PROCEEDINGS

OF

THE ROYAL SOCIETY

OF

EDINBURGH.

VOL. V.

NOVEMBER 1862 TO APRIL 1866.

EDINBURGH:
PRINTED BY NEILL AND COMPANY.
MDCCCLXVI.

CONTENTS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1862–63. No. 59.

Eightieth Session.

Monday, 24th November 1862.

Dr Christison, V.P., in the Chair.

The following Council were elected:—

President.

His Grace The DUKE of ARGYLL, K.T.

Vice-Presidents.

Sir David Brewster, K.H.
Dr Christison.
Professor Kelland.
Hon. Lord Neaves.
Principal Forbes.
Professor Innes.

General Secretary,—Dr John Hutton Balfour.

Secretaries to the Ordinary Meetings.

Dr Lyon Playfair, C.B.
Dr George James Allman.

Treasurer,—J. T. Gibson-Craig, Esq.

Curator of Library and Museum,—Dr Douglas Maclagan.

Councillors.

Professor Fraser.
James Leslie, Esq., C.E.
Dr Schmitz.
Dr Seller.
E. W. Dallas, Esq.
Rev. L. S. Orde.
Professor Tait.
John Muir, Esq., D.C.L
A. Campbell Swinton, Esq
Dr William Robertson.
Dr E. Ronalds.
T. C. Archer, Esq.

Monday, 1*st December* 1862.

Principal Forbes, one of the Vice-Presidents, delivered the following Opening Address :—

Gentlemen,—I propose to address you on this occasion with reference to the following points :—

First, to recapitulate briefly the origin, the objects, and the Constitution of Societies similar to our own.

Secondly, to trace the rise and general history of the Royal Society of Edinburgh.

Thirdly, to consider what changes the progress of science and of society render necessary or desirable in the working of associations like ours, and how far such changes are safe and prudent.

Lastly, to recall the history of this Society during the past twelve months, especially with reference to the Fellows whom it has lost.

I. *To recapitulate briefly the Origin, Objects, and Constitution of Societies similar to our own.*

Societies having any true analogy to the academies of modern Europe, or to the Royal Societies of London and Edinburgh, or the Royal Irish Academy, have arisen within about 300 years. Italy was their birth-place, and perhaps, on the whole, in no country have they flourished more. They appear to have been the direct offspring of the spirit of inquiry so active in that country throughout the sixteenth and seventeenth centuries. According to the literary historians of Italy, the cultivation of literature by academicians, salaried by the Government, commenced at Rome in 1514, under the Pontificate of Leo X. It is well known, that the cultivation of literature and the fine arts continued to be fostered in Italy by similar institutions during many generations. The *Accademia della Crusca* (named after the Italian word for bran or chaff, from the fanciful analogy of sifting the pure from the heterogeneous parts of the language), and the Society of Arcadians, which still exists or existed lately, are familiar examples. But the number of such associations was vastly greater than we can find a parallel for in other countries or in more recent times.

After all, the typical form of the modern Royal Society or Academy is traceable to the astonishing impulse given to the experimental physical sciences in Italy in the sixteenth century. The first such society recorded by Tiraboschi and Libri, the chief annalists of the revival of letters in Italy, was called "Accademia Secretorum Naturæ," founded at Naples in 1560, of which the celebrated Baptista Porta was president. It was suppressed, however, by the influence of the priests. The Society of *Lincei*, or Lynx-eyed scrutators into natural phenomena, of which Galileo was a member, held its sittings at Rome. It was founded in 1604 by Cesi, a noble Roman, and still survives, though after a long intervening period of inactivity.*

It is easy to see how the newly born interest of mankind in the investigation of nature by experiment, must, far more than mere literary discussion or dialectical argument, have fostered such associations. In those glorious days when a virgin mine of natural phenomena was first opened to the intelligent exploration of mankind, the succession of inventions, discoveries, and capital theories in physical science, kept every thoughtful mind on the stretch. The comparatively recent art of printing served to disseminate rapidly both facts and doctrines; the promulgation of the true system of the world by Copernicus, the improved astronomical observations of Tycho, the mechanics of Da Vinci and Stevinus, the telescope of Galileo, kept all Europe in a tremble of expectation for the discoveries of each succeeding year. What *could* men do in such circumstances but assemble with others like-minded, and see with their own eyes the facts which seemed to contradict the experience or prepossessions of ages, and either maintain or overthrow the new philosophy? It was under such circumstances that the Florentine Academy, "del Cimento" was founded in 1657,† under the patronage of the Grand Duke Ferdinand II. of Tuscany, and with the personal support of his brother Leopold. The withdrawal

* See Drinkwater Bethune's Life of Galileo, p. 37.

† First meeting, 18th June 1657. *Saggi*, &c., Edit. 1841; Introd. p. 95. As its name imports it was an association for making *experiments*.

of the latter from Florence in 1667, on being made a Cardinal, was followed by the decline and virtual extinction of this remarkable Society. This is considered by Mr Hallam as a proof of the inconveniences attending such exalted patronage of literary societies; yet it does not seem to afford a sufficient reason for the cessation of the labours of a society which gave such indisputable proofs of vigour, whose Transactions remain a book of reference to this day, and whose members, including the best and ablest pupils of Galileo, were well able to sustain their position amongst the learned men of Europe.

The wide reputation of the Florentine Essays contributed, no doubt, to the establishment—also under Royal sanction—of the Royal Society of London. This took place in November 1660, immediately after the Restoration, and from that time their proceedings may be traced with minute precision. Founded originally upon the basis of a private Society for the cultivation of Natural and Experimental Science instituted in 1645, it was incorporated by charter in 1662, four years before the Academy of Sciences of Paris was instituted in 1666 under the auspices of Colbert. This last was incorporated with the previously existing *Academie Française* founded for the cultivation of the French Language and Literature, much after the manner of the Crusca Academy in Italy.

The Academy of Sciences and the Royal Society of London subsist, it is needless to say, to this day; and each in their own sphere, and in varying ways, according to the exigencies of the time, have contributed in the most important way to the improvement of the Physical and Mathematical Sciences. The unbroken series of Transactions of both are without a parallel in the history of knowledge for continuity and importance. The publication of the "Philosophical Transactions" commenced in monthly numbers on the 1st March 1665. Our own Society has very recently acquired for the first time a complete set of these publications from the commencement,—an acquisition of some difficulty and importance.

An hundred and twenty years elapsed before the progress of knowledge and of organisation in the sister kingdoms of Scotland and Ireland sufficed for the formal institution of associations on similar principles and with similar ends to the Royal Society. The

Royal Society of Edinburgh was formally constituted in 1783, and that of Dublin, or the Royal Irish Academy, in 1785. Both arose out of societies previously existing, though of a more private character, and not incorporated. As most interesting to us, I shall presently proceed to trace the rise of the Royal Society of Edinburgh.

But before giving an account of this, let me interpose a remark on the organisation of such societies generally. Even in early times, they differed from one another in respect of being either under the direct influence of the State, or of being merely private associations. This distinction continues to the present day. The French Academies, for example, are national institutions, and the members receive salaries from public funds. The Royal Societies of this country, on the other hand, are free from even the vestige of State control, and pursue their aims without pecuniary objects, and according to their own regulations. This is not the place to discuss the advantage of the two systems, in favour of each of which something may be said. The place of a salaried academician is often really desirable for those whose fortunes do not enable them to pursue the unremunerative paths of science and literature. On the other hand, the pecuniary gain is liable to give rise to motives less pure than mere honorary distinctions can do, on the part both of candidates for the post and of the academical electors. It appears from the history of the *Academie Française* in its origin, that the enlargement and incorporation of it under the State influence of Cardinal Richelieu was much resented by its original members.

The two forms of constitutions—the one creating a power in the State with corresponding advantages to its associates, the other receiving an impulse entirely from within—are really so distinct, that it seems almost invidious to compare them. The latter appears, from the history of our country, to be most congenial to English habits in such matters; and perhaps we have no great reason to regret the absence of an "Institute" under Imperial or Royal administration.

But another question arises with reference to such Societies as those of London, Edinburgh, and Dublin: Whether, in default of substantial endowments in connection with membership, an artificial standard of literary and scientific distinction is to be held up as regulating the entrance or refusal of candidates?—whether, in short, the members of our Societies are to be held as unsalaried academicians,—men selected for intellectual attainment alone, and forming therefore a learned class?

On this point, which is one of considerable importance, I confess that I entertain little doubt. Whatever disadvantages may attend the admission to Societies like this of persons who have no pretensions to what, for convenience, one may call a *professional* acquaintance with science, art, or literature, I think that they ought to be eligible. It is little likely that where no emoluments or distinctions present themselves, the privilege of membership will be sought except by those who feel *some* sympathy with pursuits for which they have probably a secret leaning, but from which they have been withheld by force of circumstances. I say, Let them come, and freely, and let us regard their adhesion to our ranks as a compliment on either side.

In Britain, all experience points to this resolution of what may be in some respects regarded as a difficulty. From the day of the foundation of the Royal Societies, both of London and Edinburgh, the rule of mixture of classes, and the absence of an academic standard of exclusion, has been all but universal. The co-operation of men of all ranks, and of the most varied occupations and acquirements, was the very corner-stone of these institutions. While they diffused a taste for science amongst the nobility, gentry, and professional men, this very mixture enhanced, in no small degree, the interest of the proceedings of the Societies themselves, and conduced to the respect shown to literature and science. It also indirectly aided the progress of the latter, by raising a large fund for the publication of Transactions and the conduct of experiments.

To attempt to enforce a contrary principle, would be to reduce the members of our Societies to a select few, without the advantages which academicians properly enjoy, and without the cordial sympathy which the lay-members (as they may be termed) contribute to diffuse amongst an intelligent public, whose sentiments in such matters is never to be despised.

