniana (Brong.).
6. Cockatoo Creek (Nos. 214 to 221 incl.)—
   Glossopteris linearis (M'Coy).
   Phyllotheca Australis (Brong.).
   Glossopteris Browniana (Brong.).

VIII. *The Old Red Sandstone of Orkney.* By B. N. Peach, Esq., F.G.S., and John Horne, Esq., F.G.S. [Pl. XVIII.]

(Read 21st April 1880.)

While engaged in working out the glacial geology of Orkney, during our leave of absence from official work, in the autumn of 1879, we had occasion to pay some attention to the geological structure of the Old Red Sandstone, which is so largely represented in that group of islands. In the course of our traverses we detected certain points regarding the physical relations of the strata which have not as yet been described; and we likewise noted a new and interesting feature in the history of this formation in Orkney, viz., the proofs of contemporaneous volcanic action in Lower Old Red Sandstone times. In the paper now laid before the Society we purpose to describe briefly the general results of these observations.

The abundance of ichthyolites in the flagstones of Orkney was made known through the descriptions of Agassiz, and more recently by Hugh Miller in his well-known volume "The Footprints of the Creator." In the opening chapters of that work he makes the following statement:

"It is not too much to affirm that in the comparatively small portion which this cluster of islands contains of a system regarded only a few years ago as the least fossiliferous in the geologic scale, there are more fossil fish inclosed than in every other geologic system in England, Scotland, and Wales, from the coal measures to the chalk inclusive."

In spite of the inducement herein contained, the ichthyology of Orkney has never been so vigorously or exhaustively worked out as that of Caithness and the Moray Firth basin.

The paper published by Sir R. Murchison in the Quart. Jour. of the Geol. Soc.* contains a brief description of the geological character of the deposits, and an attempt to correlate the strata with the representatives of the same formation in Caithness. He refers to the axis of ancient crystalline rocks near Stromness on which the Lower Conglomerate

* Quart. Jour. Geol. Soc., XV., 410.

rests unconformably, to the large development of the Flagstone series, which is analogous to that of Caithness and to the great succession of red and yellow sandstones of Hoy, which graduate downwards into the flagstones.

In 1878 appeared the first part of Professor Geikie's treatise on the Old Red Sandstone of Western Europe.* This valuable monograph was the first comprehensive attempt to sketch the history of the deposits belonging to this formation in Shetland, Orkney, Caithness, and the Moray Firth basin, and to restore in outline the physical geography of the period. In that portion of the memoir which refers to Orkney, he pointed out, for the first time, the unconformity between the massive yellow sandstones of Hoy and the flagstones. He likewise called attention to the contemporaneous lavas and tuffs which lie at the base of the Upper Old Red Sandstone of Hoy, and to the existence of volcanic "necks" from which these materials had been discharged. He also controverted the idea, advocated by Murchison, that the conglomeratic strata which rest unconformably on the crystalline rocks at Stromness, form the true base of the formation. He regards them merely "as a local interruption of the Flagstone series, due to the rise of an old ridge of rock from the surface of the sheet of water in which these strata were accumulated." Moreover, he correlates the Orkney flagstones with the higher subdivisions of the Caithness series, which is so far confirmed by the fossil evidence hitherto obtained.

In the *Mineralogical Magazine* for December 1879, Professor Heddle published a paper on the Orkney Islands, in which he describes a well-marked trough which runs through the centre of the group of islands. The strata which occupy the centre of the trough he describes as "loose arenaceous freestones, with silicious granules sometimes so coarse as almost to entitle them to the designation of grits." Moreover, he notes the important fact that these arenaceous strata repose conformably on the ordinary blue flags of the islands.

* Trans. Roy. Soc. Edin., XXVIII., 345. This memoir contains references to other papers than those we have quoted on "The Old Red Sandstone of Orkney." We have chiefly referred to those publications which treat of the geological structure of the islands.

The results of our observations confirm the statements we have just quoted from the papers of Professor Geikie and Professor Heddle. In the course of our recent traverses we examined nearly the whole of the coast line of Westray, Sanday, Eday, Stronsay, Shapinshay, South Ronaldshay, and the Mainland, a portion of Hoy, and some of the small islands of the group. The succession of the strata is more clearly defined in the northern islands, and we shall therefore begin by describing the relations of the Flagstone series as they are exposed on the coast sections of Westray, Eday, and Sanday.

Along the western shores of Westray there are admirable sections of grey and rusty-coloured flags, dipping in a westerly direction at a gentle angle. The bluff cliff of the Noup Head (about 240 feet) in the north-west corner of the island, consists throughout of finely-bedded rusty-coloured flags; and similar strata are met with on the slopes of the Fitty and Gallow Hills, to the south-west of Pierowall. The remarkable terraced appearance which these hills present when seen from Pierowall or Cleat, is characteristic of the flagstones. This feature is due to the denudation of softer members of the series, which must have been mainly accomplished in preglacial times. This is evident from the occurrence of polished surfaces and ice markings in many of the successive ledges on the hill slopes.

At Nethergarth, in Tuquoy Bay, the flagstones roll over to the east, and this easterly dip continues, with some gentle undulations, along the south-western shore to the promontory of Rapness. And so also along the eastern shore from Newark by Rackwick, Stangar Head to Weatherness, the grey and rusty flags are inclined to the east and south of east. The same easterly dip is observable on the southern promontories of Papa Westray. It follows, therefore, that we have a low anticlinal arch with several minor foldings in the island of Westray, the axis of which crosses the island from Tuquoy Bay northwards in the direction of the western shore of Papa Westray. The flagstones exposed in the south-eastern part of the island are merely the repetitions of those met with in the western portions.

As we approach Weatherness, which forms the south-eastern promontory of Westray, the flagstones are more highly inclined to the east. On the islands of Fara Holm and Fara, the same high angle is observable with a similar easterly dip; and there can be little doubt that the grey flags in the latter islets are higher in the series than those at Weatherness. The flagstones exposed on the western shore of Eday between Fara's Ness and Seal Skerry are merely the southern prolongations of the flaggy beds in Fara and Fara Holm. On the whole, then, the succession of the strata between Westray and Eday is tolerably clear, notwithstanding some short gaps in the sections.

The structure of the island of Eday is comparatively simple. The strata form a well-marked syncline, the axis of which lies to the west of the Flighty and Fara's Ness Hills. The centre of this trough is occupied by a great series of yellow and red sandstones, which rest conformably on the flagstones already described. The shore sections on the east and west sides of the island are so clear and convincing, that no one can possibly dispute the conformable passage of the flagstones into the overlying arenaceous series. So strongly do the sandstones of Eday resemble the Upper Old Red Sandstones of Hoy, that Sir Roderick Murchison placed them on the same horizon. But a minute examination of the coast sections proves that they really belong to the Flagstone series, and are therefore of much older date.

A traverse along the shore from Fara's Ness to the sandy bay about a mile to the east, shows the gradual alternation of sandstones and flags at the base of the arenaceous series. At the promontory now referred to, the grey flagstones are seen dipping to the east at an angle of 30°; but not far to the east they are interstratified with bands of flaggy sandstone. These beds are overlaid by false-bedded yellow sandstones which contain numerous brecciated bands made up of angular fragments of crystalline rocks. These false-bedded sandstones likewise contain two thin zones of grey flagstones, which resemble in every respect those at Fara's Ness. It is apparent, therefore, that the change of physical conditions indicated by the respective groups of strata must have been gradual.

The same conformable passage between the flagstone and the overlying arenaceous series is observable on the east coast near the Kirk of Skail, and to the north of Warness, which forms the south-western promontory. Owing to the synclinal fold in the strata, the flagstones at Fara's Ness are brought to the surface again at Warness, and these beds are prolonged in a north-north-easterly direction towards the Kirk of Skail. At both of these localities grey and white sandstones are interbedded with the flags, and these pass upwards into conglomeratic red and yellow false-bedded sandstones.

The section exposed on the beach at Kirk of Skail and on the south side of Lonton Bay, exhibits the following succession in descending order:

Red and yellow sandstones.	
Flagstones, ...	40 feet.
Reddish shales, ...	15 ,,
Hard white sandstone, . . .	20 ,,
Grey calcareous flagstones.	

The sandstones at the top of this section are flaggy at their base, but become more massive and conglomeratic upwards. The included pebbles consist of fragments of mica schist, quartzite, gneiss, granite, and other metamorphic rocks all stained of a reddish colour. The occurrence of these pebbles tends to confirm Professor Geikie's expressed opinion that the Lower Old Red Sandstone strata of Orkney were laid down on a very uneven surface of the older crystalline rocks; for an exposure of these latter must have still existed at no great distance, when the highest beds of the Lower Old Red Sandstone series now preserved in Orkney were being deposited.

In the bay to the north-east of Stenniehill a zone of grey flagstones with fish remains is interleaved with the sandstones, as we found to be the case on the west side of the island in the bay of Fara's Ness. This zone can be traced at intervals across the island in a south-westerly direction to the coast line west of the Wart of Eday.

About half a mile to the south of the entrance to the Calf Sound, the base of the arenaceous series is again exposed on the coast line. The grey and rusty flags form a low arch on which the coarse-grained sandstones rest conformably. The flags are truncated on the north side by a small fault which brings down the overlying sandstones. The greater portion of Eday and the whole of the Calf of Eday are occupied by these sandstones. Perhaps the finest exposure of the series is to be seen on the Red Head of Eday (209 feet), which forms the northern promontory of the island. These strata form prominent hills in the centre of the island, whose features are totally different from those characteristic of the Flagstone series in Westray. As a rule the beds are extremely coarse-grained, and frequently conglomeratic, with much false bedding; indeed, as we have already remarked, they have a striking lithological resemblance to the Upper Old Red Sandstones of Hoy.

Southwards from the Kirk of Skail, along the shore, there is a steadily descending section of the flagstones for nearly a mile and a half. There is no great thickness of strata exposed however, as the coast line forms only a very small angle with the line of strike for some distance. North of Veness the Flagstone series is abruptly terminated by a fault which brings down the overlying sandstones to the west. This dislocation runs in a north and south direction, and passes out to sea to the west of the Veness promontory. There is therefore a small detached area of the arenaceous series in the south-east corner of the island.

In the island of Sanday the thick sandstone series of Eday and the underlying flagstones are repeated partly by foldings and dislocations of the strata. Along the western shore between Spurness and Stranquoy, the grey flagstones are exposed interbedded with red and grey sandstones which are conglomeratic in places. These beds are inclined to the west and north of west at angles varying from 50° to 70°. The conglomeratic sandstones and red shales interbedded with the flags are seen on the western shore, about a mile to the north of Spurness. It is highly probable, therefore, that the strip of the Flagstone series, extending from Spurness to Stranquoy, is on the same horizon with the flags, which immediately underlie the Eday sandstones.

The strip of the Flagstone series now referred to is bounded on the east by a dislocation which brings in the Eday sandstones. This fault is well seen on the shore, a short distance to the north-east of Spurness, where the red and yellow sandstones which dip to the west at an angle of 40° are brought into conjunction with the grey flags. The effect of this dislocation is also well exposed on the shore in Stranquoy Bay. The chocolate-coloured sandstones and shales are seen on the east side of the fault dipping in a south-westerly direction; while to the west of the fault the grey flags are bent round in the form of an arch. The effect of this dislocation is shown on the accompanying sheet of horizontal sections.

To the east of Stranquoy the arenaceous series, which is brought in by the fault just described, is traceable for nearly a mile. The red and yellow sandstones are admirably seen in Pool Bay and on the shore at Hack Ness, having a persistent dip to the west at angles varying from 15° to 25°. A thin zone of interbedded flagstones is exposed in the bay to the west of Hack Ness, which reminds the observer of similar zones on the same horizon in Eday.

The gradual passage of this arenaceous series downwards into the flagstones is presented on the shore at Moy Ness, where the same alternations of flags and sandstones at the base is observable, which obtains in Eday. Northwards along the shore towards Bacaskeal Bay there is a steady descending series of grey and purple flags.

In the northern promontories of the island, and specially along the shore from Hermaness Bay to the Holms of Eyre, the grey and purple flags are repeated by gentle foldings. There is, therefore, no great thickness of strata exposed in the central portion of Sanday. The time at our disposal did not permit us to visit the north-eastern promontories of Sanday, nor the island of North Ronaldshay; but from the observations of previous observers only the Flagstone series seems to be represented at these localities.

The greater portion of the island of Stronsay is occupied by the flagstones, but at one or two localities there are small detached areas of the arenaceous series. On the northern headlands, the grey flags are exposed dipping in a north-westerly direction, and the same inclination is observable in Odin Bay and Linga Sound. About a mile to the north of

Holland, on the western shore, the yellow sandstones are thrown against the flags by a fault which is admirably seen. The sandstones dip to the north of west, and, on following the coast line southwards, they graduate downwards into the grey flags.

In the south side of the island, at Housbay, and in the bay west of Lamb Head, the flagstones roll over to the south-east, and a similar passage upwards into the yellow sandstones may be noted. The small area occupied by this series at Lamb Head is bounded on the north side by a fault.

A small patch of yellow sandstone, which is quarried for building purposes, occurs between Odin Ness and Burgh Head, but as it is bounded by faults, its relation to the flagstones is not apparent.

The greater portion of the island of Shapinshay is likewise occupied by the Flagstone series. The sections exposed on the coast line prove, beyond all doubt, that the same beds are constantly repeated by gentle undulations. Along the western shore, between Stromberry Ness and the Galt, the general dip is to the north-north-west, but as the observer traverses the shore of Veantro Bay and the coast line between Balfour Castle and How, he cannot fail to note the frequent changes of dip which bring the same beds to the surface again and again. In the south-eastern corner of the island, however, there is a small patch of red and yellow sandstones interstratified with grey flags. Though the gradual passage between the two groups, which is so clear in the northern islands, cannot be made out in Shapinshay, there can be little doubt, from the character of the strata, that the patch of sandstones, between Haco's Ness and Kirkton, are near the base of the arenaceous series. A small fault separates the two groups to the south of Kirkton, which obscures the relations between them, and it is highly probable that this dislocation may be the northern prolongation of the great fault to be described presently, on the Mainland. This conjecture is strengthened by the fact that, though the flagstones on Shapinshay roll about in every direction, yet the preponderance of dips is towards the south-east, and this is especially the case on the eastern shore of the island. Bearing this in mind it is easy to account for the Eday sandstones being brought in by the aid of a comparatively small fault. It is important to note this dislocation, for these beds are continued across the channel to Inganess on the Mainland, whence they stretch across to Scapa, and are extended on to near Orphir Kirk, being cut off from the flagstones along their whole northern boundary by a large fault with a downthrow to the south.

An interesting feature connected with the patch of sandstones and the associated flags at Haco's Ness, is the occurrence of interbedded volcanic rocks, clearly proving the existence of volcanic action in Lower Old Red Sandstone times in Orkney. The lithological character of these rocks, as well as their appearance under the microscope, will be described under a separate heading.

On the Mainland, the arenaceous series just described as occurring in Shapinshay, and which is likewise represented in Stronsay, Sanday, and Eday, is well developed. But before describing the relations of the two groups as represented on the Mainland, we shall refer briefly to the development of the Flagstone series in the western part of the island. The unconformity between the flagstones and the axis of crystalline rocks at Stromness has been frequently described. Our observations tend to confirm the conclusions already arrived at by Professor Geikie, that the conglomeratic strata which repose on the gneissic rocks merely indicate a local base. It is quite true that the brecciated flagstones are mainly derived from the underlying crystalline rocks, but the conglomeratic character disappears within a short distance of the gneiss. Professor Geikie has alluded to the fact that the general dip of the flagstones in Hoy is to the north and north-west, and consequently the flaggy strata, which rest unconformably on the gneissic ridge, are probably higher in the series than those in Hoy. This evidently points to a gradual subsidence of the area during the deposition of the Flagstone series.

The strata represented in the north-western portion of the Mainland are evidently the southern prolongations of the flaggy series which we have already described as occurring in Westray. They are admirably exposed on the shore between

Burness and the Brough of Birsay, and along the western coast line. They are likewise well developed in the island of Rowsay, where they form the characteristic terrace-shaped hills. The lithological characters of the flaggy series in Westray, Rowsay, and the north-west of Pomona, are precisely similar.

On the coast line also, between Irland Bay and Houton Head, similar strata are met with, rolling about in gentle folds.

Again the flaggy series of Shapinshay reappears on the headlands of Carness and Work Head, north-east of Kirkwall, where the general inclination is to the north-west.

From Inganess Head south-westwards to Scapa Bay, and along the shore to Smoogra Bay, and thence to Orphir Kirk, a strip of red and yellow sandstones with red marls is traceable. These red and yellow sandstones are the southern prolongations of the Eday sandstones. They are bounded on both sides by faults which bring them against the underlying flagstones. The dislocation which forms the northern boundary line has been traced by us for a distance of nearly ten miles from Orphir Kirk north-eastwards by Scapa Bay to the bay east of Inganess Head. The fault is admirably seen at various localities, but perhaps one of the most interesting of these is on the west coast of Scapa Bay, where the main fault as well as a minor dislocation are seen.

On the high cliff which bounds the west side of Inganess Bay, friable red clays are associated with the red sandstones. They decompose readily, and break up into small cubical fragments.

Along the shore from Scapa southwards to Howquoy Head, the same red and yellow sandstones are brought into conjunction with the flags by a fault which runs almost parallel with the coast. At Scapa the rocks consist of red mottled sandstones, underlaid by coarse honey-combed yellow and white sandstones, which alternate with calcareous flags and dark bituminous schists. Owing to numerous foldings these beds are often repeated.

To the east of this arenaceous series, the flagstones reappear in Inganess Bay. They are well developed on the shore near Tankerness, and along the coast line between

Mull Head and Air Point. Flagstones only, are exposed on the shore to the east of St Mary's, and also along the road from Græmeshall to Kirkwall, save where the narrow patch of red sandstones already mentioned crosses from Inganess to Scapa.

In South Ronaldshay the lowest beds exposed are to be met with at its southern extremity, where they form the Old Head overlooking the Pentland Firth. Here the rocks consist of grey calcareous flags, charged with abundant remains of *Coccosteus* and other ordinary Caithness fishes, which are well preserved as in Caithness, and are not represented by a black lead-like smudge characteristic of those from Skail. Following the eastern coast line, these beds continue for a considerable distance with a northerly dip. There are several faults, some of which are occupied by veins of barytes and iron pyrites, but they seem not to be of any great magnitude. A little to the north of Halcro Head, the flags pass under a series of yellow and red sandstones and red shales, which at Windwick are suddenly truncated by a large east and west fault, the effect of which is to bring up the underlying flagstones. Near the fault flagstones are inclined towards it, but they soon recover their northerly dip, and at Stow Head once more dip below the sandstones. Owing to the sandstones being arranged in a small trough, the flags soon reappear, and after rolling about for some miles along the coast line, they finally plunge under the sandstones near the mouth of Watersound, never to reappear on South Ronaldshay; for the red sandstones, with occasional thin intercalations of red flags and massive bands of red marly clay, extend to Crow Point in the extreme north-west. These beds are continued along their strike into Burra, where the passage from the flags into the red sandstones is well shown at the eastern entrance to Watersound. The islands of Flota, Fara, and Cava, show the same alternation of flagstones with red and yellow sandstones and red marls. In Flota the dip is almost north at Pan Hope, where the passage from the flagstones to the sandstones is well seen; while in Fara and Cava, the inclination is more to the north-east.

In the district of South Walls and the promontory of Brim's Ness, in Hoy, the rocky cliffs exhibit the ordinary grey flagstones. On the shore of the Longhope, between Melsetter and the Inn, they pass under the red and yellow sandstones; and the same relation is observable on the coast facing the Atlantic, a little to the south of Melsetter. On a former visit of one of the authors with Professor Geikie considerable difficulty was experienced in tracing the fault which divides the Upper Old Red Sandstones from the arenaceous series associated with the flagstones, till the intercalation of the sandstones with the Lower series was realised.

From what has been said it will be seen that Scapa Flow occupies the site of a geological basin, towards which the rocks dip on every side, and along the shores of which the highest beds of the Lower Old Red Sandstone exposed in Orkney are to be met with as well as in Eday and Sanday.

The beds in South Ronaldshay are exceedingly like those exposed along the shores of Gills Bay on the opposite Caithness Coast and in the intermediate island of Stroma, and are, in all probability, their prolongations to the north-east, which is the direction of their strike. We have thus a definite horizon to start from, for the highest beds in Orkney are also the highest in the Caithness series.

It is worthy of note that the sandstones become coarser as they are traced northwards. In South Ronaldshay there are great masses of friable marly clays, intercalated with the sandstones. In Eday and Sanday there are only about ten feet of such strata, while the sandstones are very coarse and even conglomeratic, and approach much more to the type of the Lower Old Red strata of Shetland.

Igneous Rocks in the Lower Old Red Sandstone.—The only contemporaneous rocks of this nature occur at the south-east corner of Shapinshay, between Haco's Ness and Foot, where they form the coast line for about half a mile. They are perfectly conformable with the flagstones. The upper surface of the diabase is highly vesicular and amygdaloidal, and exhibits all the characters of a regular lava flow. The flagstones overlying it are not altered in the slightest along the line of contact. The base of the volcanic series is not seen, though the sea has cut trenches in the rock at least thirty feet in depth. Where the dip is visible, it is seawards. In the cliff they are covered by the flags, but they crop out inland not far from the coast line. These rocks are dark green in colour, weathering olive green. They may be considered as varieties of diabase, which have undergone considerable alteration. Some of the specimens contain much calcite, which fills drawn-out vesicles, indicating the flow of the molten lava. We have had some of these rocks sliced, and examined under the microscope, which confirms the opinion regarding the extreme alteration which they have undergone.

One of the sections is found to be largely constituted of a plagioclase felspar, with a small amount of intervening chlorite, but with much altered olivine. The felspar is much decomposed, and forms the bulk of the rock. The olivine, which is now changed into a pale greenish yellow serpentine, is distributed in large crystalline grains, and is abundant. In places the chlorite is represented by masses of radial and vermicular groups of crystals which appear to have undergone a change to the same serpentinous mineral as that which replaces the olivine. Magnetite is irregularly distributed as grains, and also frequently, either wholly or partly, envelopes the crystals of olivine.

Another section shows that the rock consists of closely crystallised plagioclase and much interstitial augite, with a considerable amount of olivine. The augite and the olivine have been converted into serpentine, although a few crystals, as well as portions of crystals, still remain unaltered. The felspar in many places is permeated with the same mineral. Much magnetite is present, together with quartz, some calcite, and serpentinised chlorite.*

Intrusive Igneous Rocks.—Among the few examples of this class met with are the two necks filled with volcanic agglomerate already described by Professor Geikie as occurring on Hoy, and which he has shown, in all likelihood, helped to supply the volcanic platform which underlies the main mass

* In the examination of the microscopic sections we have been kindly aided by Mr T. Davies.

of the Upper Old Red Sandstone of that island, and are therefore to be considered of that age.

Several dykes of basalt were observed among the islands. They are most numerous and conspicuous on the west coast of the Mainland from Brackness to Skail, but as they have been so often described, it is unnecessary to refer to them in detail. They have the same lithological characters, and behave exactly in the same manner as the dykes in other parts of Scotland, which have been regarded as the product of volcanic energy in Miocene times. A noticeable feature about the Orcadian representatives is, that they are usually divided up the centre of the dyke by a line of vesicles. This is not an uncommon feature elsewhere.

Summary.—The descriptions we have given of the Lower Old Red Sandstone strata as represented in the Orkney Islands, tend to confirm the conclusion previously arrived at by Professor Geikie, that these flagstones, with the associated arenaceous series, must be correlated with the higher subdivisions of the Caithness series. It is highly probable, therefore, when the ichthyology of Orkney is worked out in detail, that the fossils will be identical with those derived from the higher portions of the Caithness series. The great development of the sandstone series in the northern isles is of special interest, as it shows that the strata gradually assume the arenaceous character which is so prevalent in Shetland.

Moreover, it is of importance to note that the coarse silicious sandstones and marls, which are the highest representatives of the Lower Old Red Sandstone in Orkney, must not be confounded with the massive red sandstones which form the noble cliffs on the west side of Hoy. The latter rest unconformably on the flagstones. It is evident, therefore, that after the deposition of the Flagstone series, with its associated sandstones and marls, the bed of this inland sea was elevated so as to form a land surface. These strata were subjected to a considerable amount of denudation ere they were again carried below the water in Upper Old Red Sandstone times.

IX. *Early Chapters in the History of the Squirrel in Great Britain.* By J. A. Harvie-Brown, Esq., F.Z.S., Member of the British Ornithologists' Union.

(Read 21st April 1880.)

Geological Evidence.

We have no evidence of the occurrence of the squirrel in post-tertiary deposits. It is not, I believe, made mention of by Dr James Geikie as being found in post-tertiary deposits in Scotland in his "Great Ice Age." Mr A. Murray, in "The Geographical Distribution of Mammals," tells us: "The only fossil remains of squirrels are of recent date. . . . Remains of the living species of squirrels have been found in bone caves, but nothing indicating its presence in Europe or indeed anywhere else at a more ancient date." Nor does it appear to be of common occurrence even in more recent remains. The only evidence of squirrels in the Pleistocene Shale of Britain is that afforded by gnawed fir-cones in the pre-glacial forest bed of Norfolk, which were recognised by Professor Heer and the late Rev. S. W. King, as I am informed by Professor Boyd Dawkins, who adds further, that he "does not know of any bones of squirrels in any prehistoric deposit, and I do not think that the nuts (found in marl, etc.) are proved to have been gnawed by them and not by *Arvicola amphibia*." I may add here that I have since collected gnawed nuts from various localities and compared them with recent ones, and it seems to me quite impossible to separate them by any evidence afforded by the tooth-marks. Those gnawed by smaller rodents (such as species, probably, of field-mice), are more easily distinguishable.

This apparent absence from recent deposits in Great Britain may, in some measure, perhaps be accounted for by its arboreal habits. If traces of it however are found in the preglacial beds of Norfolk, is its absence in other localities further north not without significance as regards its distribution in time?

Names of the Species and Topography.

In endeavouring to trace the early dispersal and distribution of the squirrel, we may find it useful to call to our aid a study of the various names of the animal—ancient and modern —and of the areas in which these names occur.

A very large number of provincial names of the species in use in Italy, Spain, Portugal, France, and in our own country, are directly traceable to their common origin in the name first used by Aristotle, viz., σκιουρος (σκια=shade, and ουρος=a tail) through the Latin diminutive *sciuriolus.**

Our name *squirrel* occurs at a very early date, being used by St Hugh, dating A.D. 70-1200. Thereafter it occurs constantly in later works, through the fourteenth and fifteenth centuries, numerously in the seventeenth century, and continuing to the present time, with certain local variations and spellings. Thus we find it mentioned in the first English-Latin Dictionary in the East-Anglian dialect as "*scorel* or *squerel*,"† and we find it again evinced in the local names *skug* and *skuggie* used in Hampshire at the present day, and reappearing as a Scotch word for shade or shelter in "*skug*= umbra, shade, *skug*=a shelter: to *skug*, to hide; to *skoog* a shower;" ‡ while on the English border occurs *scuggery*= secresy, along with other evidence.

Thus the name squirrel has come to us along with the animal itself northwards, and its use is distributed over many continental countries.

The distribution of the use of the name *con* for a squirrel appears to have been in North Lancashire, in the southern portions of Cumberland, and in Westmoreland on the English side of the border, and through the south of Scotland, but is unknown in the northern parts of Cumberland. If it was ever used in the Carlisle district, the use of it must have become extinct with the possible early extinction of the

* Eugene Rolland: "Faune Populaire de la France, Les Mammiferes sauvage," pp. 64, 65, 1878.

† "Promptorium parvulorum sive clericorum, Dictionarius Anglo-Latinus Princeps," auctore Frator Galfrido, etc. *Circa*, A.D. MCCCCXL.

‡ Jamieson's "Dictionary of the Scottish Language."

species itself in that district. At present the use of the name *con* is quite extinct in the south of Scotland, but was known in 1771 to the Gaelic bard Alastair M'Donald, as he includes it in his Gaelic Vocabulary thus: "*Feoirag*=a squirrel or *conn*."

Gaelic scholars are of the opinion that *con* or *conn* is a shortening of the Gaelic word *coinein*, a rabbit. Early Scottish writers however distinguished between rabbit and squirrel thus:

> I saw the Hurcheon and the Hare,
> The *Con*, the *Cuning*, and the Cat.
> —*Cherrie and Slae*, 3.

and again—

> There was the pikit porcopie,
> The *Cuning*, and the *Con*, all thrie.
> —*Watson's Collection*, ii. 20.

And Ferguson in his "Dialect of Cumberland," gives "*con*, a squirrel's nest; in Lonsdale, the squirrel," and refers it to the Welsh word *cont*, a tail.

The absence of the name altogether from a tract of country intervening between those localities where it *is* used in England, and those where it *was* used in Scotland, viz., around the neighbourhood of Carlisle and the northern portions of Cumberland, is curiously suggestive, and, when taken in conjunction with the facts of the probable disappearance of the species from these tracts at an early date as compared with other localities further south and further north, as I propose to show further on, may not prove altogether useless in assisting us to arrive at conclusions regarding the dispersal, ancient distribution, and subsequent disappearance of the species.

But it is well known to Erse and Gaelic scholars that often extraordinary confusion exists amongst the names of animals in these languages. Thus *coinin*, the Irish for a rabbit, is a diminutive of *cú*, a dog, and means literally *a little dog*. The use of the Gaelic *coinein* is almost if not quite extinct even in districts of Scotland where the Gaelic has been preserved longest in its purity, and the rabbit is only known as the *rabbaid*, which distinguishes it as an alien, in such localities where the latter word is used. Under these circumstances the difficulties which surround the question of the identity of numerous Gaelic names, or by what process they came to be used and applied, seem almost impossible to unravel. In my original manuscript, of which this is an abstract, I go more fully into the subject, quoting and referring to all my authorities, having taken the various opinions of able Gaelic scholars; but, while the isolation of the use of the word *con* in England remains a fact, we are as yet unable to account for it, though we might easily advance theories founded upon our present information.

Of the presently used Gaelic word, *feorag*, it is probably of considerable antiquity, and the most probable interpretation seems to be "the little questioner," from Gael. *feoirich*, to question; and *ag*, the endearing diminutive termination; but, as has been pointed out to me by Mr James Macpherson—to whom I have been greatly indebted for assistance in these and similar researches—the name may have arisen from a much earlier root, viz., "a root-word, *feo*,* now lost sight of and not given in the dictionaries, meaning strictly, or in a general sense, *bearded*—*feo*, beard; *earr*, a tail; and *ag*, the diminutive termination of feminine nouns. *Earrag* is one of its actual Gaelic names."

Thus also in the Erse occurs *iora*, but this is not found in the earliest dictionaries—as O'Brien's, but only in the later ones of O'Reilly and McCurtius, and in the works of authors which are of comparatively recent date.

In old Irish occurs the word *iaronns*,† which, as far as I know, have not yet been satisfactorily identified. Other old Irish names, as *sesquirolos* and *cricharán*, occurring in the above-quoted poem, cannot be considered of value in this connection, but it would occupy too much space here to enter into a fuller attempt at the explanation of these. But upon the correct rendering of some of these old Irish names

* Recurring in *feósag*, a beard; *feochadan*, a corn-thistle; *feocullan*, a polecat; and *feorag*, the word under discussion; and so perhaps *feoir* = grass (from *feo*, beard, and *ar* or *ire*, soil), gives *beard of the soil*.

† "Two iaronns from the wood of Luadraidh," *vide* Wilde: "On Unmanufactured Animal Remains," etc., Proc. Royal Irish Academy, Vol. VII., part ix., p. 188.

probably rests the fixing of interesting facts connected with the early dispersal of several of our British mammals.

It appears possible that the Irish words *iora* and *iaronn* may have intimate relation with the Gaelic *feorag* or *fiodharag*, of which latter I speak immediately.

In Argyleshire, alone of all the Scottish counties—except in Braemar in Aberdeenshire—so far as I have been able to learn, does any trace of the squirrel appear in topography, but in Argyleshire, curiously enough, it occurs no less than five times, viz., in Innis-na-Fheórag in Ardnamurchan; Glac Fheórag in Appin; Ault Fheórag, Tom-nam-Fheórag, and Easan-Fheórag. Whether these names be correctly derived from the Gaelic name of the squirrel or not is a point about which there is a large amount of discussion and difference of opinion amongst our best Gaelic scholars. For the same reasons already given, viz., the great difficulties surrounding the identity of numerous Gaelic names, it does not seem desirable in this place to attempt to explain or unravel them, but it may be mentioned that whilst one side upholds the direct derivation from *fheórag*, a squirrel, another rather inclines to the belief that the name is derived from local features of the localities, such as is undoubtedly the commonest practice in Gaelic topography—thus; Ault *Fiarag* (pronounced slightly different from *Feorag*—genitive *Fheórag*) would be *the crooked burnie.* But if such came to be applied in one Gaelic-speaking district, why should it be so completely absent from others where many crooked burnies exist, and have not, like the squirrel, become nearly extinct?

To show the confusion existing amongst Gaelic names of animals, I will just make one quotation from the correspondence of Mr James Macpherson.

As already shown, Fheórag is supposed to derived from *feoirich,* to question, and *ag,* the diminutive; or it may be from *feo,* an obsolete root-word, *earr,* a tail, and *ag.* But now to this, Gaelic scholars add a third, viz., "possibly a corruption or softened pronunciation of *Fiodharag,* which would mean 'the wood or tree-animal.'" If this is so, the name may have been applied by the early inhabitants not to the squirrel at all but to the marten, whilst a later dispersal of the squirrel may have obtained for that species, in early times, an erroneous name. And this appears none the less probable when we are aware of the fact that any amount of confusion, as I can easily show, exists even at the present day in the minds and conversation of country people in many parts of Scotland as to what a squirrel really is. Even in Argyleshire itself I have myself heard a *ferret* called *feórag,* and in Aberdeenshire squirrels are constantly brought to Mr George Sim, the naturalist of that town, by uneducated country people as "foumarts," "futterets," or "ferrets."

It may well be asked, then, when did this awful confusion begin, and to what animal was the name originally applied? Mr Macpherson assures me that the two derivations of *feorag* given above are the most likely, meaning "the little questioner," and "the wood or tree animal."

In Scotland the marten is known by a distinctive Gaelic name, but in Ireland, though the marten is widely recognised, there are no names and no traditions now existing regarding the indigenous squirrel amongst the peasantry or older people of the country. As we will show further on in our essay, an introduction of the squirrel certainly took place in Ireland during the present century.

All these materials are intended to bear upon the question, —Did the squirrel extend its distribution into Ireland before the separation of Ireland from the south-west of Scotland? or, in other words, Was the squirrel indigenous to Ireland, and did it become extinct at an early period? But the result is still obscure. In a separate section of this essay I shall speak of the "Squirrel in Ireland."

(*To be continued.*)

X. *On an undescribed variety of Amethyst.* By Professor DUNS, D.D., President. [Plate XIX.]

(Read 21st April 1880.)

The place of the amethyst in systematic mineralogy, its chemical constituents, crystallographic form, the characters of the species of which it is a variety, its colour, geognostic situations, and geographic distribution are so well known, as scarcely to call for remark. There is still some difference of opinion as to its constituents, traceable no doubt to the fact, that these are not constant, but vary in different specimens. Rose's analysis, which is that most generally received, is as follows: silica 97·50, alumina 0·75, iron oxide and traces of manganese 0·75. In a Brazilian specimen, Heintz (quoted by Dana) found traces of magnesia and soda, whose presence he thinks accounts for the characteristic colour of this mineral. Others hold this to be due to a small percentage of oxide of manganese. Amethyst occurs in veins, or lining the oft-described agate balls. "Crystals within the geodes or hollow agate balls are very often of an amethyst colour, and some are very fine" (Cronstedt's "Mineralogy," vol. i., p. 151, 1788). I am able to show to the Society, a very beautiful group of pure amethyst crystals in an agate ball from Saxony. The gem known as oriental amethyst is spinel or *dodecahedral corundum*, a widely different mineral with an amethystine hue. The constituents of spinel are alumina 74·50, silica 15·56, magnesia 8·25, oxide of iron 1·56, lime 0·75.