II.—*Rise and Progress of the Royal Society of Edinburgh.*

Guided by an interesting passage in the "Life of Lord Kames,"* it would appear that the germ of our Society is to be found in the *Rankenian Club*, instituted in Edinburgh in 1716, for literary social meetings, and which had the unusual duration (for such associations) of almost sixty years. It expired in 1774. It included among its original or early members, Principal Wishart, Bishop Horsley, Colin Maclaurin, John Stevenson, Professor of Logic, Lord Auchinleck, several of the ministers of Edinburgh and neighbouring gentry, and, finally, Sir John Pringle, afterwards President of the Royal Society of London. No publications are known to have proceeded from this Club.†

Contemporary, in part, with the Rankenian Club was a Society for the Improvement of Medical Knowledge, instituted in 1731. This Society, of which little perhaps is now remembered save its published Transactions, appears to have been conducted with an enlightened sense of the dignity and importance of associations for the promotion of science, which its founders justly considered to be more advanced by publishing able papers, than by making a parade

* [By Lord Woodhouselee] two vols. 4to. Edin. 1807, vol. i. p. 174, and list of members, Appendix p. 50.

† Since the reading of this address I have been indebted to Professor Fraser of the Edinburgh University for a reference to an interesting allusion to the "Rankenian Club," contained in Dugald Stewart's First Dissertation on the Progress of Metaphysical and Ethical Philosophy, part ii. sect. 4, where he speaks of Berkeley's celebrated system of Idealism having "attracted very powerfully the attention of a set of young men who were then prosecuting their studies at Edinburgh, and who formed themselves into a society for the express purpose of soliciting from the author an explanation of some parts of his theory which seemed to them obscurely or equivocally expressed. To this correspondence the amiable and excellent prelate appears to have given every encouragement; and I have been told," adds Mr Stewart, "by the best authority, that he was accustomed to say that his reasonings had been nowhere better understood than by this club of young Scotsmen." To which Mr Stewart adds this note: "The authority I here allude to is that of my old friend and preceptor, Dr John Stevenson, who was himself a member of the *Rankenian* Club. . . . . . ." Mr Fraser justly remarks, that the dates tally well with this statement; Berkeley's "Dialogues" having been published in 1713, and the Rankenian Club having (as stated above) been founded in 1716.

of ceremonious meetings and printing lists of dignified office-bearers. With a reticence which we all must regret, the six volumes of *Medical Essays* give no clue to the constitution of the Society, the nature or frequency of its meetings, the names of the presidents, nor even of the diligent secretary by whom, no doubt, its Proceedings were edited.*

I think I am entitled to assume that the papers were fully equal in point of merit to those contributed on medical subjects to the Royal Society of London, or any similar institution. They went through more editions than one, were translated into foreign languages, and were highly commended by the celebrated Haller. It is reasonable to believe that the wide reputation of the Edinburgh Medical School dates from the publication of these important Essays.

In a paper on the Climate of Edinburgh, which I contributed a few years ago to the Royal Society's Transactions,† I have brought into view the early meteorological observations contained in the *Medical Essays*, though by whom they were made does not appear.

The six volumes of Medical Essays terminated in 1744. In 1737, at the suggestion of the celebrated Maclaurin, the objects of the Society had already been extended so as to include general science and literature.‡ It had not existed for many years in this form before political troubles antecedent to and during the insurrection of 1745–6 seriously impaired its usefulness, and probably prevented the separate publication of its Transactions, which was from the first contemplated.§ The death of Maclaurin, in June 1746, which

* An incidental notice, however, in the Introduction to the first volume of the Royal Society's Transactions, informs us that the secretary was the first Professor Monro, who was also a large contributor to the *Essays*.

† Vol. xxii. p. 327.

‡ The date usually assigned is 1739. But from two letters of Maclaurin printed in the "Scots' Magazine" for June 1804, the earlier date is certainly correct. Mr David Laing has shown me a pamphlet (of sixteen quarto pages) containing the Regulations of the Society and a List of Members. The List of Members is dated 1739; but at page 3, the first Thursday of December 1737 is fixed as the first day of meeting.

§ The papers read at the Society were in part printed in the later volumes of the *Medical Essays*, in the *Philosophical Transactions*, and in *Maclaurin's Fluxions*. It appears from a notice in Mr R. Chambers's *Domestic Annals* (vol.

was immediately traceable to his exertions on the side of the English in the melancholy struggles of the period, was a heavy blow to its usefulness, and a mass of papers connected with it were found to have been in his possession, which could be only partially recovered. Some of these were published in 1754, under the title of *Essays and Observations, Physical and Literary, read before a Society in Edinburgh*, and they were followed by two other volumes in 1756 and 1771. The first president of the Philosophical Society was the Earl of Morton (afterwards president of the Royal Society of London), Maclaurin and Dr Plummer (Professor of Chemistry) were secretaries. Afterwards Professor Monro (*Secundus*), and the celebrated David Hume, acted as secretaries. The Society then held its meetings in the Advocates' Library. Medical subjects still greatly predominated in the Transactions; but among the contributors appear the names of Maclaurin, Lord Kames,* John Stewart (Professor of Natural Philosophy), Matthew Stewart, Porterfield, Melvill, and Joseph Black.†

It is no small credit to this unpretending Society that it not only gave from its members two Presidents to the Royal Society of London, but reckoned amongst its contributors perhaps the two most eminent disciples of the Newtonian school which Britain produced in the whole of the eighteenth century,—namely, Colin Maclaurin and Matthew Stewart. The Philosophical Society of Edinburgh was the immediate parent of the Royal Society.‡

The Royal Society of Edinburgh took its rise in a meeting of the Professors of the University of Edinburgh, many of whom were also members of the Philosophical Society,§ on the proposition of Prin-

iii. p. 477), that, in 1743, the Society advertised for specimens of stones, ores, saline substances, bitumens, &c., to be sent to their secretary, Dr Plummer, and it is stated that "the Society undertake, by some of their number, to make the proper trials at their own charge for discovering the nature and uses of the minerals, and to return an answer to the person by whom they were sent, if they are judged to be of any use, or can be wrought to advantage." The quotation is from the *Edin. Evening Courant*, 22d Aug. 1743.

* Henry Home, Lord Kames, became president about 1769, and contributed greatly to the success of the Society.

† Dr Black's sole contribution was his celebrated "Experiments on Magnesia Alba," Essays, &c. vol. ii. p. 157.

‡ See Life of Kames, i. 184, and Trans. Roy. Soc. Edin., i. p. 6.

§ The last survivors in our body of the Philosophical Society were, Profescipal Robertson, towards the end of 1782. It is stated to have been founded "on the model of some Foreign Academies," and so far differed from the Royal Society of London, that literary objects were equally promoted with science, and the interests of literature represented by a Literary "Class" or subordinate Academy, having distinct meetings and office-bearers. It appears from a curious letter of Professor Dalzel, in Professor Innes's *Life of Dalzel*,* that the Royal Society was more particularly modelled on the Berlin Academy, and that its rise was partly due to a contest between Lord Buchan and the Society of Antiquaries on the one hand, and the University and Faculty of Advocates on the other. The result, however, of this party-war was in favour of the interests of science and literature; for the Society received a Royal Charter, and was formally constituted at a meeting held in the College Library on the 23d June 1783, under the presidency of Principal Robertson, at which were also present the Lord Provost, Lord Justice-Clerk Miller, Professors Cullen, Monro (*Secundus*), Hugh Blair, John Walker, Adam Ferguson, John Robison (who was then appointed secretary), the Solicitor-General Ilay Campbell, and several members of the Faculty of Advocates, the celebrated Adam Smith, and Mr Hunter Blair, M.P. for the city of Edinburgh.

The Society started at once into vigorous existence, and, looking especially to the reputation of the members of the Literary Class, few societies in any country have given a fairer prospect of a distinguished career. The members were either Resident, Non-Resident, or Honorary. The number of Original Residents was 102, and of Non-Residents, 71; and this before the Society had ever held a meeting. A short time later, the total number of members belonging to the Physical Class was 101, and to the Literary Class, 114. An excerpt from the MS. list of original members, in Professor Robison's handwriting (exclusive of those who have been named as founders of the Society), will give no mean idea of the eminent position of Edinburgh in the literary world of that day:—

sor James Russell and Sir William Miller, Lord Glenlee. The latter died so lately as 1846, in his ninety-first year. The Minute-Books of the Philosophical Society were expressly conveyed to the custody of the Royal Society (see Minute, R.S., of 4th August 1783); but they are, it may be feared, now irrecoverably lost.

* Page 39 (30th Nov. 1782).

The Physical Class included Joseph Black, Clerk of Eldin, Sir John Dalrymple (Lord Hailes), James Gregory, James Hutton, John Playfair, Dugald Stewart, Lords Bute and Dundonald, Sir James Hall, James Watt, Dr Small of Dundee, Patrick Wilson; and in the Literary Class we find the Lord President, Chief Baron, and Lord Advocate, John Home, David Hume, Henry Mackenzie, Alexander Tytler (Lord Woodhouselee), the Duke of Buccleuch, Archibald Alison, Dr Beattie, Edmund Burke, Lord Morton, Lord Hopetoun, John Hunter of St Andrews, Thomas Reid, Young of Glasgow, Dalzel, and Mr (afterwards Sir Robert) Liston. The earliest meetings of the Royal Society (as well as that of its incorporation) took place in the University Library. A large subscription towards the erection of the New College was made by the Society, on the understanding that the Society should be accommodated within its walls; and space was actually allotted on the north side of the building. How this was frustrated I do not know. The formal meetings continued to take place usually in the same place (the Library), at least until 1808, with an occasional substitution of the Physicians' Hall. In 1810, the Society purchased a house, No. 40 George Street, where they were accommodated until 1826; when they removed to the rooms which they still occupy, under a lease from Government, in the Royal Institution Building in Princes Street.

I proceed to trace rapidly the fortunes of the Society, which almost on the very day that I address you has completed the eightieth year of its existence.

The first President was the Duke of Buccleuch. He was succeeded in 1812 by Sir James Hall, who, resigning in 1820, was followed by Sir Walter Scott. On the death of the latter in 1832, Sir Thomas Makdougall Brisbane filled his place, to be succeeded at his decease in 1860 by the Duke of Argyll. Thus we have the remarkable and very unusual fact, that the first four presidencies endured over seventy-seven years. The chief secretaryship has in the same period been held by only five individuals, of whom but two were removed by death.

The earliest period of the Royal Society, and also the earliest volumes of its Transactions, were marked by the efficiency of the literary department. The first two volumes show a substantial if not precise equality in the extent of the published contributions devoted to literature and to science. The balance will even preponderate on the literary side, if we include the elegant biographies of deceased Fellows drawn up by accomplished authors. About 1793—only ten years from the origin of the Society—the activity of the Literary Class had already become materially impaired. But indeed at no period could the literary papers bear comparison in point of merit, as a whole, with those on science. The great men of letters, who lent the weight of their names to the institution, hardly maintained its reputation by their pens. The Robertsons, the Reids, the David Humes, the Fergusons, and the Adam Smiths, hardly contributed to the pages of the Transactions.

It appears from the minutes of the Physical and Literary Classes which are now before me, that towards the end of last century the meetings of the Literary Class became rare—not averaging three in a year—in consequence of the deficiency of communications. In 1807, when, owing to the interest excited by the geological discussions of the period, in which Sir James Hall, Professor Playfair, Lord Webb Seymour, Professor Jameson, Dr Thomas Thomson, Mr Thomas Allan, and Mr Macknight took active parts, the business of the Physical Class literally overflowed into the Literary Class, the evenings appropriated to the latter, and not taken up by literary papers, being devoted to science. In the following year the minute-book of the Literary Class ceases altogether, and the separate meetings appear to have been discontinued from that date (1808). Afterwards a few literary papers were received at the ordinary meetings, without any attempt at separation. It was, however, only in 1827 that the distinction of the two classes was finally abandoned in the annual election of office-bearers, and *that*, not from any disinclination on the part of the Society to afford honourable room to literary papers, but simply from the cessation of such communications. It is perfectly understood that a renewal of these would be considered to be a credit to the Society, and I hope that our literary friends will be induced to give us the benefit of their support and their contributions.

With the exception of the Literary Class, the Proceedings of the Society were at no time marked by more energy and importance than during the first twelve or fifteen years of the present century, when the geological discussions to which I have referred made Edinburgh the chief centre of information on such subjects. They gave rise to the masterly papers of Sir James Hall, with which at that time the Transactions were enriched.* These were followed or accompanied by the early communications of Sir David Brewster on Polarization and other parts of Optics, which added much to the scientific reputation of the Society.

The accession of Sir Walter Scott to the presidency in 1820 did not reanimate the Literary section of the Society. He contributed no paper, although he at one time very regularly presided at the ordinary meetings. From 1832, when the printing of the "Proceedings" at every meeting commenced, to the present time, nothing in the history of the Society calls for special remark. During that period, as at former ones, there have been fluctuations in the prosperity of the Society, both as regards the number and value of the communications received, and the interest taken in the meetings by the Fellows at large and by the general public. That such must occur the founders of the Royal Society were sufficiently aware. At the very opening of our Transactions we find it observed, that "Institutions of this kind have their intervals of languor as well as their periods of brilliancy and activity. Every associated body must receive its vigour from a few zealous and spirited individuals who find a pleasure in that species of business, which, were it left to the care of the members in general, would be often reluctantly submitted to, and always negligently executed. The temporary avocations, and still more the deaths of such men, have the most sensible effects on the societies to which they belonged. The principle of activity which animated them, if not utterly extinguished, remains long dormant, and a kindred genius is required to call it into life."† The truth of these remarks must be apparent to all who have had experience in such matters. They ought to encourage us to keep alive the interest of our meetings, and to maintain the character of our Society at times when

* The last meeting at which Sir James Hall appears to have presided, was that of the 5th June 1820. He resigned the presidency in November following. His last paper printed in the Transactions, "On the Consolidation of the Strata of the Earth," was read in March 1825.

† Trans. R. Soc. Edin., vol. i. p. 6.

either may appear to be in danger of flagging, resting well assured that the development of knowledge, and the intellectual resources of new generations, will ever from time to time give lustre and importance to associations destined not to meet the caprices or fashions of a time, but to promote the great cause of scientific and literary progress.

III.—I now proceed to consider *what changes the progress of science or of society renders necessary or desirable in the working of associations such as the Royal Society, and how far such changes are safe and prudent?*

The most casual reader of history, or observer of men, knows that the inevitable progress of change—material, intellectual, and social—deprives of the character of permanence all human institutions. Those Institutions are most likely to be perpetuated, in which a wise forecast of progressive change adapts their parts to the wants and circumstances of the age. If this be true of political Constitutions, of Churches, of Universities, of Charities, nay even of public Amusements, it is no less true of learned Societies. Considering that the Royal Society of London and the French Academy of Sciences are each two centuries old, we rather must wonder—taking into view the astonishing progress, or indeed reconstruction, of the sciences during that time—that so much of their original constitution still remains, than that changes have been needed, or are still required, to meet the wants of successive generations.

I shall consider some of the most obvious changes of condition under which learned associations pursue their vocation now and formerly. In doing so, I shall speak principally of their relations to the natural and experimental sciences.

The Florentine Academy was an excellent *type* of what a physical association of the seventeenth century was and ought to have been. The members collected apparatus, they had a laboratory, they furnished funds for these; and the associated philosophers (who were select in number) met to witness the experiments, and to argue upon the conclusions to be drawn from them. The Royal Society of London, as well as the lesser societies from which it sprung, took a precisely similar course: they had a paid Operator and Editor of their Transactions; and they remitted to individual members or small committees to try experiments, and to report the results to a succeeding meeting.

This seems to be the most perfect constitution of a society for investigating nature which we can well imagine. It bears a close analogy to the *Philosophical College* of Bacon,—the *Solomon's House* in the allegory of the New Atlantis,—which is generally believed to have been really an antecedent (in the way of suggestion) to the formation of the Royal Society of London. But it is now less practicable than formerly, for many reasons, of which I will enumerate a few. For example, these Societies include in our time so many members that they can no longer consult as a committee, but must rather listen as an audience. Again, the minute subdivisions into which the sciences are now split, render a perfect comprehension of one science alone almost the occupation of a single life. Hence, unless such a society were to consist all of chemists, all of astronomers, all of comparative anatomists, and so forth, the proceedings, and even the experiments, which in a former age interested nearly all well-informed men alike, are now interesting or intelligible to only a small section. In like manner, an experimental investigation is no longer the simple and absolute thing which it was. A member of the Royal Society is no longer instructed, as in former times, to try, for instance, whether spirit of wine burns or not in an exhausted receiver; whether salt is separated from water in freezing; to dissect an oyster; to measure whether pebbles and other minerals grow or not; whether eggs frozen continue fecund; to repeat the Magdeburg and Torricellian experiments; to determine the relative weight of lead and water; and to report the result of any such experiment at next week's meeting.* But the investigations are now-a-days complicated, the experimental means alone furnish matter for long and anxious preliminary consideration; the precision needed, and the calculations on which it depends, are matters consuming time, and often can be better attained by the patient efforts of an individual, than through any amount of co-operation; nay, the very results, unless involving a capital discovery (which is a rare and fortunate accident), cannot be stated without an amount of detail often wearisome to those who are not especially interested.

* These instances are all taken from the early Journals of the Royal Society of London.

These, among others, are causes why men cannot now do the hard work of science in their collective capacity as associations. How rarely do we even see two philosophers (at least in this country) engaged in a common investigation!

One result of what has been stated is the breaking down of scientific communities into special aggregations or societies for the promotion, say, of astronomy, or geology, or chemistry, or even minuter subjects, such as microscopic anatomy, numismatics, or entomology. Such associations bear testimony to the difficulty, which increases year by year, of rendering the sciences intelligible and interesting, in respect of new discoveries, to the mass of even well-educated men. They are so far a protest against the utility of associations at all, since they tend to reduce the prosecution of science more and more to an individual affair.

In communities less numerous and comprehensive than those of London or Paris, the difficulty is not less felt, though the means of meeting it (at least temporarily) are not so attainable. The largest provincial town or district cannot possibly maintain the group of associations which, even in London, may be said to enjoy a precarious intellectual subsistence. I do not mean to say, that more subordinate special associations are unadvisable, even in the provinces; on the contrary, I believe that they may do much good. But one may fairly deprecate the encouragement of a spirit of rivalry towards the larger and more national and permanent institutions which already exist, such as the Royal Society may fairly claim to be. To maintain the character, for energy and stability, of one central Society, is in reality the common interest of all of that not very numerous body of persons who cultivate science for its own sake. Delightful and instructive meetings may advantageously be held by a local body of geologists or chemists, or naturalists; but such associations require immense vitality to be permanent. Practically, they fall into abeyance, in perhaps twenty or thirty years, or even less; and if they have attempted to record their labours by publication, these publications having never attained more than a very limited circulation, become inaccessible and forgotten. The matured written results of those labours which properly form a subject of almost private discussion in minor societies, are best consigned for final preservation to the publications of a central and enduring association. A good example of what I here intend to indicate, may be found in a private Parisian Society, founded early in this century, called *La Societé d'Arceuil*, from the name of the country-house of its president, Count Berthollet, where it met. It consisted of the *élite* of the French Academy of Sciences, including Laplace, Humboldt, Gay Lussac, Biot, Arago, Decandolle, &c. But the Memoirs (in three volumes) published by this most distinguished and delightful club, including such papers of capital importance as Malus's original one on the Polarization of Light, Humboldt's on the Isothermal Lines, Thenard on Ethers, and Arago on the Colours of Thin Plates, must be considered as in fact withheld from the Proceedings of the national Academy, and they must now be sought for consultation in a small printed collection in the hands comparatively of few. It is needless to add, that the Society lasted for but a few years.