The variety of amethyst which forms the subject of this notice was presented to me, without any reference whatever to its scientific interest, but simply as an ornamental stone, by the Rev. Dr Paterson, New Glasgow, Nova Scotia, who had obtained it at Prince Arthur's Landing, on the north shore of Lake Superior, in August 1878. Looking at it with a good lens I remarked to Dr Paterson, the specimen is altogether unlike any I have seen. The dark red crystalline substance on the faces of the hexagonal pyramids is not deposited in a homogeneous layer, but seems to consist of innumerable spots, I should say of iron oxide. As the donor thought it must have been described, I consulted most of the leading authorities, without, however, finding any reference to this variety. In a note dated August 2, 1879, Dr Paterson says, "I find that the amethyst from Lake Superior has been analysed by Sterry Hunt of the Canadian Geological Survey, who discovered the colouring matter to be oxide of iron *before you.*" On being asked for a reference, he informed me in a subsequent note, that having failed to find it, he had written to Principal Dawson, Montreal, for information. Principal Dawson, writing in the absence of Dr Hunt from town, on November 5, 1879, says—"I write now merely to state what I know as to the matter referred to. The ferruginous coating which you mention is very common on crystals of amethyst from Thunder Bay, and seems to have been simply the latest coat of quartz deposited on the crystals, and containing peroxide of iron in little rounded hollow concretions with radiating spicules. This mode of arrangement of oxide of iron is not unusual in reddish agates from Nova Scotia and elsewhere, though with various modifications in detail. I am not aware that it has been particularly described, nor that any special cause of it is known further than the general one of molecular and crystalline aggregation, which has to do duty in the explanation of an infinity of curious forms in agates and other forms of quartz. I cannot find that Dr Hunt has published any particular account of the peculiar appearance in the Thunder Bay amethysts." A thin slice prepared for the microscope, and magnified ninety diameters, presented an appearance well shown in the somewhat coarse, but highly characteristic plate which accompanies this notice (see Plate XIX.). At my request Professor Crum Brown kindly took charge of a fragment which he entrusted to Dr Gibson for analysis, who reported on the specimen as follows:

"University of Edinburgh, *March* 27*th*, 1879.

"*Report upon Crystal of Amethyst Quartz.*

"A qualitative examination was made with a view to determine the nature of the red colouring matter deposited underneath the surface of the crystal. The result of this examination showed the presence of iron, and the absence of copper and other heavy metals. Ferric oxide being of very common occurrence in quartz, there is no reason to doubt that it is the red colouring matter in the crystal examined.

"J. Gibson, Ph.D."

My first impressions as to the colouring matter of the six-sided crystals of this specimen were thus verified. It might, however, be well to carry the analysis farther by testing for soda, magnesia, or manganese, having previously marked the degree of intensity of the violet blue colour of the specimen. But, apart from this, it will be seen from the pieces in the lump and in section now exhibited, that they are made up as follows: The base on which the crystals rest is a thin layer of fine vesicular trap. Above this is a mass of highly crystalline semi-transparent quartz, about an inch in thickness, thickly packed but yet showing the planes of the crystals less or more well marked, and, on the top of this a thin layer, of granular-like amorphous quartz, out of which the definitely crystallised amethyst proper seems to rise. This may or may not be generally the order of the layers, but in the specimens now before us it is well marked. The dirty red colouring matter is confined to the faces of the hexagonal pyramids—the characteristic crystalline forms of quartz—and is, for the most part, deposited in pretty separate *annuli*, ring within ring. In the specimens now under notice I have not seen any traces of the "radiating spicules," referred to by Dr Dawson. Nor are the rings on the same plane. When examined through a good binocular they are seen to lie at different levels, a fact which seems to warrant the inference that the highly crystalline glaze, so to speak, in which they lie, consists of different layers. The spots are not in all cases perfectly circular, as may be seen by referring to the accompanying plate. It would not be profitable to speculate on the probable explanation of those molecular aggregations. I may, however, ask the Society to look at the so-called *morpholites* or clay concretions, and the dolomites from Cumberland, now on the table, as illustrating, on a large scale indeed, in a somewhat striking way, the close resemblance between them in point of form and the spots figured on the plate. This resemblance suggests a topic of great interest and of which little has yet been made. I refer to the analogies between the power of concretion and that of crystallisation. But I do not wish to make more of this resemblance than to indicate the fact. The crystalline matrix in which the spots occur has, for want of a better term, been called a glaze. Is the presence of this necessary in order to the iron oxide arranging itself in such spots? In the New College Museum is a large lump of rock crystal, on which the faces of the six-sided pyramid are covered with a layer of iron oxide, lying wholly on the surface, in the form of rough amorphous particles, and destitute of this glaze.

As I have been unable to find any published description of this variety of amethyst, and as it presents some features of considerable interest, I have thought it not unworthy the attention of the Society. The plate is an attempt to reproduce, in a rough way, the colours and the forms of some of the spots shown in the section, exhibited to the Society under the microscope.

XI. *On the Habits of the Water Vole* (Arvicola amphibia). By Professor Duns, D.D., President.

(Read 21st April 1880.)

The water vole is well known under the name of the water rat in most parts of Scotland. Yet, up to a comparatively recent date, much uncertainty prevailed both as to its true zoological place and its habits. Its structural relations may now be held fixed, but something still remains to be put on record as to its habits. Bell ("British Quadrupeds," p. 322) has shown good reasons for placing the water vole nearer the beavers (*Castoridæ*) than the mice (*Muridæ*), but it is doubtful if he has made out a case for the rejection of the family designation *Arvicolidæ*. The erroneous notion that it feeds on small fishes, and even on the young of water birds is still popular. This no doubt arises from its being mistaken for the brown or Norway rat (*Mus decumanus*), which takes readily to the water, and is destructive to ducklings. The water vole is a vegetable feeder, its food being commonly the succulent stems and roots of aquatic plants. It is thus to be regretted that Owen ("British Fossil Mammals and Birds," p. 204) should seem to countenance the notion that it feeds on animal substances. Referring to traces of its presence in some of the British bone caves, he says, "remains of the *Arvicola amphibia* (lower jaws) were found in the ossiferous cavern at Berry Head, Devon. Some of the bones from the cavernous fissures at Oreston show marks of nibbling, which may be referred more probably to the incisors of a small rodent than to the canines of a weasel."

Two specimens of the water vole have come into my hands recently, in circumstances suggestive of peculiarities of habit not hitherto noted. One of these is from Elie, Fife; the other from the garden of 14 Hope Terrace, Whitehouse, Edinburgh. The former was taken in a mole trap in the grass plot of a garden not far from the sea; the latter was trapped in a run in all respects similar to that of the mole, even to the throwing up of "hillocks" at short distances in the run. As the Elie specimen had nothing under ground on which to feed, except the rootlets of the grass, it must have been in the habit of leaving its run for the purpose of feeding. Macgillivray says he had seen the black variety feeding on grass (*Mem. Wernerian Nat. Hist. Soc.*, vol. vi., p. 428). The part of the garden frequented by the Hope Terrace specimen was planted with beet (*Beta vulgaris*). For some time before its capture, the gardener had noticed that many of the roots of the beet were being destroyed by some underground animal—the roots being gnawed or scooped out in most cases about an inch below the surface of the soil. The specimen was taken about the middle of October 1879. That it had been feeding on the beetroot was abundantly plain. An examination of the animal showed that the digestive and other organs, and even the body wall touched by them, were stained the bright red colour of beet juice. This still continues quite apparent, after the lapse of more than six months.

It is worthy of notice, that the water nearest the garden is the burn on the north side of Blackford Hill, Jordan Burn, about a quarter of a mile distant. Between it and the garden lie Blackford Road and Whitehouse Terrace, with their own wall-fenced gardens, and, farther to the south, other villas also bounded by high walls, especially on the north.

The object I have chiefly in view in this notice, is to call attention to the variety of the kinds of food taken readily by this form, to its habit of burrowing in runs like the mole, and its wandering far from the banks of streams, where alone it has hitherto been held to live.

Some years ago my attention was called to two young apple trees, in the Newington district of Edinburgh, which had begun to wither after showing full healthy blossom buds. Close by the surface of the soil the bark had the appearance of a ring of rottenness, and the only explanation thought of was the unsatisfactory one of the presence of some element on the surface of the ground injurious to the bark, or the ravage of some vegetable feeding grub. Since that time I have had clear proof that the field vole (*Arvicola agrestis*) attacks saplings, and gnaws the bark in a ring so regular, that one would be inclined to believe a saw had been passed round the stem by a skilful workman. May not the larger form attack trees in the same way? This question seems to me to be answered in the *Proceedings* of the Berwickshire Naturalists' Club, Vol. viii., p. 189, 1877. Mr Hardy reports instances, on the authority of Rev. J. F. Bigge, Stamfordham, and Mr Hughes of Middleton Hall, of damage done to young trees by the water vole. In both cases, however, the damage was done to plants in close proximity to what has ever been held the usual and natural habitats of the animal. "Last year," says Mr Bigge, "I planted some sycamore trees, about one inch in diameter, up a bank side here; and late in the autumn in taking hold of them to see that they were firm in the ground they came up. . . . About a month ago, I saw a willow tree, about eight feet high, lying on the ground by the side of the same bank; I pulled it across, and, to my surprise, I found that the roots had been gnawed in two; the roots were three inches in diameter. This, no doubt, was the work of the water rat. I then went to the sycamore trees, and found they had been cut by the same agents." At Middleton Hall they had cut through several young ornamental oaks planted near a pond much frequented by them. In this case, it is to be regretted, we are not informed whether it was the root or the stem which had been cut. These instances, however, again show that this form is not dependent for food on succulent water plants alone.

I have referred to the field vole. It has been long known that this comparatively small vole is very destructive to young trees, indeed periodically threatening the very existence of all young trees in whole forests. Bell quotes Jessie's "Gleanings" to illustrate this in connection with the havoc at one time made on the new plantations in the Forest of Dean. The vast numbers of these animals which swarmed over that district can be imagined, when it is remembered, that not fewer than 200,000 were known to have been killed in one season. The plants were eaten through just below the surface of the ground, in some instances; in others they were barked just above the surface. These facts indicate that gardens in the suburbs of cities are open to attack from both species of vole.

I do not know of any instance of the black variety (*Arvicola ater*, Macgillivray) ever having been met with at any considerable distance from the water. It is more rare than that now under notice, though it is described as abundant at Aberdeen (*Wernerian Memoirs*, loc. cit.), and Mr Gray, our Secretary, informs me it was very plentiful near Dunbar some years ago. I have seen it only twice; in both cases in localities, widely separated, in the neighbourhood of Oban. It may be stated in closing, that not long ago two related forms were captured on the same night in one trap in the vinery of the garden in which the water vole was taken. These were the long-tailed field mouse (*Mus sylvaticus*) and the common mouse (*M. musculus*).

XII. *On the Occurrence of the Night Heron* (Nycticorax griseus) *in Clackmannanshire, and the American Night Heron* (Nycticorax gardeni) *in Ayrshire.* By Robert Gray, Esq., F.R.S.E. (Specimens exhibited.)

(Read 18th February 1880.)

The European night heron (*Nycticorax griseus*) is so rarely met with in the British Islands that ornithologists have given but a very few records of its occurrence in Scotland. I have therefore thought its appearance last year in Clackmannanshire of sufficient interest to entitle it to a short notice in our *Proceedings.*

This species is not confined to Europe, but has a somewhat extensive geographical range, being found in Africa, India, China, and, according to some authors, Japan. Captain Shelley, in his "Birds of Egypt," says, it is abundant throughout Egypt, usually in flocks, frequenting palm trees; and the Rev. A. C. Smith, in his work on the "Attractions of the Nile and its Banks," speaks of flocks of night herons passing the day on the tops of the palms, whence they would take flight on being disturbed, and rise in the air to a great height, sailing round in circles, and returning again to the trees after the disturbance had subsided.

Mr J. H. Gurney, jun., in his "Rambles of a Naturalist in Egypt," published two years ago, but without a date, mentions having met single birds frequently, and having also seen it in flocks of about thirty upon the tops of the trees. Hasselquist, a pupil of the great Linnæus, states, in his "Travels in the Levant," that in Lower Egypt it builds its nest in the date trees and sycamores about Cairo, and that it feeds on the frogs, insects, and little fish, which it gets in the overflown fields. Hasselquist calls the bird the Egyptian kingfisher (*Alcedo Ægyptia*), and adds, "its voice resembles that of the raven."

A most interesting account of the breeding habits of this bird is given in the *Ibis* for 1861, by Mr Swinhoe, in a paper entitled, "Notes on the Ornithology of Hong-kong, Macao, and Canton." At page 53 of this Journal he says, with reference to *Nycticorax griseus*—the Cantonese name being "moon-shóó-haw"—"This is the sacred bird of the great Nonam Temple, Canton. The courtyard in front of this temple contains some venerable banyans, as well as a few towering cotton trees (*Bombax malabaricum*). On the higher branches of the former the small flat wicker nests of the night heron may be seen in all directions, some only a foot or so from others; and the croaking and flapping and fighting that goes on overhead bears some distant resemblance to the crowded deck of an emigrant steamer on first encountering a turbid sea. The granite slabs that form the pavement beneath these trees are so bedaubed with the droppings of old and young that permission to scrape them clean daily might prove a fine speculation for the guano collector. The birds, from the protection afforded them, were remarkably tame, and we could stand beneath the trees and watch them without their evincing the slightest fear. This was in April. Some might be seen sitting on their nests with their long legs bent under them, the weight of their bodies resting for the most part on the tarsal joint; others standing on single leg close by with shortened neck, the beak and head occasionally moving partially round as on a pivot; others flapped to and fro ruffling up their head-gear and occasionally sparring together. In their various movements the dark green black of the head and back, with the thin snow-white occipital streamers flowing and quivering over the latter, gave a quaint though not ungainly look to the birds. From some of the nests we heard a subdued chattering, like the cry of young, and it was to feed these hungry mouths that the parents were constantly leaving the trees to seek for food at all times of the day, while others were returning with supplies. As the sun set, however, they became more active. While I sat watching them from a neighbouring roof-top in the evening, numbers of them emerged from the leafy darkness, and one by one settled on the stark bare outstanding arms of the cotton tree. After resting for a little time like gaunt spectres on the tree-top, off they went, one after the other, with a '*Kwa*,' seldom more than two in the same direction. As darkness set in, many returned, and the noise and hubbub from the trees rose to a fearful pitch. Until night hid them from my view, I could see the old birds going and coming, and hear the clamour of the young. What kind of nocturnal slumbers the priests enjoyed in the temple below I never took the trouble to inquire, though I have little doubt that from constant use the noise of these *Croakers* has become quite essential to their good night's rest."

In the same paper Mr Swinhoe mentions that he found in this colony a bird in the second year's plumage, sitting upon a nest containing eggs narrower and of a darker blue than those of the mature bird, and that a bird in immature plumage was brought to him with the testes so developed as to afford actual proof that young birds were capable of breeding.

The crest feathers of this species vary in number from two to six, the usual number, however, being three. Mr E. Hearle Rodd, of Penzance, in a communication to the *Zoologist* (p. 4913), records the occurrence of a specimen in Cornwall with *ten* occipital plumes.

I am indebted to the Earl of Mar for an opportunity of submitting to the fellows of the Society for inspection the beautiful specimen now on the table. His Lordship could give no particulars as to the sex, contents of stomach, or even the precise date of the bird's occurrence. I, however, had previously recorded in one of my note-books that the bird was shot on the 23d May 1879, while perched on a tree on the banks of the Black Devon, adjoining Alloa Park policies, by one of his Lordship's gamekeepers.

Regarding the occurrence of the European night heron in other parts of Scotland, I may be allowed to refer to a volume on the "Birds of the West of Scotland," published in 1871. This may be regarded as the fifth recorded example during a period of about sixty years.

About two months ago I received a letter from Mr Oliver Eaton, Kilmarnock, in which he informed me that three years ago a young night heron was shot near that town by a young gunner, who had been in the habit of supplying him with specimens, but that having lost my address he had been prevented acquainting me sooner of the circumstance. I at once wrote to him, and begged him to forward the bird, which he has since done; and as it appears to me to possess the distinctive characters, so far as I can ascertain from the mutilated state of the specimen, of the American night heron (*Nycticorax gardeni*), I exhibit it as such to you this evening, reserving to myself, however, the alternative of pronouncing this form to be a mere variety of the *Nycticorax griseus*. I may here remark that it is now ascertained that the original description of the night heron (*Ardea gardeni*) was given by Gmelin from a young example of the American bird, and not its European representative, the *Nycticorax* *griseus* of Linnæus; and that Dr Elliot Coues, one of the most recent, and perhaps the most scientific, writers on American ornithology, considers it a variety, the bird appearing in his "Key to North American Birds" as *Nyctiardea grisea*, var. *nævia*. Spencer Baird says, the American night heron is larger than the European, although it is right to mention that Audubon states it is subject to considerable variation in size at all seasons of the year. Prince Bonaparte holds the two to be distinct, and Wilson, in contrasting them, does not conceal the fact of the European bird being the smallest. Another difference, however, is referred to by Bonaparte and Baird—namely, that the quill feathers of the American bird are tipped with white, which feature is not observed in the European. Wilson distinctly refers to the white spots on the tips of the quills, but from the scarcity of British killed specimens in immature plumage few have been described, and in these few descriptions no mention is made of the apical spots, except in the case of one killed in Aberdeenshire in January 1866, and referred to in the "Birds of the West of Scotland" (p. 282) as probably new to Britain.