I may also include among the causes which have of late years affected the prosperity of our own and similar societies, that tendency to *centralization* which, during the last half century, has affected so many interests, political, social, commercial, and also scientific and literary. The facility of communication with London has facilitated that tendency to southward emigration, so long, and not unjustly, attributed to Scotchmen. But far from aiding their return, the facility seems to be all in one direction. The larger arena for practical talent to be found in the metropolis attracts even our writers of literary essays, and our labourers in the cause of physical science. It is a fact which admits of no doubt, that the Scottish Geological School, which once made Edinburgh famous, especially when the Vulcanist and Neptunian War raged simultaneously in the hall of this Society and in the class-rooms of the University, may almost be said to have been transported bodily to Burlington House. Roderick Murchison, Charles Lyell, Leonard Horner, are Scottish names, and the bearers of them are Scottish in everything save residence. Even the field of their labours is in no small measure Scottish; and the Silurian standard is waved over half the length and breadth of our "primitive" Highlands. Our younger men are drafted off as soon as their acquirements become known. Professor Ramsay was early called from his voluntary labours in

Arran to English soil; and we only retain the services which our townsman Mr Geikie volunteers for our instruction, so long as the central forces of Jermyn Street suffer him to linger within the Scottish border. Others, who still reside in Scotland, not unnaturally seek a larger audience, and a more rapid publicity for their memoirs, by transmitting them to London. This is reasonable and inevitable. Yet a certain feeling of patriotism might still retain a portion of their labours for the Transactions of our Scottish Royal Society. Indeed, it is remarkable that the centralization of which I have spoken seems to reside in London chiefly; for we do not find much tendency in Scottish towns or universities (with a few honourable exceptions) to contribute to the literary and scientific wealth of our national metropolis. I believe that the original list of the Royal Society of 1783 includes more provincial members, at all events from the Universities, than we can reckon in 1862. Of all the changes which have befallen Scottish science during the last half century, that which I most deeply deplore, and at the same time wonder at, is the progressive decay of our once illustrious Geological School. Centralization may account for it in part, but not entirely.

But I have allowed myself to be partly withdrawn from the enumeration of the causes of change which have affected the business and functions of societies for the promotion of science and literature. Another of these is the alteration of domestic habits in some important particulars. Most of the older societies commenced in *Clubs*, which met at taverns, in conformity with the all but universal usage of the period. The "Philosophical Club," which foreshadowed the Royal Society of London, met in 1649 at the Bull's Head in Cheapside; and the germ of the Royal Society of Edinburgh was a club meeting at Ranken's Tavern. All this is past and gone. The Drydens, the Addisons, and the Johnsons of our day, hold forth no longer at "Will's" or "The Mitre." If a more domestic, we are certainly a less "clubable" generation.* The effect tells even upon our literary and scientific undertakings. The clubs of modern London are rather institutions for the luxurious accommodation of individuals than for social intercourse; and the attempt of Sir H. Davy and others to combine them systematically with literary conversation, in the case of the "Athe-

* "Boswell is a very *clubable* man." Johnson, in *Boswell's Life.*

næum," proved a failure. An analogous influence is found in the vast expansion of intellectual intercourse through the means of the press, and in the filtering of knowledge of all kinds—of scientific knowledge, perhaps, especially—through the widely extended system of popular lectures. In these two features of the age, we find sufficient reasons alone to account for much of the social change to which I have referred. Newspapers, magazines, and ephemeral literature of every kind, supplant the oral intercommunication characteristic of the days of clubs. A man takes home with him to his fireside the gossip, the jokes, the discoveries, the discussions, grave or gay, of the day. And in matters of science it is somewhat the same. Much he finds of all that is most occupying the thoughts of able men pursuing natural knowledge set down in the pages of the "Athenæum," or "Macmillan," or "Good Words," perhaps by the very persons who really are most able to speak of such things. Nothing of importance can be communicated to a society which does not soon become matter of public notoriety through such channels.

But still wider is the influence of those popular discourses or lectures which now practically supply to many persons of general information, but not professed students, the intellectual interest formerly sought in the meetings of our learned Societies, and I believe I might add, in the case of Edinburgh, in some measure from our University courses also. The Royal Institution of London commenced this system with splendid advantages, and its popularity (which could scarcely increase) has been maintained with little if any diminution for sixty years. But in fulfilling its own task of instructing intelligent persons in the latest results of scientific discovery, often from the very mouths of the discoverers themselves, it has deprived of one great attraction the meetings of the Royal Society, the great fountain and source whence such knowledge ought naturally to flow. Similar influences have prevailed in Edinburgh, to the diminution of the attendance in this place. Those who can look back to the audiences assembled in this room when ordinary scientific papers were read, from twenty-five to thirty years ago, will corroborate my testimony as to the change which less than even one generation has brought about. The social spirit of coming together for common objects, self-improvement in the first place, and the charm of a periodical, a fortnightly meeting with like-minded persons (seldom perhaps met with in the interval), counteracted the tendency to criticise, and the intolerance of hearing something read not immediately or directly interesting to the hearer.

Were I to enumerate the names of that large band of our fellow-citizens, our professors, our distinguished lawyers, our country gentlemen and mere amateurs, who, meeting after meeting, used to occupy almost the same individual places on these benches, so that their loss or absence could in a moment have been noticed—I should recall to many, even now present, the different phase, in this respect, which the society of Edinburgh presented then from now. Let me first name, almost at hazard, a few of those whose images live in my memory as I now address you, as among those who as a rule attended, and as a rare exception were absent: There was the ever animated, zealous, and punctual president, Sir Thomas Brisbane; the polite and decorous Dr Hope; the indefatigable, unassuming Lord Greenock; the sagacious Dr Abercrombie; the lively, unresting Sir George Mackenzie; the hospitable Professor Russell (whose academic suppers are not even now forgotten); the beneficent, large-minded Dr Alison; the kindly, genial Professor Wallace, close to whom usually sat Mr James Jardine, with his finely chiselled features and intellectual forehead, the accurate Mr Adie, and the conscientious, modest astronomer, Mr Henderson: there was also the ingenious Sir John Robison, fertile in expedients; the frank and manly Dr Graham; the quietly humorous and ornithological Mr James Wilson; the encyclopædic Dr Traill; and the shrewd and well read, but reserved Mr W. A. Cadell. Besides, there were many others who, if they rarely took an active part in the business of the Society, were not the less persevering in their attendance,—thus giving evidence of an interest in its welfare and permanence, which any exigency, or even opportunity, would have called in action: there were Sir Henry Jardine and Lord Meadowbank; Dr Brunton and Dr Neill, occupying probably the same bench with Mr R. Stevenson and Mr Bald; Mr John Craig, Sir William Newbigging, Professor J. S. More, Mr William Wood, Archdeacon Williams, Mr George Swinton, Sir Joseph Straton, Dr Borthwick, and Mr Stark. I could far more than double the list by including those who, though not absolutely regularly, attended so frequently that their faces were familiar in this room, and their presence missed in the social gathering round the tea-table later in the evening.

I fear, gentlemen, that we now-a-days allow ourselves to become too mechanically intellectual, and also too intellectually fastidious. If the recent movement which has been set on foot for deepening and enlarging the interest felt by the members in our meetings is to take any root and produce any results, I am persuaded that it must be, though not solely, yet mainly by our Fellows recollecting that though the meetings of the Royal Society are intended for the communication of knowledge by the reading of papers, they always were, and still are, intended quite as much to promote a cordial feeling amongst those (at best but a small number in the midst of a teeming and busy population) who profess an interest in the progress of literature and science, and whose presence and conversation may contribute to this end, as well as the more formal contributions of others. I ask the more numerous portion of our Associates, if they are not disposed to contribute papers to our meetings, at least to make a contribution of *themselves*—their personal attendance, their approving interest, their mite of influence towards our commonwealth of letters. We have seen how much popular lectures have done elsewhere towards individual improvement, and the increase of a certain kind of knowledge amongst various classes; we have attributed a still wider and more beneficial influence to the periodical literature of the day; but neither of these is a *social* form of scientific and literary effort. It is *that* which we claim as one of the two remaining (perhaps only permanent) functions of our great Societies planted in different times from the present: the *one* is to afford to authors, especially to the authors of learned dissertations on science, the means (otherwise wholly unattainable) of bringing their labours in a printed form before the scientific public; the *other* function is to encourage, by an expression of personal sympathy and interest, the labours of those who devote themselves to the too often ungrateful toil of original investigation.* To the utility of the first, our Transactions bear, I

* To the two permanent functions of scientific associations mentioned in the text—namely, the printing and circulation of memoirs, and the promo-

will take it upon me to say, satisfactory testimony. Of these Scotland has just cause to be proud. Nor, on the whole, have we to complain of any deterioration in the memoirs by which this Society becomes known to the learned world. The second fulfilment of our objects of incorporation seems in some danger of being forgotten. While the older members of the Society must feel a pleasure in meeting, fortnight by fortnight, those with whom they worked in earlier days, or with whom they perhaps strove in generous rivalry, thus keeping alive those embers of mutual interest which the changing gales of life are too ready to disperse and extinguish, they may also lend their countenance to the efforts of younger men who are treading in their steps, and who may soon, if they have not already done so, occupy their own seats of influence or of honour. They may thus aid in giving coherence to the chain which binds generation to generation in the pursuit of truth, and in establishing a *personal* relation between the intellect of each, the impressive influence of which we are too apt to forget. I say, gentlemen, that this is a personal affair, which no abstract ideas can supersede,—I say that no popular lecture, listened to by hundreds of persons immediately to be dispersed into their specific individuality, no perusal of scientific digests in the study or at the fire-

tion of personal intercourse amongst literary men—we may add a *third*, that of rewarding meritorious papers or discoveries by medals and other more or less honorary distinctions. Such have existed both in British and Foreign Societies from an early period until the present. They are of two classes : rewards offered by anticipation for researches on definite subjects proposed (this obtains mostly abroad) ; and premiums awarded to the best paper or most considerable discovery, either in science generally, or in some specified branch of it. This last form is more usual in this country ; and such premiums are our Keith, Brisbane, and Neill medals. I think we must conclude that the foreign system has worked best. Many considerable memoirs of the last century on physical astronomy and similar subjects were offered in competition for such prizes. The stimulus is one which addresses itself variously to different minds, and on the whole seems to be less effective in these later times. One disadvantage of the award of medals for researches not previously defined, is the greater difficulty of awarding them without partiality or bias. A *fourth* kind of encouragement to science which our societies sometimes exert is the bestowal of funds for the prosecution of experimental investigations. This is frequently a stimulus of no small value. It was first systematically applied in this country by the British Association ; and the Government of the country have wisely committed an annual fund for such purposes to be dispensed by the Royal Society of London.

side, can replace such influences. I could speak from personal experience, if necessary, of the influence of meetings like ours, dull and commonplace though they may appear to some, upon the mind of the young student; of the zest with which he feels himself, perhaps for the first time, made the recipient of knowledge in its actual dynamic progress, not through its past hoarded acquisitions merely; the enthusiasm with which he sees (perhaps also for the first time) men of whom he has read in books, and on whom he looks with possibly excessive, yet still elevating and generous respect; how, meeting after meeting, he approaches somewhat nearer to those thus distantly regarded, and finally addresses them, though with something of reverence, as friends having a common interest in common and noble pursuits. If such alone were a result of our periodical meetings, such would alone be an adequate object for us to aim at. It is only by a certain measure of self-denial, a certain throwing off of passive or indolent habits, that we can hope to render our meetings attractive to ourselves and to one another. If all come, all will be interested; let each man, instead of pleading his inability to contribute his share to the literary and scientific proceedings, contribute at least his countenance. There is something magnetic in the concourse of intelligent persons. Not only does each element attracted increase the aggregate by its adhesion, but the aggregate so increased draws new molecules with greater force within its sphere, till the whole gathers in an increasing progression, and (as physical philosophers tell us) evolves by the mere act of aggregation that heat and light which maintain energy and vitality even to the bounds of the universe.

We all know the history of the British Association for the Advancement of Science; some here remember its origin; few have not been present at some of its meetings. Let me remind you how small a fraction of that animated whole is composed of direct contributors to the advancement of those sciences which the Society was formed to promote. Let me ask you, what would be the result if every member were requested to withdraw, who had not some paper to communicate or some remark to offer. You may imagine the dire scramble which would ensue, the clearing of benches, the faces of dismay. The dismay would not be all on the side of the retreating listeners. The small knot of studious philosophers left behind would feel discouraged by the removal of that sympathising auditory. Have we not all heard with patience, sometimes almost with interest and admiration, papers read, from which we must afterwards have confessed to ourselves if not to others that we were able to carry little or nothing away? Yet that intelligent concourse of partially instructed persons gives life to the meeting, sanction and encouragement to the really knowing, a taste for knowledge, respect for its professors, and some portions at least of positive acquirements to those who are not so. I believe that we ignore too much this element as inherent in the constitution of our learned societies. If we continue to do so, we shall degenerate (I venture to call it a degeneracy) into mere publishing clubs, whose Transactions are read by a select few, but which exist and shine by a mere "*lumen siccum*,"—disembodied existences claiming no sympathies, calling forth no regard, combining no diversities of interest.*

* I may perhaps be allowed to call attention to a striking change (on the whole) in the character of the publications of learned societies; I mean the great detail into which the papers generally run, especially in those on experimental Physics, mixed Mathematics, and Natural History. The bulk of these communications is, it may be feared, too often out of proportion to the intrinsic value of the matter which they contain. It is by no means without example to see the pages of Transactions (as well Foreign as British) occupied by a description of experiments of which the results were merely negative, and by mathematical investigations with no less indefinite conclusions. Such papers are rarely read by any one. They increase the bulk and expense of Transactions, and bewilder the unaided student. Even in cases less extreme they are encumbrances to scientific literature. An author, who has before him no fear of a printer's bill, or the remonstrances of an impatient publisher, is but too apt to please himself by expanding a small amount of matter over a goodly number of those handsome quarto pages, in which his lucubrations appear so advantageously to the eye. Even where numerical precision in the results is of primary consequence, excessive elaboration in printing the steps of calculation and instrumental corrections is often unnecessary, as well as extreme minuteness in describing forms of apparatus, and results of chemical reactions, especially where such details are not remote from common apprehension. A stricter editorial censorship than the Councils of societies usually venture to exert (similar in *kind,* though not in *degree,* to that which the editors of our leading periodicals exercise over contributors not less eminent in their departments), seems to be called for, by the expanding bulk of the volumes published by learned Bodies.

An evil nearly allied to this, is the fragmentary manner in which authors are apt to contribute the results of their inquiries. This is a consequence of

IV.—*On the Changes in the Society during the last Twelve Months.*

The past year has produced more than the usual number of casualties both on the home and foreign lists of the Society. During its course the Society has had to deplore, in common with the whole British Empire, the premature decease of H.R.H. the Prince-Consort. It would be out of place here to offer a detailed eulogy on one whose connection with our body was comparatively slight and indirect, but whose loss has been profoundly felt in nearly every home in these islands. An enlightened patronage of Science and the Arts was one of the especial characteristics of his patriotic, unselfish, and too short life.

Amongst Foreign and Honorary Fellows we miss three, all of whom were on the verge of, or had exceeded, fourscore years. These would by themselves afford topics for an address. I must allude to them very briefly.

The venerable JEAN-BAPTISTE BIOT was born 21st April 1774. He has been an Honorary Member of this Society for the uncommon period of forty-seven years, having been elected in January 1815.* He had become a member of the French Academy of Sciences in 1803, his jubilee having been celebrated nearly ten years ago. But it is also a singular and probably unprecedented fact, that at the time of his death he was a member of three out of four of the Academies composing the Institute of France; that is, of the *Académie Française*, and that of Inscriptions and *Belles Lettres*,

the struggle for priority in even second and third rate results of scientific investigation, though these are often no more than corollaries to propositions well established, or assumed to be so. Such *caveats* are better adapted for the weekly or monthly journals, where they properly and reasonably find a place. It seems to be the business of societies to consult more than they usually do, the instruction and convenience of readers, and less exclusively the sometimes inconsiderate demands on the part of authors. There is, perhaps, no society to which these remarks do not more or less apply; but the case of the *Comptes Rendus* of the French Academy of Sciences supplies an example of excessive publication so generally admitted to be an embarrassing evil that it may be referred to as a warning.

* I find by the old minute-books of this Society, that a paper by Biot on the Polarization of Light by Crystals, was read by Sir David (then Dr) Brewster at the ordinary meeting of the 15th January 1815.

as well as of the Academy of Sciences. His diversified abilities as an author are well exemplified in the miscellaneous writings collected by him before his death under the title of *Mélanges Scientifiques et Littéraires.**

His fame, however, chiefly rests on his scientific productions, especially in connection with the polarization of light. His writings on astronomy, though voluminous, are not original, except, perhaps, in their historical and antiquarian aspect. Even in his own subject, that of optics, there did not fall to his share so many capital discoveries as from his opportunities, zeal, and unbounded perseverance, might perhaps have been expected. His discovery (independently of Seebeck) of the rotation of the plane of polarization caused by liquids, is the chief of these, and he pursued it with unflagging energy into its numerous consequences during at least forty years. Biot was an instance of all that mere talent and perseverance, unsustained by great genius, can attain. His long life was one scene of intellectual labour from first to last. Brought up at the feet of the great Laplace, he was perfectly conversant with his writings, and with all that belonged to the most advanced state of mathematics of the time. His optical researches were pursued according to the traditions of the same school, as contained in the Emission- or Corpuscular-Theory. First in his latest years did he begin to betray a consciousness that Young, Fresnel, and Arago might be right, and that light is an undulation after all. But the imperfect concession had then lost all grace. His theory of Moveable Polarization, and generally his modes of conceiving complex physical phenomena, were more elaborate than satisfactory.

One of Biot's most considerable contributions to science was his determination of the length of the seconds-pendulum in different latitudes. It was the occasion of (I believe) his only visit to Scotland, which took place in the summer of 1817, when he made numerous observations at Leith Fort, and then undertook his memorable journey to the Isle of Unst, the northmost of the Shetlands, of which he has left an interesting memorial in the first volume of his published Essays.† Thus he had the no small distinction

* 3 vols. 8vo. Paris, 1858.