The habits of the American night heron are very graphically pictured by Wilson and Audubon, but as the works of both authors are readily accessible, I need not take up the time of the meeting in referring to these. Wilson states that the bird is a night feeder, and that its food consists of fish, the stomachs of many birds which he opened being full of such prey, though he does not say what species of fish they prefer.

With regard to the probabilities of the American night heron being driven to the shores of Britain occasionally, I think the annual migrations of the species are quite sufficient to account for its erratic appearances. We know that young birds of the year assemble in large flocks at the close of the breeding season and proceed southwards to a great distance. We also know that in Bermuda, which lies about six hundred miles almost due east of the Southern States of America, flocks of these birds arrive in September and disappear in March, thus effecting a journey of twelve hundred miles across what must be to them a waste of turbulent waters, and during which they must occasionally be exposed to gales of wind of such force as to drive the birds far out of their reckoning. In such circumstances it is not difficult to imagine how these herons at times find their way to our shores.

Audubon mentions that his friend John Bachman informed him of having repeatedly seen great numbers of young night herons congregated near Charleston during winter, as if they had been arrested in the course of their migratory flight southwards; and Major Wedderburn, in his "Naturalist in Bermuda," alludes to the fact of all the night herons found in that island being birds of the first year. The route taken by the birds is from Cape Hatteras to the Bermudas, a distance, as I have already said, of six hundred miles.

The specimen now on the table, which I am sorry to say is of somewhat disreputable appearance, having been much injured by mice while in Mr Eaton's possession, was shot in February 1877, in a wood on Kameshill farm on the banks of Irvine Water. The lad who shot it states that he had seen it for some time previously haunting a mill lade at night near the same place.

This is the second night heron Mr Eaton has had through his hands, but I had not an opportunity of examining the first one: it is referred to in the "Birds of the West of Scotland," and was shot on the banks of Kilmarnock Water, about two hundred yards from the old Dean Castle.

If the apical spots on the quill feathers may be relied upon as a specific distinction, this bird clearly belongs to the American form, and must therefore be regarded as the second instance of the occurrence of the species in Britain, if not in Europe.

XIII. *Note on the Occurrence of the Pintail Duck* (Dafila acuta) *in the Outer Hebrides.* By Robert Gray, Esq., F.R.S.E.

(Read 21st April 1880.)

Some years ago, while engaged in preparing a few notes on the pintail duck as a British bird, I had considerable difficulty in determining, from the various sources of information at my command, its exact range throughout Scotland, many of the records of its occurrence in the Northern Counties especially being referable to the longtailed duck (*Harelda glacialis*), which bird had evidently been mistaken for the species in question. I came to the conclusion, however, that the pintail duck was a very much commoner bird in North Britain than previous records would have led us to believe, as I had reliable evidence to show that it had occurred in almost every county north of the Tweed. But in the Outer Hebrides I could only trace one instance of the species having been obtained, namely a specimen that was shot in the island of South Uist in the winter of 1869-70.* It is therefore with some satisfaction that I now exhibit a male bird which was obtained in January last from the island of North Uist. It was shot by Mr John Macdonald, factor for Sir John Orde of Kilmory, out of a flock of fourteen which rose from a marsh in the vicinity of his residence. I have no doubt that on closer attention being given to the ducks that fall to the gun of the sportsman in the Outer Hebrides, this bird will be found to be a somewhat regular winter visitant. Much depends, of course, upon the season, the direction of the wind, and other elements which are known to regulate the movements of migratory water-fowl; but, seeing that the species is very abundant over the whole of North America, and that it makes Iceland and the Faroe Islands a resting place for a short time in its flight southwards from Greenland, it does not seem inconsistent with what we know of its regular migrations to suppose that occasional flocks may be driven out of their direct line of flight, and forced to seek shelter on the north-western shores of Britain, or those of its outlying islands.

The pintail duck is a bird of very wide distribution. Its geographical range indeed is greater than that of any other duck that occurs in this country. It is abundant, as has been said, in North America, from west to east, and also in Canada and Newfoundland. It is likewise common in Central America. In Greenland it is well known, and in Iceland and the Faroes it is seen yearly during its migrations. It is

* Birds of the West of Scotland, p. 368.

distributed over the whole of Europe and a great part of Asia, being common in India, China, and Japan, besides various groups of islands, whose avi-fauna has only of late years been investigated. In Egypt, as mentioned by Captain Shelley and Mr J. H. Gurney, jun., it occurs in considerable flocks, and is regarded there as a bird of some worth in the market. In France and Holland great numbers are taken in decoys and sent to this country as table luxuries. Sir William Jardine states, that in the winter of 1842-43, quantities from these countries were sent to the markets of Edinburgh.*

Major W. Ross King appears to be the only writer who has thrown out a hint that the American pintail and the European are distinct; indeed, it would seem, from his statement in his "Sportsman in Canada," that the flesh of the one is superior to that of the other.† If there should be a difference in the plumage or other specific characters, it would be well to scrutinise carefully all the specimens that are procured from the Outer Hebrides, as these would be the most likely birds to show such differences, assuming, as we may fairly do, that they have come across the Atlantic from the New World.

XIV. *Notes on* Epomophorus comptus (*Allen.*), *one of the Large Fruit-Eating Bats; from Old Calabar, West Africa.* By JOHN ALEXANDER SMITH, Esq., M.D.

(Specimens of males, female, and young exhibited; also specimens of *Nycteris hispida* and *Nycteris grandis*, Insectivorous Bats from Old Calabar.)

The Rev. Alexander Robb, D.D., formerly missionary of the United Presbyterian Church, Old Calabar, and now their Theological Professor at Kingston, Jamaica; to whom I have been indebted for various interesting specimens of African natural history; sent me specimens of this bat some considerable time ago, and I have since been indebted for additional

* British Birds, part iv., p. 121.

† Sportsman and Naturalist in Canada, p. 207.

specimens to the late Dr W. C. Thomson, who was surgeon to the mission at Old Calabar, and latterly practised at Partick, near Glasgow. A stuffed specimen of a male of the same bat was also presented to the Museum of Science and Art here, a good many years ago, by Dr Archibald Hewan, a former mission surgeon at Old Calabar, now settled in London.

The specimens in my possession have been for a consider-

Epomophorus comptus, MALE (*a.*) (natural size).

able time preserved in spirits, and are now unfortunately, I regret to say, some of them in rather a bad state of preservation. They consist of an adult male (*a*), another adult male (*b*) slightly smaller in size; a female, and a young male which she was nursing when captured.

Comparing these specimens with the detailed account of the bat given in the recently published important "Catalogue of the Chiroptera in the Collection of the British Museum, 1878," by G. E. Dobson, M.A., M.B., A.M.D., I find Mr Dobson had been able to get a female only of this bat for examination, apparently the single specimen at that date in the collection of the British Museum. He was accordingly in some little doubt as to the presence of some of the specialities of the male. As these specimens of mine give an additional locality to this species along the extensive African coasts (the genus *Epomophorus*, indeed, being entirely confined to the great continent of Africa), I exhibit them to the Society, and shall also attempt to supplement, so far, Mr Dobson's excellent description, with some details of these different specimens, and a table of their various relative measurements.

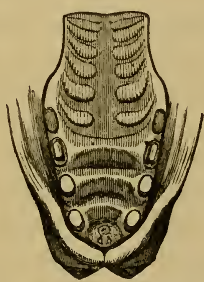
The *Head* of these bats is large and full, especially in the temporal region; the muzzle rather broad; nostrils lateral, about four-tenths of an inch apart, deep groove vertically between them with distinct mesial line. (*See* the annexed careful drawings of head of bat and palate, by Mr John Adam.)

Ear, oval in outline, slightly concave at outer surface below tip, measures about ·6 of an inch in male (*a*), in greatest breadth below this, and ·9 of an inch in length from base of outer margin. Small tuft of lighter coloured hair at base of inner margin.

Lips, smooth, large, and full. A warty projection from the inside of upper lip on each side fits in behind the first projecting ridge of palate, when the mouth is shut.

Palate.—The variety in the ridges of the palate in this genus, is a valuable, distinctive, and specific character, first pointed out, I believe, by Mr Dobson in his British Museum Catalogue of Chiroptera. They are very distinct and similar in all these specimens, and a carefully drawn figure of the palate of the male (*a*) is here given, the size of nature. This character, of course, can only be distinctly seen in a recent specimen or one preserved in spirits. The arrangement of ridges and lobes on the palate is like, in a general way, to that figured by Mr Dobson in his "Catalogue," the difference being probably due to his specimen being apparently a skin, afterwards preserved in spirits (?).

There is in front of palate a rounded portion, with central depression, immediately behind the incisor teeth. Behind this there are three distinct undivided ridges crossing the palate; the first ridge crosses the palate between the canine teeth; the second between the first præmolars; the third and last crosses the palate between the next præmolars. There is next a somewhat oval lobe, which projects partially across the palate from the inside of the next or molar teeth on each side; then there are other four similar, but rather smaller, distinct lobes, slightly toothed or fringed in front, which project from each side of the palate, and behind these one or two fringed lines; gradually diminishing in size towards the back part of the bony palate.



PALATE OF MALE (*a*), *Epomophorus comptus* (natural size).

Tongue large; has an oval patch of large *papillæ,* with divided extremities, projecting backwards, down its centre, towards the front, bordered with smaller *papillæ* all round, on the margins and point of the tongue.

The *Body.*—Chest large, broad, and full above; abdomen small, and tapering below.

The *Shoulder Glandular Pouches* are large and distinct in the male at lower and lateral parts of neck on each side; in male (*a*), measuring ·5 of an inch across, and there springs from them an abundance of lighter coloured hairs, forming a distinct epaulette, as it has been called (*see* figure).

The *Wings* are full and large; above, they spring from sides of body below shoulder (*see* figure); below, they rise in a straight line from distal extremity of first phalanx of second toe.

The *Interfemoral membrane* is small, and springs from base of tarsus, with a distinct projection or free margin, in breadth about ·3 of an inch; it widens upwards opposite the knee to ·65 of an inch, and is about ·5 of an inch in breadth, where it unites in the mesial line with that of the other side. It is covered with hair, longest above and below in mesial line.

Penis prominent.

Tail rudimentary.—A small papilla or point, about a tenth of an inch and a half in length, indicates the existence of a tail, below and free of the interfemoral membrane, in the male.

The *Fur* or *Hair* over body generally thick and short in character; of a yellowish brown on the shoulders and back, rather lighter on top of head and towards muzzle; sides of head and neck darker brown, as well as chest and flanks; wings brown, rather darker in front and on interfemoral membranes. As my specimens have all been kept in spirits, I take these details from the stuffed specimen already referred to in the Museum of Science and Art; but I cannot detect the peculiar parti-coloured hair on the "back of the neck and shoulders" which Mr T. Allen seems to consider a specific character in his description of this species of bat (*Proc. Acad. Nat. Scien., Philadelphia*, 1861). In this bat there seems no such peculiarity. The specimen has been for some time exposed in the case, and has probably suffered from the bleaching influence of the light; the front of the specimen is, however, next the light. There is also a large oval patch of light greyish or dirty-white colour over the front of the abdomen, the flanks being reddish brown. A small lighter coloured tuft of hair at anterior base of margin of ear, and from the shoulder glands a very conspicuous tuft of light or fawn-coloured hairs; the lighter colour also passes down the base of neck a little below the glandular opening.

Female Bat.—The female is smaller in size than the male. When killed, this specimen was nursing an immature bat, to be next referred to. The female has no glandular pouches on the sides of the neck as in the male, but simply rather deep depressions, without the light-coloured hair.

Palatal ridges as in the male.

The *ears* are relatively larger than in the male, being ·8 of an inch long and ·6 of an inch in greatest breadth.

The *mammæ* are situated on the lateral aspect of the thorax. The *nipples,* below and a little in front of the anterior line of the axilla, are large in this female, measuring ·35 of an inch in length by ·3 of an inch in breadth.

YOUNG OR IMMATURE MALE.—Palatal ridges similar to adult, but lobes less distinct behind. No distinct glandular pouches or depressions at sides of base of neck.

Tail.—A small point projecting about a tenth of an inch and a half-tenth at the junction of the thighs below the interfemoral membrane, shows the indication of a tail; this is more distinct in this female and young, as the hair has come off at that part.

Dentition of Male (*a*).—*Incisors,* $\frac{1 \cdot 1}{0 \cdot 0}$. Two central incisors of upper jaw only remain; in lower jaw all are wanting. *Canines,* $\frac{1 \cdot 1}{1 \cdot 1}$; (*Molars,* $\frac{3 \cdot 3}{5 \cdot 4}$); or *Præmolars,* $\frac{2 \cdot 2}{3 \cdot 3}$; and *Molars,* $\frac{1 \cdot 1}{2 \cdot 1}$.

In upper jaw, first præmolar on each side large and projecting; next, less so, but longer, and grooved on surface; and behind this, one rather smaller grooved molar. In lower jaw, first præmolar is very small; the second is large and projecting; the next, less so, but longer, and grooved on surface; and behind these are two molars, grooved and flattened, on right side of jaw; the last being less than half the size of the one before it. On the left side of jaw there is only one molar behind the three præmolars.

Dentition of Male (*b*).—*Incisors,* $\frac{2 \cdot 1}{2 \cdot 2}$. In upper jaw central incisors the largest, more apart than the lateral ones. Two on right side of mesial line; only central incisor present on left; they are unicuspidate. The lower incisors are two on each side, all well worn, and are at more equal distances from each other.

Canines, $\frac{1 \cdot 1}{1 \cdot 1}$; (*Molars,* $\frac{3 \cdot 3}{4 \cdot 4}$); or *Præmolars,* $\frac{2 \cdot 2}{3 \cdot 3}$; *Molars,* $\frac{1 \cdot 1}{1 \cdot 1}$.

In upper jaw the first præmolar is large, projecting, and pointed, as in male (*a*); the second is flatter, and grooved; and the third, or first true molar, is also flattened and grooved, or, like the former, well worn. In lower jaw the first is a small pointed unicuspidate tooth; the second, large, pointed, and unicuspidate; the third is longer, and flattened and grooved; and so is the last, or true molar, which is indeed more worn or flattened.

Dentition of Female.—Incisors, $\frac{2 \cdot 1}{1 \cdot 2}$. In upper jaw, central incisors a little apart, one lateral on right side nearer, unicuspidate; central largest. In under jaw central incisors closer together, rounded above, unicuspidate; one lateral present to left side, bicuspidate, smaller cusp to outside.

Canines, $\frac{1 \cdot 1}{1 \cdot 1}$; (*Molars,* $\frac{3 \cdot 3}{5 \cdot 4}$); or *Præmolars,* $\frac{2 \cdot 2}{3 \cdot 3}$; *Molars,* $\frac{1 \cdot 1}{2 \cdot 1}$. The first præmolar in upper jaw is conical and projecting, bicuspidate, small internal; second, shorter, also bicuspidate, with smaller internal cusp; the molar more flattened and grooved longitudinally along its surface. In lower jaw the first præmolar is very small and slightly bicuspidate, with small inner cusp; the second is large and pointed, with small inner cusp; the third is flattened or grooved, with small inner cusp; the first molar is grooved and flattened; and the last molar is smaller in size, flattened, and also grooved along centre. Last, absent on left side.

Dentition of Immature Male.—Incisors, $\frac{2 \cdot 2}{1 \cdot 1}$. In upper jaw, two on each side unicuspidate, lateral largest. In lower jaw only one on each side present, bicuspidate, smaller cusp external. *Canines,* $\frac{1 \cdot 1}{1 \cdot 1}$; (*Molars,* $\frac{2 \cdot 2}{4 \cdot 4}$); *Præmolars,* $\frac{2 \cdot 2}{3 \cdot 3}$; *Molars,* $\frac{0 \cdot 0}{1 \cdot 1}$. On right side of upper jaw a small pointed deciduous conical or milk tooth, behind canine; on left side this tooth also present, and another still smaller pointed milk tooth between first and second præmolar. In lower jaw there is also a small pointed deciduous milk tooth behind canine, and behind this the regular small first præmolar; behind it the two pointed præmolars; a third tooth or molar is seen behind, just coming above the gum. There is an additional small pointed conical deciduous or milk tooth also present between the second and third præmolars.

The perfect dentition of this species of bat may therefore be stated as follows: *Incisors,* $\frac{2 \cdot 2}{2 \cdot 2}$; *Canines,* $\frac{1 \cdot 1}{1 \cdot 1}$; (*Molars,* $\frac{3 \cdot 3}{5 \cdot 5}$); or *Præmolars,* $\frac{2 \cdot 2}{3 \cdot 3}$; *Molars,* $\frac{1 \cdot 1}{2 \cdot 2}$; $= \frac{12}{16} = 28$. Apparently in old individuals the two upper central incisors only remain, the others dropping out.

TABLE OF MEASUREMENTS.