† Taken from the Memoirs of the Academy of Sciences.

of having carried on these important labours, under very great difficulties, over a terrestrial arc of 22° of latitude, extending from the Isle of Iviça in the Mediterranean, to that of Unst, not very far from the Arctic Circle. Of his true devotion to the scientific career which he had proposed to himself, it is impossible to speak too strongly. No distinctions except literary ones had any attraction for him. He carefully eschewed those political promotions coveted by too many of his academic compeers. His views on politics, though definitely monarchical, were never obtruded. The isolation induced by his habits of unremitting study fostered a coldness of disposition often manifested by him towards other scientific men. He had few intimate friends out of his family circle, and his encouragement towards young aspirants was cautious and intermitting. It is worthy of being added in his favour, that during the last thirty years of his life he recognised, in a marked manner, the obligations of his religious creed. Notwithstanding his very advanced age, he continued his studies on Indian astronomy to within a very short time of his death, which he met with Christian composure, on the 3d February 1862, when he had nearly completed his eighty-eighth year.

Friedrich Tiedemann, the eminent anatomist and physiologist, was born at Cassel in 1781, and died on the 22d January 1861, in the eightieth year of his age. His death was inadvertently not noticed at our last anniversary. Tiedemann was one of the most eminent comparative anatomists and physiologists of Europe. His earliest paper of note, that on the Circulation of the Echinodermata, obtained a prize offered by the French Academy of Sciences. He became Professor of Anatomy at Heidelberg in 1816, and continued so until 1848. During this period he published a celebrated work on the Human Brain, and another on that of the Monkey, as well as several works in conjunction with Oppel and Treviranus. He was blind during some of the later years of his life, but recovered his sight through an operation for cataract. Subsequent to his leaving Heidelberg, he lived in great retirement at Bremen and Frankfort.

Louis Albert Necker, honorary Professor of Mineralogy and Geology at Geneva, was born there in 1786, and died at Portree, in the Isle of Skye, on the 20th November 1862, in his seventy-sixth year. Mr Necker was far more intimately connected with this country and with this Society than our foreign members usually are; indeed he might be called a naturalised Scotchman, and he contributed papers to our Transactions. It was my intention to have entered on his biography here at some length. But I think it will be best to bring before the Society in a separate form the facts and reminiscences which I have to offer.

On our home list, we have to lament the loss of 12 of our Ordinary Fellows; a considerable number of whom had, however, also attained the full term of human life. Their names are,—Robert Bald, John Cockburn, Norwich Duff, James Forsyth, James P. Fraser, John Fyfe, J. Burn Murdoch, James Russell,* John Russell, Thomas Stewart Traill, James Walker, and Alex. Maconochie Welwood.

To replace these we reckon also 12 new Fellows,—namely, Professor Archer, Rev. W. G. Blaikie, Mr Henry Cheyne, Mr Nicholas A. Dalzell, Mr A. M. Edwards, Rev. V. G. Faithful, Dr James Hector, Dr J. P. Macartney, Dr W. B. Mackinlay, Mr Edward F. Maitland (now Lord Barcaple), Dr E. Ronalds, and Rev. Robert B. Watson.

Our numbers, therefore, remain the same as last year.

I must confine myself to a very short obituary notice of a few of our deceased Fellows who showed most interest in the proceedings of the Society.

The senior in standing as a Fellow was Mr Alexander Maconochie Welwood, better known during his active life here as Lord Meadowbank. His father also bore the same title; and was a man of much acuteness, and an original Fellow of this Society. The late Mr Maconochie Welwood was born in March 1777, he joined the Faculty of Advocates in 1799, was made Lord Advocate in 1816, and a Judge in 1819. He retired from the Bench in 1843. He joined this Society in 1817, but was not, so far as I know, a contributor to our Proceedings. He, however, took an interest in them, and for many years attended the meetings regularly. He had a large circle of acquaintances in and out of the Society; and

* Who died since the Annual Lists were made up.

though in public matters his manner was occasionally dogmatic, he was of a kind and hospitable nature, and was much regarded by a large circle of personal friends. The frequency of his attendance here contributed to excite a spirit of interest in the meetings. For about twenty years past he had lived in calm retirement in the midst of his family, and on the property which he had an hereditary pride in cultivating and adorning. He died at Meadowbank on the 30th November 1861, in the eighty-fifth year of his age.

Elected in the same year with Mr M. Welwood, but his senior by one year, was Mr Robert Bald, who for many years occupied a very high position as a mining engineer. He was born at Culross, in Perthshire, in 1776, and soon after removed to Alloa, where he early gave his attention to mining, and attracted the notice of the Earl of Marr. He was ultimately engaged in the extensive Marr Collieries,—a connection which he held for a very long period. He commenced general practice as a mining engineer in Edinburgh about the year 1820, and was very extensively employed in Scotland, England, and Wales. He was requested by the Swedish Government to report on the coalfields of that kingdom, and received from the King of Sweden marked acknowledgments of the value attached to his report by the Government of that country. Mr Bald was elected a member of the Royal Society of Edinburgh in 1817, and was a contributor to its Proceedings. He was author of a "View of the Coal Trade,"* of the article "Mine" in the Edinburgh Encyclopædia, and of numerous other papers bearing on his profession. Mr Bald was universally esteemed; and during his long stay in Edinburgh he formed many lasting friendships, which death alone terminated. He was for long in ill health, and bore his protracted and severe illness with truly Christian resignation. The latter years of his once active life were spent in retirement at Alloa, where he died in December 1861, in his eighty-sixth year.

As connected by the nature of his occupations with Mr Bald, I next notice a third octogenarian among our Fellows, Mr James

* In this work he made a benevolent and much required appeal on behalf of the miserable lot of women then employed in coal mines, under the name of "Bearers."

Walker, the eminent civil engineer, who was born at Falkirk on the 14th of September 1781. He was educated at the parish school of Falkirk, and thereafter removed to Glasgow, where he studied at the University. He went to London in the year 1800, and commenced the study of engineering under his uncle the late Ralph Walker, who was then engaged in constructing the West India Docks. Mr Walker devoted himself almost exclusively to marine engineering, in which important branch of the profession, though his rise was gradual, he ultimately attained the position of the first authority of his day. He had not a very inventive cast of mind, but he had great caution and sound judgment, and above all the faculty of profiting by his large and varied experience. His works were, in consequence, eminently successful. It would be out of place in this brief notice to attempt even an outline of his works, so varied were they in character, and so many in number. It may be sufficient to say that at the time of his death he was conducting, as Government engineer, the national harbours of refuge at Dover, Alderney, and Jersey, and the refuge harbour at the mouth of the Tyne. As engineer to the Trinity House of London, he constructed various lighthouses, including that on the Bishop's Rock, a very exposed situation. He was largely consulted in navigation and canal works; and the Stockwell Street Bridge at Glasgow may be adduced as a favourable specimen of his bridge architecture.

Mr Walker received the degree of Doctor of Laws from the University of Glasgow. He was appointed president of the Institution of Civil Engineers on the death of Mr Telford in 1834. He was a fellow of the Royal Society of London; and in 1824 he was elected into the Royal Society of Edinburgh. He had been for some time before his death in declining health, but to a robust constitution he added an abundant flow of cheerfulness and spirit; and even on the day before he died he was writing a report to the Admiralty on the subject of Alderney Harbour of Refuge. He was suddenly seized with a stroke of apoplexy, and expired on the 8th October 1862, in his eighty-first year. At his own request, his remains were interred in his family burial-place, at St John's Chapel, Edinburgh.

Dr Thomas Stewart Traill was born on the 29th October 1781, at Kirkwall, in Orkney, of which place his father was minister. Throughout his life he retained a most affectionate interest in his native islands. "He was," as we read in a contemporary notice, "*Orcadiensibus orcadiensior*, and his face lighted up, and his hand gave an extra grip, when he met with a man whose young eyes had seen the Old Man of Hoy, and who had heard the roar of the Pentland Firth from the south."

He graduated in medicine in the University of Edinburgh in 1802, where he had been the fellow-student of Lord Brougham, Sir David Brewster, Principal Lee, and other eminent persons. He is believed to have settled in Liverpool in 1804, where he constantly resided as a physician in good practice until 1832. He was highly esteemed, professionally and personally, in that great mercantile city, and formed intimate friendships with its leading men. He promoted warmly the societies founded there for the diffusion of literature and science, especially the Royal Institution of Liverpool, of which he was one of the founders and the first secretary. He maintained throughout life an intimacy with Lord Brougham, having a common interest with him in many philanthropic objects. In 1832, he was appointed to the Chair of Medical Jurisprudence in this University, which he filled until his death thirty years later. He took great pleasure in lecturing. Chemistry, mineralogy, and meteorology, were his favourite sciences. In 1804, he delivered a popular course on chemistry for a benevolent object in Kirkwall. This is said to have been the first course of the kind given in Scotland. He lectured frequently in Liverpool; and after he became a professor in Edinburgh, he not only delivered his own course of lectures, but also repeatedly that of Professor Jameson on natural history; and once at least he lectured for a session in the chemical class, during Dr Hope's decline.

He was a diligent attender on this Society, and for many years curator of the library, with a seat in the Council. He contributed a great many papers to our Proceedings, and some are printed in the Transactions.* They are not always of an important class, but are of a kind very serviceable in promoting the interest of

* In volume ix., "Account of a Mineral from Orkney," and "Electro-magnetic Observations and Experiments." Vol. xiv., "On a New Writing Ink." Vol. xv., "On Fossil Fishes found in the New Red Sandstone of

meetings such as ours, and a taste for science generally. This, indeed, was Dr Traill's *forte*. His tenacious memory storing up the results of considerable reading and extensive conversational intercourse, supplied him with ready materials for illustrating any topic brought under his notice. It is not surprising that, trusting largely to memory, his accuracy is not in all cases perfectly to be relied on. He was nominally editor of the eighth edition of the Encyclopædia Britannica, and he certainly contributed to it some forty articles; but his responsibility was, I believe, chiefly confined to the earliest volumes, the greater part having been practically edited by the able publisher, Mr Adam Black.

Latterly, owing to infirmity, Dr Traill ceased to attend the meetings of this Society, where he had, for a quarter of a century, occupied a familiar place. But his lectures he never discontinued, and persevered with them until within twelve days of his death. It was well known to his colleagues, that had he lived to complete that course, which was his thirtieth, he would then have resigned his chair. He died at Edinburgh, on the 30th July last, in his eighty-first year, being the *fourth* octogenarian on our list.

Yet one more venerable colleague and useful member remains to be noticed.

Mr John Russell, writer to the Signet, and for eighteen years treasurer of the Society, was born 22d February 1780. He was descended from three generations of men who had exercised in Edinburgh the same respectable calling. By his mother's side, however, he inherited of right a taste for literature; for she was daughter of Principal Robertson, an honourable connection, which Mr Russell always loved to recall. In point of fact, Mr Russell retained throughout an active professional career both the tastes and acquirements of a well-educated man and a scholar. He was intimate with many of

Orkney," and on "*Berg-meal*, or Mineral Flour of Degersfors, in Swedish Lapland." In vol. xvi., "Memoir of Dr T. C. Hope." In vol. xx., "On a Peruvian Musical Instrument." In vol. xxi., "On the Torbanehill Mineral." These titles give a good general idea of the varied subjects of Dr Traill's communications. His last contribution to the Society seems to have been that made on 15th February 1858, "Description of the Sulphur Mine of Conil [in Spain], preceded by a Notice of the Geological Features of the Southern portion of Andalucia." An abstract appears in our "Proceedings," vol. iv. p. 77.

those who, some forty years ago, rendered the literary society of Edinburgh famous, with not a few of whom he was associated as one of the founders of the Edinburgh Academy, in which he took a life-long interest. He became a Fellow of this Society in 1822, and its Treasurer in 1838. He fulfilled the duties of the latter office in a very exemplary manner, as I can testify from personal knowledge. He devoted to it not a little of his time, and brought the finances into a better state than they had been for a long time previously. For a good many years past his health prevented him from taking his place at the evening meetings; but so long as he possibly could, he assiduously attended at council meetings, and in 1857, when he could no longer do so, he resigned his office. On that occasion he received from the Society a piece of plate as a recognition of his valuable services. His latter years were tranquilly spent at Southbank, near Edinburgh, a charming villa bequeathed to him by his uncle, General Robertson. I have very often visited him there, and found him ever cheerful and occupied, generally with literary pursuits, in which to the last he took a real pleasure. At my very latest visit I found him refreshing his recollections of the Latin Classics. He was a man of wide sympathies, and had many friends of all parties. He was a sincere Christian, and died at peace with all men. This happened on the 30th January 1862, when he had almost completed his eighty-second year. He is therefore the *fifth* octogenarian on our list, besides foreign members.

Of the remaining names on our obituary list I do not feel called on to say much. But I must mention Dr Fyfe, a highly respectable chemist, and a well-known lecturer in Edinburgh. He was at first chemical assistant to Dr Hope. In and after 1817, he lectured at the Society of Arts, and in 1844 was appointed to the Chair of Medicine in Aberdeen, having already been President, the year before, of the Royal College of Surgeons of Edinburgh. He died on the 31st December 1861, aged nearly seventy years.

Admiral Norwich Duff, born in 1793, was descended from the first Earl of Fife. His earlier years were spent in active service in various parts of the world. Even before he was twenty he had taken part in several great naval battles. About the time of entering this Society, in 1823, he was well known in Edinburgh, where he spent several winters, though he may be perhaps recollected by few persons now present. He married in 1833 a lady of Bath, and he died in that city in the course of last summer.

Mr Burn Murdoch and Mr John Cockburn (brother of the late Lord Cockburn) both frequently attended our meetings, but otherwise require no detailed notice here. The former was an active agriculturist and country gentleman, and died in August last in his seventieth year.

Dr James Russell, whose death, at the age of sixty-one, occurred only on the 21st November last, was the eldest son of Mr James Russell, Professor of Clinical Surgery, and grandson of the Professor of Natural Philosophy (also in this university), who was the predecessor of Dr Robison. Dr Russell lived a retired life, and although a physician, had not for many years practised his profession.

I have now, gentlemen, with some prolixity I fear, attempted to go over the ground which I had in view when we started. My great object has been to induce you to give a fair consideration to the claims which the objects of this really national institution—the Royal Society—has upon you, its members. I have asked you to look back to your origin,—to the constellation of eminent men who assisted at your incorporation,—to the important labours which the Transactions include,—to the social meetings which, with varying brilliancy and significance, have for eighty years connected generation with generation of the literary and scientific men of this metropolis and university-seat with one another; and I ask you to assist now, by your personal efforts, by your literary contributions if possible, at least by your attendance at our evening meetings, in adding to the interest and value of these meetings; I ask you to encourage those who labour for the promotion of original research, to maintain the credit of a society established for purposes the most disinterested and humanizing, and by so doing to justify the position which the Royal Society of Edinburgh assumes, of representing in some degree before the academies of Europe the intellect and original talent of our native country.

The following Gentlemen were duly elected Ordinary Fellows:—

Robert Campbell, Esq., Advocate.
Hugh F. C. Cleghorn, M.D., Conservator of Forests, Madras.
Professor Blackie.

The following Donations to the Library were announced:—

Ἱπποκράτους καὶ ἄλλων ἰατρῶν παλαιῶν λείψανα. Hipporcatis et aliorum Medicorum veterum reliquiæ. Mandatu Academiæ regiæ disciplinarum quæ Amstelodami est. Edidit Franciscus Zacharias Ermerins. Volumen Primum. Trajecti ad Rhenum. 1859. 4to.—*From the Academy.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Natuurkunde. Achste Deel. 8vo.—*From the same.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Natuurkunde. Negende Deel. I. II. en III. Stuk. 8vo.—*From the same.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Letterkunde. Vierde Deel. I. II. en III. Stuk. 8vo.—*From the same.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Letterkunde. Eerste Deel. Met Platen. 4to.—*From the same.*

Verhandelingen der Koninklijke Academie van Wetenschappen. Zevende Deel. Met Platen. 4to. *From the same.*

Jaarboek van de Koninklijke Academie van Wetenschappen gevestigd te Amsterdam voor 1858. 8vo.—*From the same.*

Verlag van het Verhandelde in de Algemeene Vergadering van der Provincial Utrechtsche Genootschap van Kunsten en Wetenschappen, 25 en 26 June 1861. 8vo.—*From the Association.*

Aanteekeningen van het Provincial Utrechtsche Genootschap van Kunsten en Wetenschappen, 1859, 1860, en 1861. 8vo.—*From the same.*

Memorias da Academia real das Sciencias de Lisboa: Classe de Scientias Mathêmaticas, Physicas e Naturaes. Nova Serie. Tomo II., Parte 1 e 2. 4to.—*From the Academy.*

Resúmen de las Actas de la real Academia de Ciencias de Madrid por los años 1857, 1858, 1859, y 1860. 8vo.—*From the Academy.*

Memorias de la real Academia de Ciencias de Madrid. Tome III., IV., y V. 4to.—*From the same.*

La Botánica y los Botánicos de la Península Hispano-Lusitana: Estudios bibliográficos y biográficos per don Miguel Colmeiro, Madrid. 8vo.—*From the same.*

Notiser ur Sällskapets pro Fauna et Flora Fennica Förhandlingar: IV., V., and VI. Häftet, 1858, 1859, and 1861. Helsingfors. 8vo.—*From the Society.*

Diatomaceis Fenniæ Fossilibus Additamentum scripsit William Nylander (Aftryck ur Sällskapets pro Fauna et Flora Fennica Notiser VI., ny serie, 3 Häftet) Helsingfors. 8vo.—*From the Author.*

Berichte über die Verhandlungen der Königl. sächsischen Gesellschaft der Wissenschaften zu Leipzig. I. and II. von der Mathematisch-physischen Classe; und II., III., u. IV., von der Philologisch-historischen Classe. 8vo.—*From the Society.*

Preisschriften gekrönt und herausgegeben von der fürstlich Jablonowski'schen Gesellschaft zu Leipzig. IX.: Victor Böhmert's Beiträge zur Geschichte des Zunftwesens. 8vo.—*From the Society.*

Locke's Lehre von der Menschlichen Erkenntniss in Vergleichung mit Leibniz's Kritik derselben dargestellt von G. Hartenstein. No. II. 8vo.—*From the same.*

Die Deutsche national-ökonomik an der Grenzscheide des 16ten u. 17ten Jahrhunderts von William Roscher. No. III. 8vo. —*From the same.*

Messungen über die Absorption der Chemischen Strahlen des Sonnenlichts von W. G. Hankel. 8vo.—*From the same.*

P. A. Hansen's Darlegung der theoretischen Berechnung der in den Mondtafeln angewandten Störungen. Erste Abhandlung. 8vo.—*From the same.*

Verhandlungen des Vereins für Naturkunde zu Presburg. IV. Jahrgang, 1859, u. V. Jahrgänge, 1860 u. 1860. 8vo.—*From the Society.*

Klimatographische Uebersicht der Erde von A. Mühry, M.D. 8vo. —*From the Author.*

Physica Sacra Johannes Jacobi Schevchzeri, Medicinæ Doctoris, et Math. in Lyceo Figvrino Prof., etc., Iconibvs aëneis illvstrata. Tomi quattvor. Avgvstæ Vindelicorvm et Vimæ 1831. Folio.—*Presented by Patrick Miller, Esq., M.D., F.R.S.E., Exeter.*

Monthly Notices of the Royal Astronomical Society. Nos. 7–9. 1862. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society of London. Nos. 3–5. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society, May to November 1862. 8vo.—*From the Society.*

Proceedings of the Medico-Chirurgical Society of London. Vol. IV., Nos. 1, 2. 8vo.—*From the Society.*