Epomophorus comptus.	ADULT MALE (*a*).	ADULT MALE (*b*).	FEMALE.	IMMATURE MALE.
	Inches.	Inches.	Inches.	Inches.
Length—Head and body, . .	6·5	6·5	5·5	4·8
,, Head, . . .	2·25	2·2	1·8	1·4
,, Eye from tip of nostril,	1·0	1·0	0·8	0·6
,, Front of eye to front of ear, . . .	1·0	1·0	0·8	0·6
,, Ear, ...	0·9	0·9	0·8	0·8
,, Forearm, . . .	3·7	3·7	3·3	2·5
,, Thumb, metacarpal bone,	0·65	0·65	0·5	0·45
1st phalanx, .	0·85	0·85	0·7	0·6
2d, ph., claw, .	0·3	0·3	0·3	0·25
,, Second finger, metacarpal	2·1	2·05	1·8	1·2
1st phalanx, .	0·4	0·35	0·4	0·25
2d ph., . .	0·3	0·3	0·2	0·2
3d ph., claw, .	0·2	0·2	0·15	0·15
,, Third finger, metacarpal,	2·8	2·85	2·4	1·5
1st phalanx, .	1·7	1·65	1·55	0·8
2d ph., . .	2·4	2·5	2·1	1·4
,, Fourth finger, metacarpal	2·6	2·65	2·3	1·55
1st phalanx, .	1·3	1·3	1·2	0·8
2d ph., . .	1·45	1·45	1·3	0·9
,, Fifth finger, metacarpal,	2·7	2·8	2·3	1·6
1st phalanx, .	1·3	1·3	1·2	0·75
2d ph., . .	1·35	1·35	1·15	0·8
,, Tibia, . . .	1·6	1·6	1·35	1·0
,, Foot, ...	0·10	0·10	0·8	0·8
Expanse of wing membranes from extremities of 3d fingers,	24·0	24·5	23·0	16·25

In the allied genus *Pteropus* we have one very large species, found in the Indo-Malayan subregion designated *P. edulis,* I suppose, because used for food. These fruit-eating bats now described, are regularly sold for food in the markets of Old Calabar. The fingers and wing membranes being cut off, they are disembowelled, and trussed, two or three being placed together on wooden skewers, like larks, and they are then ready for sale and for being cooked. As long ago as 1869 three of these bats, trimmed and trussed together in this way, were given by Dr W. C. Thomson to the late Andrew Murray, Esq., and were presented by him to "The Food Collection" in the Bethnal Green Museum, London, where they may still be seen with the following title attached :—

"Frugivorous or Fruit-Eating Bats (*Sp. of Pteropus*).

"As brought into the market, ready trussed for cooking. From Old Calabar, West Africa. Presented in 1869 by Andrew Murray, Esq."

The late Andrew Murray, F.L.S., a well-known naturalist, was some years ago among the most zealous members of the Royal Physical Society here, and was formerly one of our presidents. He afterwards removed to London, where, I regret to say, he died not long ago, after doing much excellent work as a naturalist, preparing, among other works, one of the South Kensington Science Handbooks—that on "Economic Entomology," "*Aptera*," the first of an intended series of most valuable handbooks. Many years ago Mr Murray exhibited to this Society, also from Old Calabar, another fruit-eating bat, the singular *Hypsignathus monstrosus* of Allen, described in (*Proc. Acad. Nat. Sc., Phil.*) 1861; which he at that time was inclined to consider as an undescribed genus, and named it accordingly *Spyrocephalus labrosus.* Mr Dobson, however, includes the subgenus *Hypsignathus, H. monstrosus,* in his "Catalogue," but classes it simply as a very distinct species of *Epomophorus*, the *E. monstrosus.*

I also exhibit two other smaller but insectivorous bats from Old Calabar, the *Nycteris hispidus* and *Nycteris grandis.* These bats are found in other parts of West Africa, and I now include them among those found in Old Calabar.

It is interesting to notice the special adaptation of these different bats to their peculiar necessities.

The large fruit-eating bats, with little or no tail, and very small interfemoral membranes; nothing more being required than the simple powers of a straightforward flight to enable them to reach their food, growing on the various fruit-bearing trees, and, at the same time, the greatest possible freedom of motion of their unincumbered lower extremities, to enable them to clutch with facility the branches over the fruit. The dependant bat then seizing it between the thumb and forefinger of each wing, both being specially provided with claws, and so, with roughened tongue and sharp teeth, breaking up, sucking, and eating the fruit at its pleasure.

The other and smaller bats exhibited (*Nycteris*), being insect-feeding bats, have long tails and widely-expanded interfemoral and caudal membranes; enabling them thus to change and vary at will their most rapid flight in pursuit of their varied and active insect prey. It is stated, as Mr Dobson also tells us, that they can at pleasure curl upwards and inwards the long tail and its inclosing membranes, and thus add to their facilities in capturing, as in a trap, and seizing for food, the larger and more active insects.

It gives me much pleasure to send this series of Old Calabar bats to my friend Dr A. Günther, to be added to the valuable collections of the British Museum.

JOURNAL OF PROCEEDINGS.

SESSION CVIII.

Wednesday, 20th November 1878.—J. Falconer King, Esq., President, in the Chair.

The following gentlemen were elected as Ordinary Fellows of the Society: Edward Sang; James F. Mackay, W.S.; R. Vary Campbell, Advocate; Alexander Matheson.

An Opening Address was delivered by Mr King, the retiring President, on "The Early History of Chemistry."

Dr J. A. Smith exhibited several British Birds (see *Proceedings*, p. 33), also a large Skull of *Halichœrus gryphus* on which he made some remarks.

Wednesday, 18th December 1878.—Professor J. Duns, D.D., President, in the Chair.

The following Office-Bearers were elected:

Presidents—Ramsay H. Traquair, M.D.; Professor J. Duns, D.D.; Robert Etheridge, Jun.

Secretary—Robert Gray. *Assistant Secretary*—John Gibson.

Treasurer—E. W. Dallas. *Librarian*—Rev. J. Kennedy, M.A.

Councillors—David Grieve; John Hunter; T. W. Drinkwater; J. F. King; Professor Archibald Geikie; Charles Prentice; Thomas White, S.S.C.; James Anderson; John Murray; William Ferguson; Andrew Taylor; Principal Williams.

The following gentlemen were elected Ordinary Fellows of the Society: J. Hamilton Buchanan; Robert Kidston; and A. Macconochie.

The following communications were read:

1. "Notes on the Natural History of Islay." By R. Scot-Skirving.
2. "On Fossil Fishes from the Oil Shales of Edinburghshire and Linlithgowshire." By Dr R. H. Traquair.

Wednesday, 15th January 1879.—Mr D. Grieve, President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: John Sutherland Mackay, M.A., M.B., C.M.

The following communications were read:

1. "Note on the Migration of the Pied Wagtail (*Motacilla Yarrellii*)." By A. B. Herbert.
2. "Notes on some examples of Torrent Action near Blairgowrie and Edinburgh." By Andrew Taylor.
3. "Note on an Electrical Phenomenon exhibited by Geissler's Tubes." By W. C. Crawford, M.A.

Mr Crawford drew the attention of the Society to a phenomenon of

Geissler Tubes, which does not seem to have been noticed previously, and which may help to explain the nature of the discharge within exhausted tubes. If a wire from one pole of an induction coil be wound round a Geissler Tube—a narrow part of the tube is to be preferred—on setting the coil in operation the tube appears luminous. The wire is in connection with one pole only; if the circuit is completed by attaching it to the other pole the luminosity will not make its appearance. The tube may be placed at a considerable distance from the coil, to avoid any effect arising from induction of the coil itself. The explanation of the phenomenon seems to be that the wire becomes statically charged, and the luminosity arises from induction caused thereby, there being no current through the tube.

4. "Exhibition of a Maigre (*Sciæna aquila*) caught in the Firth of Forth, July 1878, and measuring three feet two inches in length; and of a Garfish (*Belone vulgaris*) also caught in the Firth of Forth, and measuring 32½ inches in length." By JOHN GIBSON.

Wednesday, 19th February 1879.—Professor DUNS, President, in the Chair.

The following gentleman was elected a Corresponding Fellow of the Society: Charles Lapworth, F.G.S., St Andrews.

The following communications were read:

1. "On Splenic Fever, with a Short History of the *Bacillas anthracis.*" By Principal W. WILLIAMS.
2. "On the Old Red Sandstone of Shetland." By B. N. PEACH, F.G.S., and JOHN HORNE, F.G.S., H.M. Geological Survey.
3. "On Spawning Season of *Hyas araneus.*" By ROBERT KIDSTON.
4. "On Ramose Form of *Plantago maritima.*" By ROBERT KIDSTON.
5. Professor DUNS exhibited, with remarks (1.) A specimen of *Vesicularia spinosa*, showing abnormal branching, and adventitious membranes at the forks of the branches; (2.) Specimens of *Fucus Mackii* from Orkney —a new locality for this seaweed.

Wednesday, 19th March 1879.—Dr R. H. TRAQUAIR, President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Johnson Symington, M.B., C.M., F.R.C.S.E.; Henry Aubrey Husband, M.B., C.M., F.R.C.S.E.; Alfred Daniell, M.A., B.Sc.

The following communications were read:

1. "On the Influence of the Recent Storm on Bird Life." By Professor J. DUNS, D.D.
2. "Notes on a Visit to the Baths of Mont Dore." By W. T. BLACK.
3. "Notes on the Occurrence of the Stockdove (*Columba œnas*) in Berwickshire." By ROBERT GRAY.
4. "List of the Birds which have been observed in the Parish of Callander." By J. HAMILTON BUCHANAN.
5. "Note on the Occurrence of the Starry Ray (*Raia radiata*) in the Firth of Forth." (Specimens exhibited.) By C. W. PEACH.
6. "Notes on the White-winged Crossbill (*Loxia leucoptera*) and Grasshopper Warbler (*Calamodyta locustella*)." By WILLIAM EVANS. (Communicated by the Secretary.)

7. Dr TRAQUAIR exhibited, with remarks, the following birds:
   (1.) Great Crested Grebe (*Podiceps cristatus*) from Orkney.
   (2.) Egyptian Goose (*Anser Ægyptiacus*), shot on the Forth, 7th March.
   (3.) Gadwall (*Anas strepera*), shot near Kincardine-on-Forth, 12th March.
8. Dr J. A. SMITH exhibited two specimens of the Great Crested Grebe (*Podiceps cristatus*) from North Berwick and Portobello, killed in the last week of January; also a Sclavonian Grebe (*Podiceps cornutus*) from Dirleton.
9. The Secretary exhibited two specimens of the Shoveller (*Anas clypeata*), male and female; one shot on 6th May 1878, and the other five days later, at Scrimerston, near Jedburgh, by Mr Elliot. The ovary of the female had contained an egg almost ready for extrusion.

Wednesday, 16*th April* 1879.—Professor DUNS, President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: George Leslie.

The following communications were read:

1. "On Fossil Fishes from the Lower Coal Measures of Derbyshire." By Dr R. H. TRAQUAIR.
2. "Note on the Specimen of *Actinia mesembryanthemum* which belonged to the late Dr M'Bain." By JOHN SADLER.
3. "On an Abnormal Form of *Euplectella aspergillum*." By GEORGE LESLIE.
4. "Note on the Harvest Mouse (*Mus messorius*)." (Living specimens exhibited.) By A. B. HERBERT.
5. "Note on the Nesting of the Woodcock (*Scolopax rusticola*) near Penicuik, Midlothian." By WILLIAM EVANS. (Communicated by the Secretary.)
6. The Secretary exhibited, with remarks, a specimen of the Hoopoe (*Upupa epops*), shot near Elie, Fifeshire, on 8th April; also a specimen of the Red-throated Diver (*Colymbus septentrionalis*), killed near Queensferry, 31st March, the bird being in full summer plumage.

Wednesday, 29*th May* 1879.—Dr R. H. TRAQUAIR, President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: William Melven.

The following communications were read:

1. "On the 'Tabulate Corals' of the Palæozoic Period." By Professor H. A. NICHOLSON, F.G.S., etc.
2. "Note on the recent Destruction of Fish in Linlithgow Loch." By R. SCOT-SKIRVING.
3. "Evidence of the Predatory Habits of the Larger *Palæoniscidæ*." By Dr R. H. TRAQUAIR.
4. "On the Genus *Nemagraptus* (*Nematolites*) of Emmons. By CHARLES LAPWORTH, F.G.S.
5. "On the Nesting of the Common Pochard (*Fuligula ferina*) in Perthshire." (Eggs exhibited.) By J. HAMILTON BUCHANAN.
6. Exhibition of the following birds by the Secretary:
   (1.) Black-throated Diver (*Colymbus arcticus*), taken in a pike net in Loch Ard on 14th May, the bird—a male—being in full summer plumage.
   (2.) Iceland Gull (*Larus Islandicus*), shot at Port Seaton, Haddingtonshire, 8th May.

SESSION CIX.

Wednesday, 19th November 1879.—Dr R. H. Traquair, President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: D'Arcy W. Thompson; W. Abbott Herdman; and D. Noël Paton.

An Opening Address was delivered by Dr Traquair, the retiring President, on "The History of Scottish Fossil Ichthyology."

Wednesday, 17th December 1879.—Professor Duns, President, in the Chair.

The following Office-Bearers were elected:

Presidents—Professor J. Duns, D.D.; Robert Etheridge, jun., F.G.S.; Professor Archibald Geikie, F.R.S.

Secretary—Robert Gray. *Assistant Secretary*—John Gibson.

Treasurer—Charles Prentice, C.A.

Librarian—Rev. J. Kennedy, M.A., B.D.

Councillors—Thomas Whyte, S.S.C.; James Anderson; John Murray; William Ferguson; Andrew Taylor; Principal Williams; J. F. King; Alexander Galletly; George Leslie; A. B. Herbert; R. H. Traquair.

The following gentlemen were elected Ordinary Fellows of the Society: D. J. Balfour Kirke; Rufus D. Pullar; Henry Coates; Earnest Ady.

The following communications were read:

1. "On the Occurrence of the Pomarine Skua (*Lestris pomarinus*) in the East of Scotland in the Autumn of the present Year." (Specimens were exhibited.) By Dr R. H. Traquair.
2. "On the Occurrence of the Greater Shearwater (*Puffinus major*) at North Berwick." (Specimen exhibited.) By Dr R. H. Traquair.
3. "On the Algæ of the Firth of Forth." By G. W. M. Traill. Communicated by Professor Duns. (Specimens new to the locality were exhibited.)
4. "On the Distribution of the Goosander (*Mergus merganser*) in Scotland during the Breeding Season." By J. H. Buchanan.
5. "Obituary Notice of the late Dr M'Bain." By David Grieve.

Wednesday, 21st January 1880.—Dr Traquair in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Thomas Bond Sprague, M.A.; William Drummond, S.S.C.; James Drummond, C.A.

The following communications were read:

1. Mr Edward Sang demonstrated experimentally the contraction of water from the freezing point to its maximum density, and the expansion thereafter.

This experiment was exhibited not as containing anything novel, but only as showing in a very striking way the peculiar law according to which the density of water changes with variations in temperature.

A number of variously coloured closed glass balls, adjusted to different specific gravities had been placed in a tall bottle ; this had then been completely filled with hot distilled water, and the carefully ground stopper luted down with paraffin. The vessel was thus entirely free of air.

Having been exposed to the cold of the evening until the water had just begun to freeze, the bottle was placed on the table. A considerable number of the balls were at the bottom, the greater number at the top. As the water was slowly warmed by the air of the room, it contracted while the glass of the balls expanded, as was shown by the ascent, one after another, of the heavy balls, until the last of them—which was barely lighter than water at its greatest density—had gone up.

On being still further warmed, the expansion of the water in excess of that of glass was shown by the subsequent descent of the balls in inverse order.

It was mentioned that, if in repose, the water may be cooled considerably below the usual freezing point, several of the lighter balls then descending. When the freezing begins, the spikes of ice shoot through the fluid, entangling these balls, which as the ice thaws ascend rapidly. It is thus shown, that water continues to expand on being cooled below the zero of the thermometer.

2. "On the Marine Invertebrate Fauna of Lamlash Bay." By WILLIAM ABBOTT HERDMAN, B.Sc.

3. "Note on the Flight of Wild Geese, etc., seen near Edinburgh, and on the migratory flights of birds as observed in the Dardanelles." By D. CHRISTISON, M.D. (Communicated by Dr J. A. Smith.)

Dr CHRISTISON writes as follows: "About the 18th of December, when driving in an open carriage, and nearly opposite the fourth milestone on the Queensferry Road, about four o'clock in the afternoon, my brother drew my attention to a flight of birds overhead, numbering about forty, in a perfectly regular wedge formation ; one side of the wedge, however, being much longer than the other and giving off a branch, which again gave off a subsidiary branch.

"They were flying in the direction of Loch Leven, and I thought at the time that they were migrating northwards, as the weather then was much milder in Scotland than in England or the Continent, as indeed it continued to be almost to the present time.

"But on Christmas Day at the same spot and hour, and flying in the same direction, we saw a very much larger flight which must have numbered several hundreds if not a thousand birds. We first noticed a body very much the same in numbers and formation as that of the previous occasion ; then after some interval two or three groups numbering from two to half-a-dozen ; then another wedge-shaped body of about thirty ; and lastly a very long string of them, which my brother and I estimated to be about a quarter of a mile long : certainly not less. Unfortunately, not anticipating this large flight at the end, we had driven on so far that we could not make out the precise formation. Seeing it so much from the side, it resembled a long and somewhat irregular line.

"The occurrence of this second flight, at precisely the same spot and time in the evening as in the instances a week previously, inclined me to the view that these were not instances of migration, but that the birds were merely flying home in the evening to Loch Leven from feeding excursions in the wild country about the Pentlands. I am not aware, however, whether it is the habit of geese to fly such long distances for feeding purposes. It is so far in favour of this view, that my brother saw at Loch Leven, on the 2d May last year, two flocks of wild geese numbering about a thousand, which, he was informed by the boatman, had been there all winter. Such at least is his recollection.

"These flights brought to my recollection the great annual migrations of birds which I witnessed in 1855-56, when stationed at Renkioi Hospital, on the Dardanelles. The hospital was situated on a flat triangle of low ground projecting into the Dardanelles from the mountainous southern shore, and it so happened that the course taken by the birds was right over this promontory. The southward flight took place in October and lasted almost the whole month; nearly every day immense numbers passed, generally at a great height, and always in the wedge formation, but often in such multitudes as to resemble a vast network covering the sky for miles. There was a great difference of opinion at the hospital as to what these birds were. By aid of a telescope I concluded that some of the armies were composed of storks, some of geese. The latter when they came overhead sometimes broke up their array and flew round and round in great confusion, cackling or rather trumpeting loudly all the time, and then gradually got into order and passed on. Possibly they had been accustomed to halt at this spot of land, and were amazed to find it occupied by man. Previous to our arrival there was not a house on the place. Some of us thought that they mistook the shining tin roofs of our hospital huts for water. Some of the armies kept up this peculiar trumpeting without breaking up or halting in their march. The storks of course would be silent, as they have no voice. The only sound I ever heard them make is when nestling in the Turkish villages. They then are in the habit of bending the neck over the back till the beak nearly lies along the back, and in that strange position open and shut the beak rapidly several times in succession, producing a merely mechanical noise, from which the Turks very appropriately call them 'klek klek.'

"It is worthy of remark that we had fine warm weather for a month after the last of those mighty armies passed.

"The return northward migration took place towards the end of March and in April.

"Although the general formation was kept up, it was easy to see that the individuals were continually changing their relative position; the leader, in fact, seemed to be changed every few seconds. These mighty migrations, continuing for a month together with little interruption, were certainly among the most wonderful sights of animated nature conceivable, and I shall be glad if this account of them has interested you as a student of birds."

On 11th January, Dr CHRISTISON again writes: "With regard to my observations on the flocks of geese, I must make one correction on my letter. On passing the spot again to-day and consulting the map, my brother and I concur in thinking that the direction of their flight would take the geese considerably to the east of Loch Leven. This is a pity, for it is somewhat tempting to find that a line drawn from Loch Leven over the fourth milestone hits directly on St Mary's Loch! It would be so convenient to conclude that the birds were flying from one loch to the other, but facts are unfavourable.

"Probably it is only because we have not eyes in the top of our heads that we do not more often see flights of birds at a considerable height, particularly towards evening when wending their way homeward to roost. As I drive a good deal into the country in an open carriage, this defect is partially supplied by the half raised position of the head and the eyes being freed from the care of looking after the legs, as in walking they are constantly obliged to do.

"Thus I became aware the other day of an immense flight of plovers which would certainly have escaped the vision of a walker. They were at a great height, about five miles out the Glasgow Road, and were flying westward in what in military language might be called a line of ten or twelve battalions, quite separate from each other, forming irregular masses, some of which sometimes circled round for a little and then resumed their westward course. They must have numbered many thousand birds in all. It is difficult to see any reason for such enormous gatherings. They were so high that I could only guess them to be plovers from the faintly seen motion of the wings.

"The great plain there seems favourable to monstrous public meetings of birds. Early in the winter I saw five of the very large fields in that quarter covered with rooks and gulls, particularly the latter. My brother, our coachman, and myself agreed that we had never seen such a multitude."

4. "On the Occurrence of a Small Naticiform Gasteropod, showing Colour Bands, in the Cement Stone Group of Fifeshire." By R. Etheridge, jun.

Wednesday, 18th February 1880.—Prof. Arch. Geikie, F.R.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: L. L. Rowland, M.A., M.D.; William Laughton; John Alex. Robertson, C.A.; A. N. Denton, M.D.

The following communications were read:

1. "The 'Pitchstone' of Eskdale—a Geological Retrospect and Comparison of Geological Methods." By Professor A. Geikie, F.R.S.
2. "On the Occurrence of the Night Heron (*Nycticorax griseus*) in Clackmannanshire, and the American Night Heron (*Nycticorax Gardeni*) in Ayrshire." By Robert Gray. (Specimens exhibited.)
3. "Report on a Collection of Fossils from the Bowen River Coalfield and the Limestone of the Fanning River, North Queensland." By Robert Etheridge, jun.

Wednesday, 17th March 1880.—Professor J. Duns, President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: James Hunter, F.R.C.S.E.; James T. Carter; George Muirhead; William Allan Carter, Assoc.M.Inst.C.E.; Henry Leck; George H. Johnston; Duncan Shaw; Arthur Cowell Stark; Hunter Jackson Barron.

The following communications were read:

1. "On some of Plateau's Experiments on Surface Tension." By Alfred Daniell, M.A., B.Sc.
2. "Notes on the Winter Birds of Islay." By Robert Scot-Skirving.
3. The Secretary exhibited, with remarks, a hybrid Pheasant, between *Phasianus pictus* and *Phasianus amherstia*, which had been reared near Linlithgow.

Wednesday, 21st April 1880.—Prof. ARCHIBALD GEIKIE, F.R.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: William Evans, Actuary; W. H. Caldwell; William Gibson Bloxsom, Actuary; Walter Campbell, L.D.S.Eng.; John A. Johnston.

The following communications were read:

1. "On an Undescribed Variety of Amethyst." By Prof. J. DUNS, D.D.
2. "On the Habits of the Water Vole (*Arvicola amphibia*)." By Professor J. DUNS, D.D.
3. "The Old Red Sandstone of Orkney." By B. N. PEACH, F.G.S., and JOHN HORNE, F.G.S.
4. "Note on the Occurrence of the Pintail Duck (*Dafila acuta*) in the Outer Hebrides." (Specimen exhibited.) By the Secretary.
5. "Notes on *Epomophorus comptus* (Allen.), one of the Large Fruit-Eating Bats; from Old Calabar, West Africa." By JOHN ALEX. SMITH, M.D. Dr SMITH exhibited specimens of males, female, and young; also specimens of *Nycteris hispida* and *Nycteris grandis* from Old Calabar.
6. "Early Chapters in the History of the Squirrel in Great Britain." By J. A. HARVIE-BROWN, F.Z.S.
7. The Secretary exhibited, with remarks, a male specimen of the Marten Cat (*Martes foina*), killed at Balquhidder on April 2.

DONATIONS AND ADDITIONS

TO

LIBRARY OF THE ROYAL PHYSICAL SOCIETY

DURING SESSIONS 1878-80.

(*a.*) U.S. Geological Survey of the Territories, Vol. 7; Tertiary Flora, by Lesquereux; (*b.*) Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States; (*c.*) Bulletin, Vol. 4, No. 2. *From the U.S. Department of the Interior, per F. V. Hayden.*

(*a.*) Transactions of the Zoological Society of London, Vol. 10, Parts 6-12; (*b.*) Proceedings for 1878, Parts 1-4; and for 1879, Parts 2, 3. *From the Society.*

Proceedings of the Royal Society [of London], Vols. 27-29; Vol. 30, Nos. 200, 201. *From the Society.*

Journal of the Linnean Society—(*a.*) Zoology, Vol. 14, Nos. 74-80; Vol. 15, No. 81; (*b.*) Botany, Vol. 17, Nos. 96-103. *From the Society.*

Proceedings of the Academy of Natural Sciences of Philadelphia for 1877, Parts 1-3; 1878, Parts 1-3. *From the Academy.*

Transactions of the Manchester Geological Society, Vol. 14, Parts 18-22; Vol. 15, Parts 1-11. *From the Society.*

Bollettino della Società Adriatica di Scienze Naturali in Trieste, Vol. 3, No. 3; Vol. 4, Nos. 1, 2; Vol. 5, No. 1. *From the Society.*

Proceedings of the Berwickshire Naturalists' Club, Vol. 8, Nos. 2, 3. *From the Club.*

Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger, 1876, No. 3; 1877, No. 3; 1878, Nos. 1, 2; 1879, Nos. 1, 2. *From the Society.*

(*a.*) Bulletin of the U.S. Geological and Geographical Survey of the Territories, Vol. 4, Nos. 1-4; Vol. 5, Nos. 1-3; (*b.*) Jackson's Descriptive Catalogue of the Photographs of the North American Indians (being No. 9 of the Miscellaneous publications). *From the U.S. Department of the Interior, Washington.*

Proceedings of the Geologists' Association [of London], Vol. 5, Nos. 5-8; Vol. 6, Nos. 1-4. *From the Association.*

Transactions of the Watford Natural History Society and Hertfordshire Field Club, Vol. 1, Parts 4-9. *From the Society.*

Journal of the Cincinnati Society of Natural History, Vol. 1, Part 1. *From the Society.*

Proceedings of the Boston Society of Natural History, Vol. 19, Parts 1, 2. *From the Society.*

Proceedings of the Philosophical Society of Glasgow, Vol. 11, Nos. 1, 2. *From the Society.*

Proceedings of the Californian Society of Sciences, Vol. 6 (for 1875) and Vol. 7, Part 1 (1876). *From the Society.*

Canadian Journal of Science, Literature, etc., Vol. 15 (1878); New Series, Vol. 1, Part 1. *From the Canadian Institute.*

Brady's Monograph of the Free and Semi-Parasitic Copepoda of the British Islands, Vol. 1 (Ray Society). *Subscription Copy.*

Verhandlungen der Kais. Königlichen Zool.-Botanischen Gesellschaft in Wien, Band 27. *From the Society.*

Natuurkundig Tijdschrift voor Nederlandsch-Indië: uitgegeven door de Koninglijke Natuurkundige Vereeniging, Deelen 35–38. *From the Society.*

(*a.*) Journal and Proceedings of the Royal Society of New South Wales, Vols. 11, 12; (*b.*) Railways of New South Wales—Report on their Construction and Working during 1876; (*c.*) Annual Report of the Department of Mines of New South Wales for 1877. *From the Royal Society of New South Wales, Sydney.*

(*a.*) Map of the Upper Geyser Basin on the Upper Madison River; (*b.*) Map of the Lower Geyser on the Upper Madison River; (*c.*) Map of the Sources of the Snake River. *From the U.S. Department of the Interior.*

(*a.*) Boletin del Ministerio de Fomento de la República Mexicana, Tomo 3, Núm. 41-83; Tomo 4, Núm. 1-150; (*b.*) Determinacion de la longitud del Péndulo de Segundos y de la gravedad en México, 1878-79. *From the Ministry of the Interior, Mexico.*

Reports of the Medical and Surgical Registrars of the Middlesex Hospital for 1876-77. *From the Directors.*

(*a.*) Bulletins de l'Académie royale des sciences de Belgique, Deuxième Série, Tomes 41-45; (*b.*) Annuaire de 1877-78. *From the Academy.*

Jahresbericht XVI. (1878-79) des Vereins für Erdkunde zu Dresden; (*a.*) Wissenschaftlicher Theil; (*b.*) Geschäftlicher Theil. *From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool, Session 67th (1877-78). *From the Society.*

(*a.*) Transactions and Proceedings of the Botanical Society [of Edinburgh], Vol. 13, Parts 2, 3; (*b.*) Report concerning the Royal Botanic Garden of Edinburgh, by the Regius Keeper. *From the Society.*

(*a.*) Transactions of the Royal Society of Edinburgh, Vol. 28, Parts 2, 3; Vol. 29, Part 1; and Proceedings for 1877-79. *From the Society.*

Acta Horti Petropolitani, Tomus 5, Fasc. 2; Tomus 6, Fasc. 1. *From the Imperial Botanic Garden, St Petersburg.*

Buckton's British Aphides, Vol. 2. *Ray Society publication for* 1877.

Memoires de la Société Nationale des Science Naturelles de Cherbourg, Tome 21 (1878). *From the Society.*

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, Vol. 5, Part 1 (1878-79). *From the Institute.*

Transactions of the Edinburgh Geological Society for 1879. *From the Society.*

Medical and Surgical Reports of the London Hospital for 1877. *From the Registrar.*

University of Durham School of Medicine; Prospectus for 1879-80. *From the Secretary of the University.*

Wärme und Elastizität. Von Dr Hermann Scheffler. *From the Author.*

Estudio del Terremoto de 17 de Mayo de 1879. Por Mariano Bárcena. *From the Author.*

Annales de l'Observatoire de Moscou, Vol. 6, Livraison 1, 2. *From the University of Moscow.*

Videnskabelige Meddelser fra Naturhistorisk Forening i Kjöbenhavn for Aaret 1877-78-79, No. 1. *From the Society.*

Medical Inquirer—new series, Vol. 4, Nos. 5-7. *From the Editor.*

Transactions of the Royal Scottish Society of Arts, Vol. 9, Part 5, and Vol. 10, Parts 1, 2. *From the Society.*

Report on Temperatures during the Winter of 1878-79 at the Royal Botanic Garden, Edinburgh, by JOHN SADLER, Esq. *From the Author.*

Annual Report of the Smithsonian Institution for 1877. *From the Institution.*

(*a.*) U.S. Geological Survey of the Territories: Coues on the Birds of the Colorado Valley, Part 1 (Miscellaneous publications, Vol. 11); (*b.*) Tenth Annual Report of the U.S. Geological and Geographical Survey, 1878, by F. V. HAYDEN. *From the Department of the Interior, Washington, U.S.*

(*a.*) The Capercailzie in Scotland; (*b.*) The Shiant Islands and their Bird Life. By J. A. HARVIE-BROWN, Esq. *From the Author.*

Fleming's Lithology of Edinburgh: with Memoir by Professor DUNS, D.D. *From Professor Duns.*

On the Structure and Affinities of the "Tabulate Corals" of the Palæozoic period. By H. ALLEYNE NICHOLSON, M.D. *From the Author.*

LIST OF FELLOWS.

ORDINARY.

Date of Election.
1879. Ady, Ernest, Mason College, Birmingham.
1856. Anderson, John, M.D., F.R.S., Director of the Indian Museum, Calcutta.
1872. Anderson, James, 17 Lonsdale Terrace.
1856. Baillie, Rev. Zerub.
1846. Balfour, Professor J. H., Inverleith House.
1849. Barbour, G. F., Esq. of Bonskeid, 11 George Square.
1880. Barron, H. J., Tavistock Square, London.
1877. Barry, J. W., M.D., B.Sc., 23 Duke Street.
1878. Beattie, William Hamilton, 68 George Street.
1875. Bennie, James, Geological Survey Office, India Buildings.
1880. Bird, George, 12 Warrender Park Terrace.
1873. Black, W. T., 2 George Square.
1880. Bloxsom, William Gibson, 10 Napier Road.
1863. Brett, Alfred, Veterinary College, Clyde Street.
1878. Brown, A. B., 1 Roseberry Crescent.
1860. Brown, Robert, M.A., Ph.D., F.L.S., 26 Guildford Road, Albert Sq., London, S.W.
1852. Brown, William, F.R.C.S.E., 25 Dublin Street.
1876. Bruce, W. P., 18 Athole Crescent.
1878. Buchanan, John Hamilton, 32 Stafford Street.
1880. Caldwell, W. H., Caius College, Cambridge.
1878. Cameron, John, S.S.C., 63 George Street.
1878. Campbell, R. Vary, 37 Moray Place.
1880. Campbell, Walter, 27 South Tay Street, Dundee.
1876. Carmichael, T. D. Gibson, Castlecraig, Dolphinton.
1877. Carmichael, Sir W. H. Gibson, Bart., Castlecraig, Dolphinton.
1858. Carruthers, William, F.R.S., British Museum, London.
1880. Carter, James T., Duddingston.
1880. Carter, W. A., C.E., 5 St Andrew Square.
1873. Clark, G. B., 5 Blackwood Crescent.
1878. Clark, Robert, F.R.S.E., 7 Learmonth Terrace.
1857. Cleland, Professor J., M.D., University of Glasgow.
1879. Coates, Henry, Bridgend, Perth.
1853. Cobbold, Spencer, M.D., F.R.S., London.
1878. Cornillon, Hypolite W., S.S.C., 67 George Street.
1874. Crawford, W. C., 1 North Kelvinside Terrace, Glasgow.
1850. Crole, David, 3 Ramsay Gardens.
1877. Dalgleish, John J., 8 Athole Crescent.
1879. Daniell, Alfred, M.A., Gillespie Crescent.
1869. Davidson, David C., Kingsknowes, Slateford.
1869. Davidson, James A., Kingsknowes, Slateford.
1880. Denton, A., M.D., San Marcus, Hays Co., Texas, U.S.
1876. Drinkwater, T. W., F.R.C.P.Ed., Laboratory, Marshall Street.
1880. Drummond, James, C.A., 27 Ann Street.
1880. Drummond, William, S.S.C., 4 Learmonth Terrace.
1864. Duns, Rev. Professor, D.D., F.R.S.E., 14 Greenhill Place.
1869. Durham, William, F.R.S.E., Portobello.
1863. Edmonston, Alex., 5 Rosendale Villas, Norwood Road, Herne Hill, London.
1880. Erskine, William, Oaklands, Trinity Road.
1877. Etheridge, Robert, jun., F.G.S., British Museum, London, *President.*
1880. Evans, William, Actuary, 2 Merchiston Bank Terrace.
1874. Ferguson, William, Esq. of Kinmundy, F.R.S.E., 21 Manor Place.
Galbraith, E. L., Pitlochrie.
Gall, Rev. J., 47 Forrest Road.
1867. Gallie, J. B., 24 Mayfield Terrace.
1877. Galletly, Alexander, Museum of Science and Art.
1858. Geddes, John, 9 Melville Crescent.
1878. Geikie, Professor Archibald, F.R.S., Edinburgh University, *President.*
1877. Gibb, Philip B., M.A., 14 Picardy Place.
1869. Gibson, John, Museum of Science and Art, *Assistant Secretary.*

Date of
Election.

1875. Goldie, John, Register House.
1878. Gray, Archibald, 13 Inverleith Row.
1878. Gray, Joseph T., M.A., 14 Findhorn Place.
1874. Gray, Robert, F.R.S.E., 13 Inverleith Row, *Secretary.*
1828. Grieve, David, F.R.S.E., Hobart House, Dalkeith.
1877. Grieve, Somerville, Salisbury View, Dalkeith Road.
1871. Herbert, A. B., 19 Strathearn Road.
1879. Herdman, W. A., D.Sc., St Bernard's, Bruntsfield Crescent.
1858. Home, D. Milne, Esq. of Milne Graden, LL.D., F.R.S.E., York Place.
1878. Horne, John, F.G.S., Geological Survey Office, Edinburgh.
1863. Hossack, B. H., Kingscroft, Stanley Road, Edinburgh.
1880. Hunter, James, F.R.S.E., Minto House, Chambers Street.
1874. Hunter, John, Minto House Medical School, Chambers Street.
1878. Hunter, J. R. S., LL.D., Daleville, Braidwood, Lanarkshire.
1850. Jenner, Charles, 47 Princes Street.
1877. Joass, C. Edward, 1 Rankeillor Street.
1880. Johnston, J. A., 4 Hamburgh Place, Leith.
1880. Johnston, J. H., 9 Claremont Crescent.
1858. Keir, Patrick Small, Esq., Kindrogan.
1869. Kennedy, Rev. J., M.A., B.D., 17 Melville Terrace.
1878. Kidston, Robert, Victoria Place, Stirling.
Kilpatrick, H. Grainger, 104 South Bridge.
1869. King, J. Falconer, F.C.S., Minto House Medical School, Chambers Street.
1879. Kirke, D. J. B., Greenmount, Burntisland.
1858. Laidley, J. W., Esq. of Seacliff, 2 Moray Place.
1880. Laughton, William, Kinleith Paper Works, Currie.
1868. Lawson, Robert.
1880. Leck, Henry, Hollybush, Ayr.
1858. Lees, George, LL.D.
1879. Leslie, George, 3 William Street.
1861. Logan, Alexander, Register House.
1850. Logan, R. F., Spylaw House, Colinton.
1871. Lorrain, J. G., 34 St Andrew Square.
1849. Lowe, Wm. Henry, M.D., Wimbledon, London.
1870. Lyon, F. W., M.D., Albany Street, Leith.
1855. Macadam, Stevenson, Ph.D., Surgeons' Hall.
1878. Macconochie, A. H. M., Geological Survey Office, Edinburgh.
1878. Maclauchlan, John, Albert Institute, Dundee.
1878. Mackay, James F., W.S., 81 Princes Street.
1879. Mackay, J. S., 8 Clarence Street.
1878. M'Laren, W. A., W.S., 8 Blackford Road.
1878. Matheson, Alexander, M.A., 19 Northumberland Street.
1879. Melven, William, 2 Marchmont Crescent.
1873. Miller, R. K., 4 Bonnington Terrace.
1862. Mitnish, H. W., M.R.C.S.L.
1876. Moffat, Andrew, 8 Kirk Street, Leith.
1876. Moinet, Francis, M.D., 13 Alva Street.
1880. Muirhead, George, Paxton, Berwick-on-Tweed.
1874. Murray, D. R., M.B., C.M., 37 Albany Street, Leith.
1877. Murray, John, F.R.S.E., "Challenger" Office, 32 Queen Street.
1880. Nicholson, Prof. Alleyne, M.D., F.L.S., University of St Andrews, *President* (*corresp.* 1873).
1858. Paterson, Robert, M.D., 32 Charlotte Street, Leith.
1879. Paton, D. Noël, 33 George Square.
1858. Paul, Henry, Melbourne, Australia.
1870. Peach, B. N., 8 Annandale Street.
1867. Peach, C. W., A.L.S. (*non-res.* 1850), 30 Haddington Place.
1877. Philip, James, 5 Argyle Place.
1879. Pullar, Rufus D., St Leonard's Bank, Perth.
1877. Prentice, Charles, C.A., 40 Castle Street.
1855. Redpath, Hugh, Grangebank, Morningside.
1868. Reid, Rev. J. Brown, Airdrie.
1858. Rigg, Dr C. M., The Vines, Rochester.
1867. Ritchie, Walter, New Register House.
1870. Robertson, Alexander, 29 Dick Place.
1880. Robertson, J. A., C.A., North St David Street.
1861. Robertson, Thomas, 57 Frederick Street.
1880. Rowland, L. L., M.D., Salem, Oregon, U.S.
1863. Sadler, John, Royal Botanic Garden.

Date of Election.

1878. Sang, Edward, F.R.S.E., 2 George Street.
1875. Saundby, Robert, M.D., Saughton Hall.
1869. Scot-Skirving, R., 29 Drummond Place.
1880. Shaw, Duncan, 9 Heriot Row.
1878. Sievewright, Peter, 12 Danube Street.
1878. Smith, James D., 30 Buckingham Terrace.
1850. Smith, John Alex., M.D., 10 Palmerston Place.
1880. Sprague, T. B., Actuary, 29 Buckingham Terrace.
1880. Stark, A. C., 4 North Charlotte Street.
1878. Stewart, Rev. James, Wilton, Roxburghshire.
1861. Struthers, James, M.D., 22 Charlotte Street, Leith.
1878. Surenne, David J., 6 Warriston Crescent.
1879. Symington, Johnson, F.R.C.S.E., Minto House, Chambers Street.
1851. Taylor, Andrew, 6 South Clerk Street.
1878. Thomson, Alexander, Newbank, Trinity.
1876. Thomson, Andrew, 13 Inverleith Place.
1848. Thomson, Sir Charles Wyville, LL.D., F.R.S., Edinburgh University.
1876. Thomson, John, 26 Queen Street.
1878. Thomson, Mitchell, 7 Carlton Terrace.
1874. Thomson, Robert, LL.B., Rutland Square.
1861. Thomson, W. Burns, St John Street.
1867. Thorburn, Archibald, General Register Office.
1859. Traquair, Ramsay H., M.D., F.R.S.E., Museum of Science and Art, *Hon. Librarian.*
1858. Turner, Professor W., F.R.S., Edinburgh University.
1862. Waddel, Peter, Claremont Park, Leith.
1874. Walcot, John, 50 Northumberland Street.
1872. Walley, T., Principal, Veterinary College, Clyde Street.
1855. Wardrop, James, 16 Carlton Street.
1878. Watson, G. W., 4 Stafford Street.
1878. White, Thomas, S.S.C., 114 George Street.
1872. Williams, Principal, F.R.S.E., New Veterinary College.
1856. Wilson, Andrew, 21 Young Street.
1875. Wilson, Andrew, Ph.D., 118 Gilmore Place.
1861. Wilson, John, Janefield House, Duddingston.

NON-RESIDENT.

1864. Belairs, George, Caroline Lodge, Duddingston.
Bentham, George, F.R.S.
1862. Bethune, Norman, M.D., Toronto, Canada.
1872. Brown, D. J., Glasgow.
1862. Brown, J. Crichton, M.D., London.
1867. Brown, Geo. H. Wilson, Vancouver Island, British Columbia.
1862. Cæsar, Rev. W., D.D., Tranent.
1861. Cameron, A. G. H., Lakefield, Inverness.
Carpenter, W. B., M.D., C.B., 56 Regent Park Road, London, N.W.
Cleghorn, Hugh, M.D., Stravithie, Fife.
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1868. Davies, A. E., Ph.D., F.C.S., Lowes Moor, Worcester.
1870. Dick, Thomas, Kirknewton.
1858. Drummond, Captain H., India.
1863. Fair, George, M.D., Buenos Ayres.
1863. Galbraith, George L., Loch Tummel Lodge, Pitlochrie.
1859. Grierson, T. B., L.R.C.S.E., Thornhill.
Handyside, P., M.D., Surgeons' Hall, Edinburgh.
1876. Harvie-Brown, J. A., Dunipace House, Larbert.
1855. Hector, James, M.D., C.M.G., F.R.S., New Zealand.
1851. Heddle, Professor M. Forster, University of St Andrews.
1849. Hepburn, Archibald, Barwood House, Ramsbottom.
1874. Hitchman, Wm., M.D., 29 Erskine Street, Liverpool.
1862. Hargitt, Edward, London.
1872. Hoggan, George, M.D., London.
1861. Home, Lieutenant-Colonel George Logan, Edrom, Dunse.
1860. Hunter, Rev. Robert, Library of the Royal Historical Society, London.
1868. Kennedy, John, M.D., Elie.
1850. Lawson, George, Professor, LL.D., Windsor, Nova Scotia.

Date of Election.

1861. Logan, Robert, Carluke.
1862. Macnab, Professor W., M.D., F.L.S., Royal College of Science, Dublin.
1858. M'Vicar, Rev. J., D.D., Moffat.
1862. Manson, George W., Bengal Staff Corps.
1849. Melville, Professor A. G., Queen's College, Galway.
1870. Middleton, James, M.D., Strathpeffer.
1871. Paterson, J., M.D., Brazil.
1878. Prentice, Norman, Otago, New Zealand.
1862. Roome, Major Frederick, Bombay.
1856. Sanderson, R. Burdon, M.D., F.R.S., London.
1857. Shields, Robert, Kentish Town, London.
1861. Stevenson, William, Dunse.
1861. Struthers, Rev. John, Prestonpans.
Swift, Herbert M., Whitehall, London.
1861. Thomas, F. W. L., Captain, R.N., Trinity.
1861. Thomson, Murray, M.D., Professor, Calcutta.
1860. Valentine, Colin S., LL.D., Jeypore.
1861. Wanklyn, Professor J. A., London.
1870. Wilson, Robert, *Standard*, London.
1874. Young, David.

CORRESPONDING.

Andrew, Rev. J., D.D., Newbury, Fifeshire.
1875. Coughtrey, Millen, M.D., Dunedin, New Zealand.
1858. Duncan, Rev. J., Denholm.
1877. Edward, Thomas, A.L.S., Banff.
1870. Fraser, Rev. Samuel, Melbourne.
1861. Gordon, Rev. G., LL.D., Birnie, Elgin.
1871. Grieve, A. F., Brisbane, Queensland.
1852. Howden, J. C., M.D., Montrose.
1874. Joass, Rev. J. M., Golspie.
1874. Jolly, William, Inspector of Schools.
1879. Lapworth, Charles, F.G.S., Madras College, St Andrews.
1871. Macdonald, John, S.S.C.
Mushet, David, Gloucester.
1867. Robb, Rev. Alexander, Old Calabar.
1874. Stewart, Rev. Alexander, Ballachulish.

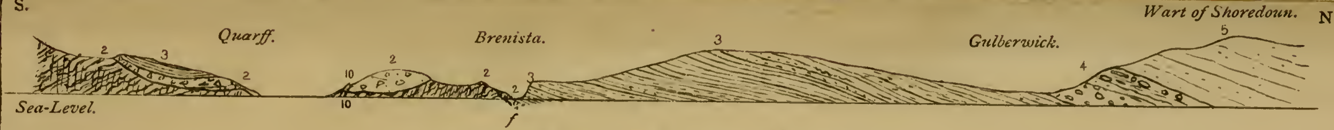
HONORARY.

1857. Boheman, Professor C. H., Royal Academy of Sciences, Sweden.
1857. Chevrolat, Auguste, Paris.
1857. Dohrn, C. A., Stettin.
1857. Fairmairé, Leon, Paris.
1865. Frauenfeld, George Ritter von, Zoological and Botanical Society, Vienna.
1857. Gerstaecker, A., Berlin.
1857. Guenée, Achille, Chateau-dun.
1857. Javet, Charles, Paris.
1857. Kraatz, G., Berlin.
1865. Kotscky, Dr Theodor, Zoological and Botanical Society, Vienna.
1869. Lütken, Dr Chr., University Museum, Copenhagen.
1857. Lacordaire, Professor Theodore, Liege.
1857. Lenectere, Marquis de Laferte, Tours.
1857. Marseul, L'Abbe de, Paris.
1857. Meneville, Guerin, Paris.
1865. Mannsfeldt, Prince, Colloredo, Vienna.
1858. Motschoulsky, Count Victor, St Petersburg.
1857. Milne-Edwards, A., Paris.
1857. Macquerys, Emile, Rouen.
1857. Obert, M., St Petersburg.
1857. Reiche, M., Paris.
1858. Schlossberger, Dr, Tubingen.
1857. Zeller, P. C., Silesia.
1857. Zetterstedt, J. W., University of Lund, Sweden.

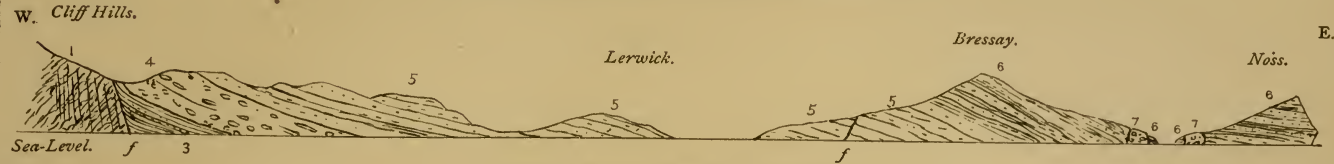
Fellows are requested to intimate change of address to the Assistant Secretary.

INDEX.

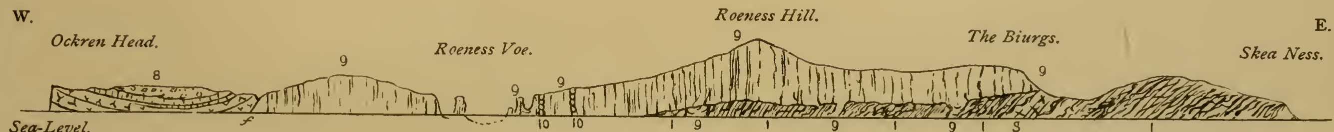
M'Farlane & Erskine, Printers, Edinburgh.



(*a*) Section from Quarff to Wart of Shoredoun.



(*b*) Section from Cliff Hills to Noss Head.



(*c*) Section across Mainland from Ockren Head to Skea Ness.

REFERENCE.

PRE-OLD RED SANDSTONE ROCKS.

1. *Metamorphic rocks, Gneiss and Schist.*

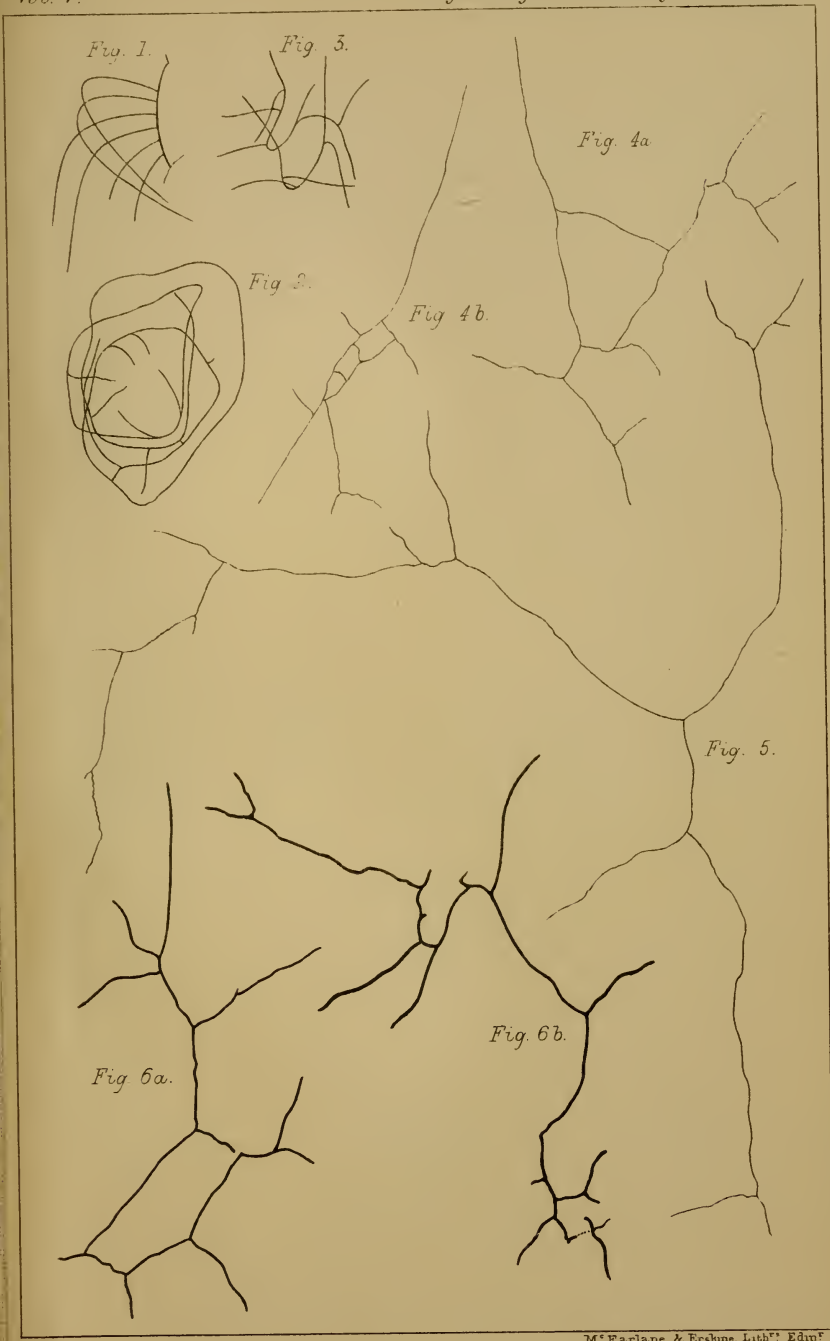
ROCKS OF OLD RED SANDSTONE AGE.

2. *Basement Breccia.*
3. *Brenista Flags.*
4. *Rovey Head Conglomerate.*
5. *Lerwick Sandstones.*
6. *Bressay Flags.*
7. *Volcanic Agglomerate in Vents.*
8. *Porphyrite, Tuff, and Sandstone, of West side of Shetland.*
9. *Pink Granitoid Quartz-Porphyry.*
10. *Porphyrite Dykes.*

S—Serpentine.   *f*—Faults.

B. N. Peach, del^t   M^c Farlane & Erskine, Lith^rs Edin^r

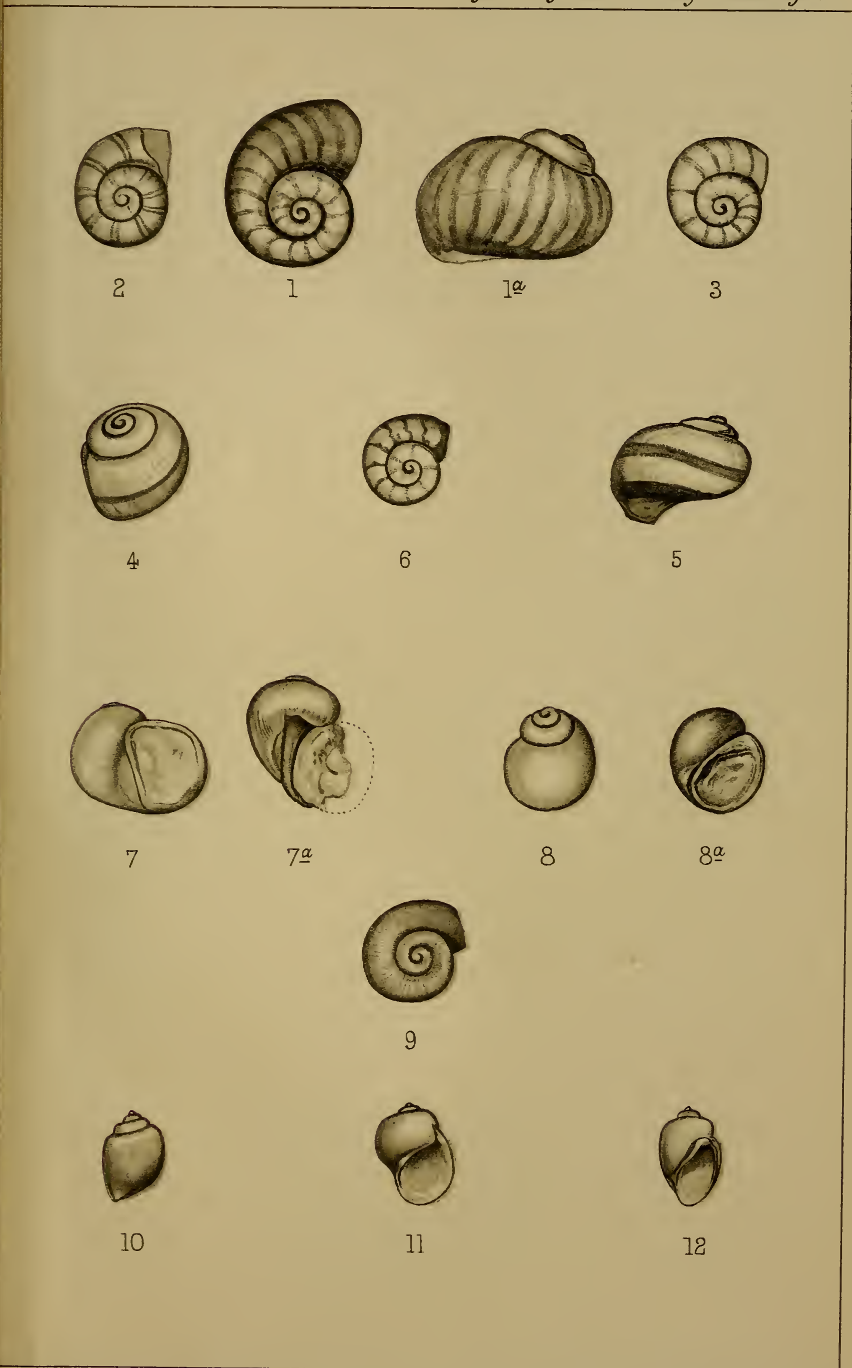
To illustrate Messrs Peach and Horne's Paper on the Old Red Sandstone of Shetland.



Mc Farlane & Erskine. Lithrs Edinr

NEMATOLITES.

Vol. V. PLATE III. Royal Physical Society Edinburgh.

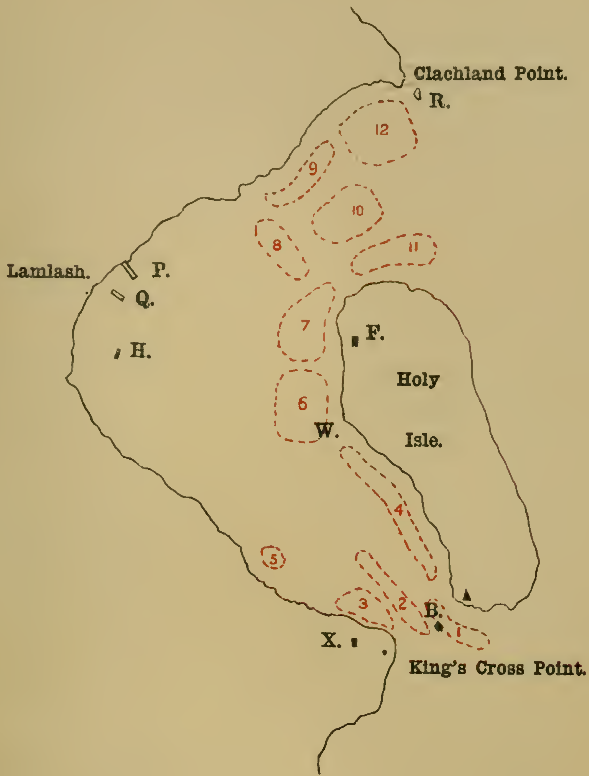


C. Berjeau. del.

x 10 diameters.

McFarlane & Erskine, Lith[rs] Edin[r]

PLATYOSTOMELLA.



Scale One Inch to the Mile

F. Farm-House on Holy Isle.
W. White Point, Holy Isle.
B. Buoy at South Entrance to Bay.
X. The Point House, King's Cross.
H. Old Wreck, near Lamlash.
Q. The Old Quay, Lamlash.
P. The Pier, Lamlash.
R. Hamilton Rock.

Nos. 1 to 12 indicate the Dredging Stations.

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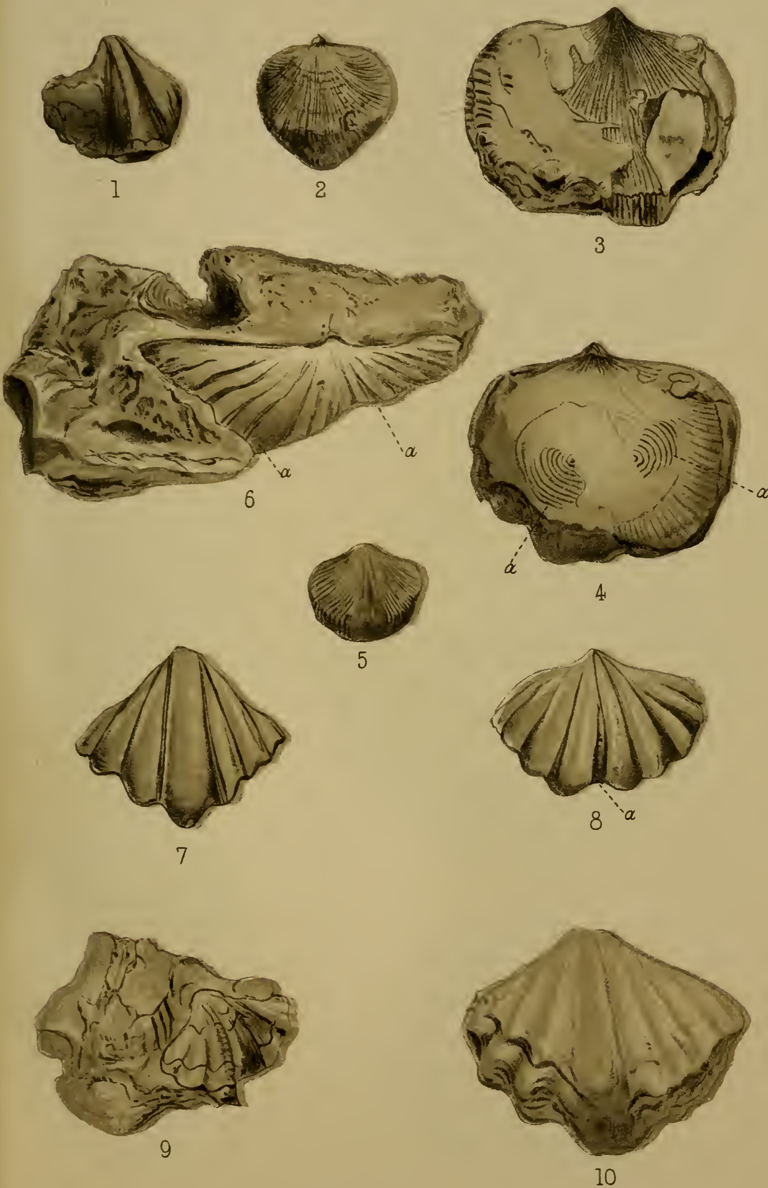

P. E. Ewen, del. M^c Farlane & Erskine, Lith^rs Edin^r

17

18a

18

19

20

21

P. E. Ewen, del.

McFarlane & Erskine, Lith^rs Edin^r

22

23

25

26

24

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P. E. Ewen, del. M^c Farlane & Erskine, Lith^rs Edin^r

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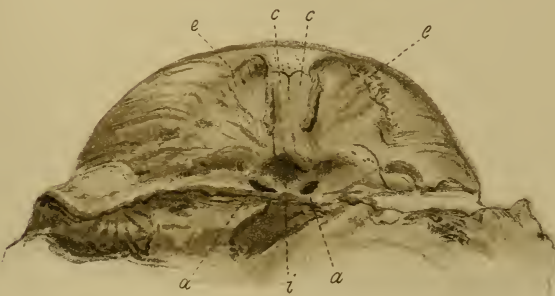

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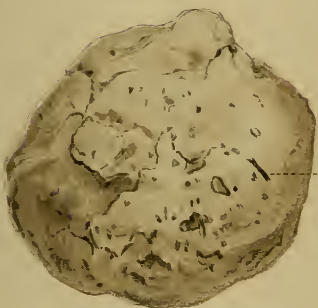

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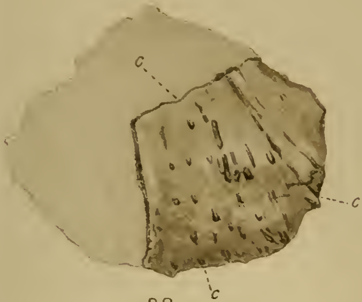

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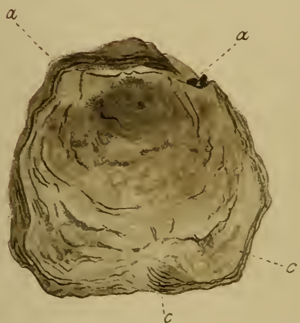

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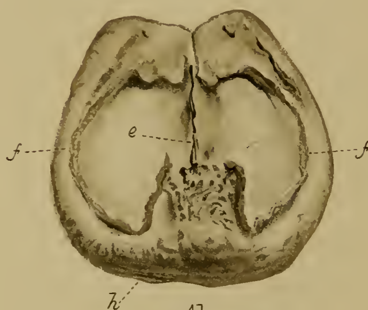

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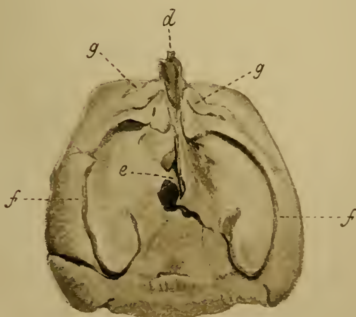

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P. E. Ewen, del.

McFarlane & Erskine Lithrs Edinr

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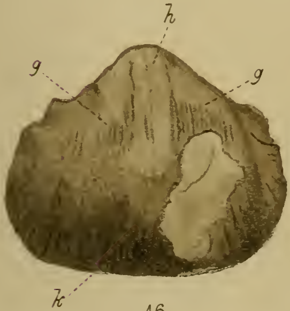

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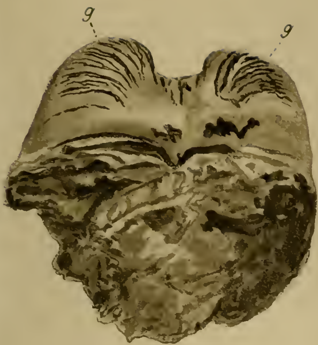
P. E. Ewen, del. M

M^c^Farlane & Erskine, Lith^rs Edin^r



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P. E. Ewen, del.

McFarlane & Erskine, Lith.rs Edin.r

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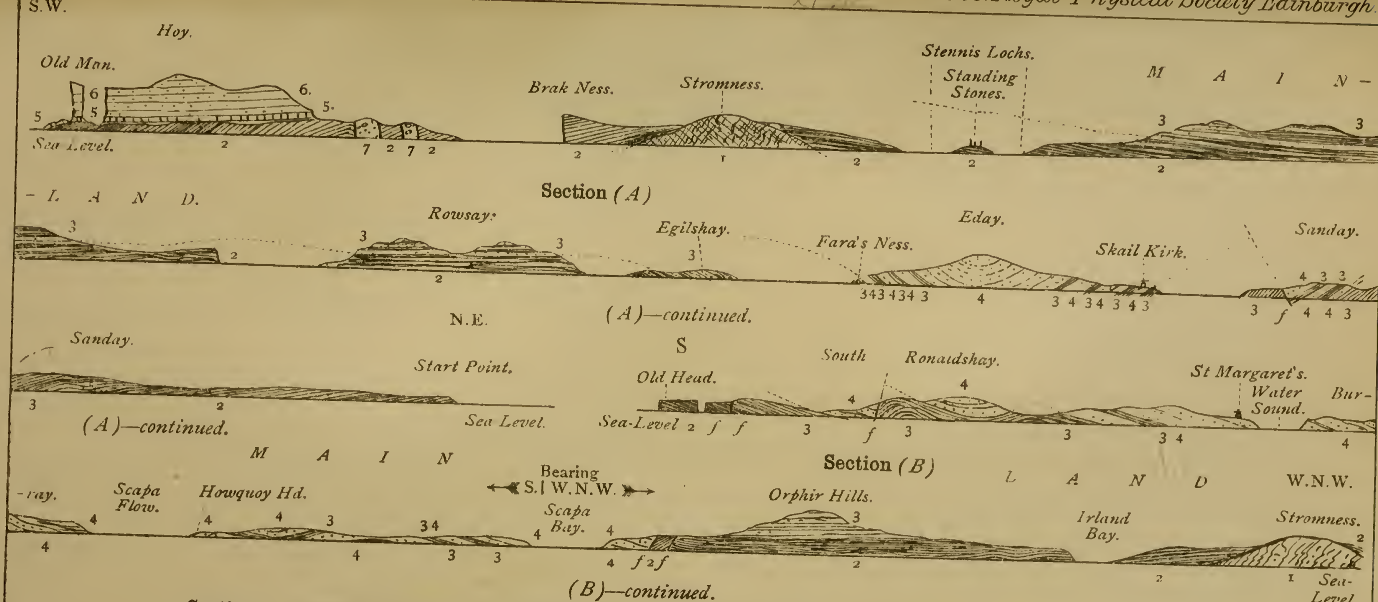
P. E. Ewen, del. M^c Farlane & Erskine, Lith^rs Edin^r



Section (A) extends from Hoy to Sanday; shows relation of rocks in the Northern Islands.

Section (B) extends from South Ronaldshay to Stromness; shows relation of rocks in Southern Islands.

REFERENCE.

OLD RED SANDSTONE SERIES.

UPPER.

7. *Agglomerate in Volcanic Vents.*
6. *Red and Yellow Sandstones.*
5. *Diabase (Lava).*

LOWER.

4. *Red and Yellow Sandstones and Marl.*
3. *Grey Sandy Flags.*
2. *Grey Flags.*

PRE-OLD RED SANDSTONE ROCKS.

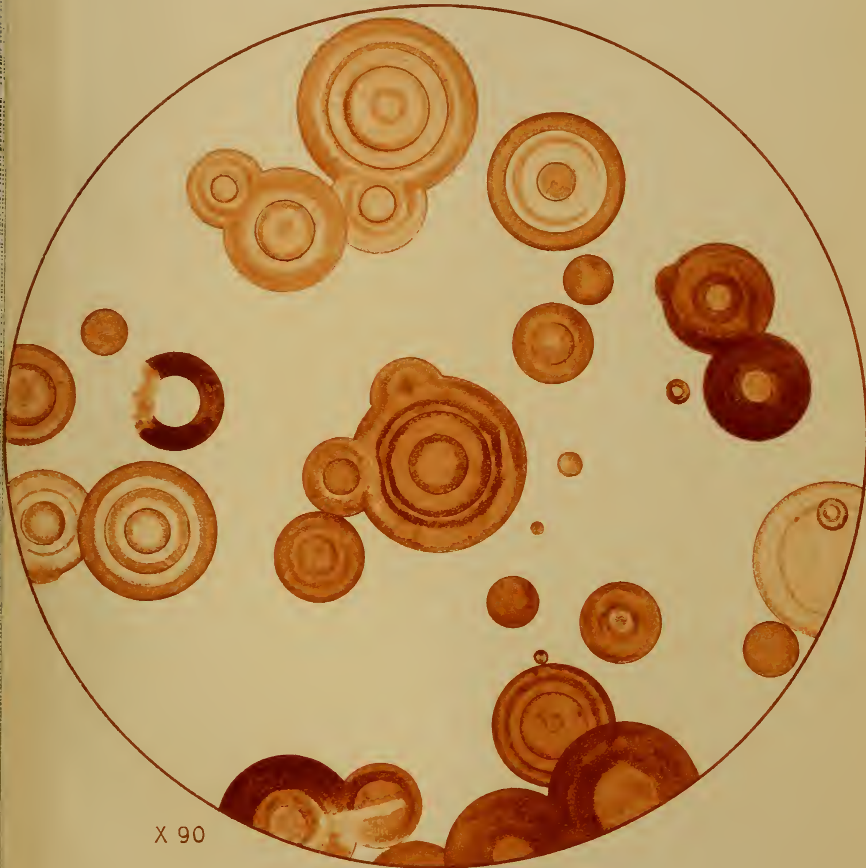
1. *Crystalline Rocks of Stromness and Gremsay.*

f = Faults.

B. N. Peach, del[t]

M[c]Farlane & Erskine, Lith[rs] Edin[r]

SPOTS OF IRON OXIDE ON AMETHYST.



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McFarlane & Erskine, Lithrs Edinr

ne 5, 1886

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION 1878–79.

EDINBURGH: M'FARLANE & ERSKINE.
1879.

Nov. 5, 1886

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION 1879-80.

EDINBURGH: M'FARLANE & ERSKINE.
1880.

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SESSION CIX.