The Assurance Magazine. Vol. X., Part 5. 8vo.—*From the Society.*

Journal of Agriculture, July and October 1862. 8vo.—*From the Highland Society.*

Journal of the Chemical Society, from May to November 1862. 8vo.—*From the Society.*

Proceedings of the Linnean Society. Vol. VI., Nos. 23, 24. 8vo. —*From the Society.*

Journal of the Asiatic Society of Bengal. No. 4, 1861; and Nos. 1 and 2, 1862. 8vo.—*From the Society.*

Journal of the Royal Asiatic Society. Vol. XIX., No. 3; and Vol. XX., No. 1. 8vo.—*From the Society.*

Journal of the Statistical Society, June and September 1862. 8vo. —*From the Society.*

Journal of the Royal Geographical Society. Vol. XXXI. 8vo. —*From the Society.*

Medico-Chirurgical Transactions. Vol. XLV. 8vo.—*From the Society.*

Transactions of the Historic Society of Lancashire and Cheshire. New Series. Vol. I. 8vo.—*From the Society.*

Manual of Hydrology. By Nathaniel Beardmore, C.E. 8vo.—*From the Author.*

Radcliffe Observatory. Vol. XX. 8vo.—*From the Radcliffe Trustees.*

The American Journal of Science and Arts. Nos. 97–101. 8vo. —*From the Conductors.*

Philosophical Transactions of the Royal Society of London, Parts 1, 2, and 3, and Part 1, 1862, 4to.—*From the Society.*

Proceedings of the Royal Society. Vol. XII., Nos. 49–51. 8vo. —*From the same.*

Transactions of the Royal Society of Literature. Second Series. Vol. VII., Part II. 8vo.—*From the Society.*

The Canadian Journal of Industry, Science, and Art. Nos. 38–40. 8vo.—*From the Institute.*

The Journal of the Royal Dublin Society. Nos. 24, 25. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. IX., Part II. 8vo.—*From the Society.*

The Geographical Distribution of Material Wealth. By A. K. Johnston, F.R.S.E. II. Historical Notes regarding the Merchant Company of Edinburgh, and the Widows' Scheme and Hospitals. 8vo.—*From the Right Honourable the Lord Provost.*

Geology of Canada, and Geological Survey of Canada. Two Parts. 8vo. *From Sir W. E. Logan.*

The Mechanism of the Heavens. By James Reddie, Esq. 8vo. —*From the Author.*

Memoirs of the Literary and Philosophical Society of Manchester. Vol. I. 8vo.—*From the Society.*

Proceedings of the Literary and Philosophical Society of Manchester. Vol. II. (with the Society's Rules.) 8vo.—*From the Society.*

Notice of a Mass of Meteoric Iron. By J. A. Smith, M.D.; and Chemical Analysis of the same, by Murray Thomson, M.D. 8vo.—*From the Authors.*

Madras Journal of Literature and Science. December 1861. 8vo. —*From the Society.*

Memoirs of the Geological Survey of India. Vol. III., Part 1. 4to.

Proceedings of the Literary and Philosophical Society of Liverpool. No. 16. 8vo.—*From the Society.*

The Museum of Natural History—Art. "Fishes." By Sir Joh. Richardson, C.B., &c. 8vo.—*From the Author.*

Errata in Hansen's Lunar Tables. 8vo.—*From J. R. Hind, Esq.*

Monthly and Quarterly Returns of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. From May to October 1862. 8vo.—*From the Registrar-General.*

Atti dell' Imper. Reg. Istituto Veneto di Scienze, Lettere, ed Arti. 1861, dispenza decima; 1862, dispense 1, 2, 3. 8vo.—*From the Institute.*

Memorie del Reale Istituto Lombardo di Scienze, Lettere ed Arti. Vol. VIII., Fasc. VI. Milano. 8vo.—*From the Institute.*

Sur le Magnétisme et sur l'Electricité pendant les Orages. Par A. Secchi et Ad. Quetelet. 8vo.—*From the Royal Belgian Academy.*

Sur l'Etoiles Filantes. Par E. Herrick et Ad. Quetelet. 8vo.—*From the same.*

Annuaire de l'Academie Royale. 12mo.—*From the same.*

Annuaire de l'Observatoire Royale de Bruxelles. Par Ad. Quetelet. 16mo.—*From the same.*

De la Nécessité d'un Système Général d'Observations Nautiques et Météorologiques. Lettre de M. Maury, Directeur de l'Observatoire de Washington, à M. Ad. Quetelet. 8vo.—*From the same.*

Observations sur Différents Sujets d'Astronomie et de Physique du Globe. Par M. Ad. Quetelet. 8vo.—*From the same.*

Etoiles Filantes et Magnétisme. Par M. Ad. Quetelet. 8vo.—*From the same.*

Sur la Statisque Générale des Différents Pays. Par M. Quetelet.—*From the same.*

Mémoires Couronnés et Autres Mémoires, publiés par l'Academie Royale de Bruxelles. Tomes XI. and XII. 8vo. *From the Academy.*

Bulletins de l'Academie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique, 1861. Tomes XI. et XII. 8vo.—*From the same.*

Annales de l'Observatoire Royal de Bruxelles. Par. A. Quetelet. 4to.—*From the Academy.*

Mémoires Couronnés et Mémoires des Savants étrangères publiés. Par. l'Academie Royale de Belgique. Tome XXX. 4to.—*From the same.*

Observations des Phenomènes Périodiques. 8vo.—*From the same.*

Bulletin de la Société des Sciences Naturelles de Neufchâtel. Tome V. 8vo.—*From the Society.*

Mittheilungen der Naturforschenden Gesellschaft in Bern aus dem Jahre 1861. 8vo.—*From the Society.*

Bulletin de la Société Vaudoise des Sciences Naturelles. Tome VII., 48. 8vo.—*From the Society.*

Observations Astronomiques, 1^er^ Supplement au Tome XVI., 17^e^ et 18^e^ serie. 4to.—*From the Natural and Physical Society of Geneva.*

Nouvelles Récherches sur les Aurores Boréales et Australes, &c. Par M. de la Rive. 4to.—*From the Author.*

Further Researches on the Aurora Borealis. By M. de la Rive. 8vo.—*From the same.*

Résumé Météorologique de l'Année 1860, pour Genève et le Grand St Bernard. Par E. Plantamour. 8vo.—*From the Author.*

Note sur les Variations Périodiques de la Temperature et de la Pression Atmospherique au Grand St Bernard. 8vo.—*From the same.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München. Heften i. u. ii., 1861, u. I. Heften i. ii., u. iii., 1862. 8vo.—*From the Academy.*

Ueber Vertheilung des Magnetismus in Cylindrischen Stahl-Stäben. Von Dr Casper Rothlauf. 8vo.—*From the same.*

Annalen der königl. Sternwarte bei München, XI. Band. 8vo.—*From the Royal Observatory.*

Verzeichniss der Mitglieder der k. b. Akademie der Wissenschaften, 1862. 4to.—*From the Academy.*

Zum Gedächtniss an Jean Baptiste Biot, von C. F. Philipp von Martius. 4to.—*From the same.*

Abhandlungen der historischen Classe der k. b. Akademie der Wissenschaften zu München. IX^tes^ Bandes 1^te,^ u. 2^te,^ Abtheilung. 8vo.—*From the same.*

Von der Bedeutung der Sanskrit-studien für die Griechische Philologie. Von Dr Wilhelm Christ. 4to.—*From the same.*

Reden gehaltene am 26^ten^ März 1861, und am 28^ten^ November 1861. Vom Freiherrn von Liebig. 4to.—*From the same.*

Denkrede auf Gotthilf Heinrich von Schubert gehaltene von Dr A. Wagner am 26ten März 1861. 4to.—*From the same.*

Gedächtniss-rede auf Friedrich Tiedemann vorgetragene am 28ten Nov. 1861 von Dr T. L. W. Bischoff. 4to.—*From the same.*

Denkrede auf Dr Georg Thomas V. Rudhart gelesene am 26ten März 1861 von K. A. Muffatt. 4to.—*From the same.*

Ueber Briefstellen, u. Formelbücher in Deutschland während des Mittelalters. Von Dr L. Rockinger. 4to.—*From the same.*

Ueber die lange Dauer u. die Entwickelung des Chinesischen Reichs. Von Dr H. Plath. 4to.—*From the same.*

Abhandlungen der mathematisch.-physikalischen Classe der k. b. Akademie der Wissenschaften zu München IXtes Bandes 1te u. 2te Abtheilung. 8vo.—*From the same.*

Ueber Parthenogenesis. Von Dr C. Th. E. von Siebold. 4to.—*From the Author.*

Reise der österreich. Fregatte "Novara" um die Erde. Nautico-Physical Part. First Section. 4to.—*From the Austrian Government.*

Beilage to the above.—*From the same.*

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften zu Wien. November and December 1861; January, February, March, April 1862. 8vo. *From the Academy.*

Sitzungsberichte der kaiserl. Akademie der Wissenchaften; October, November, December 1861; January 1862. 8vo.—*From the same.*

Sitzungsberichte der kaiserl. Akademie der Wissenschaften. Mathematisch-Naturwissenschaftlich Classe. April, June, July, October, November, December, 1861; January and February 1862. 8vo.—*From the same.*

Almanach der kaiserl. Akademie der Wissenschaften. 12ter Jahrgang. 1862. 8vo. *From the same.*

Jahrbücher für Meteorologie u. Erd. Magnetismus von Karl Kreil. VIIItes Band. Jahrgang 1856. 4to.—*From the same.*

Felsöbb Eggentletek egy Ismeretlennel irta D. Vallas Antal: Elzö Füzet. 8vo.—*From the Academy of Pest.*

Természettudomanyi Palyamunkák, 1st, 2d, and 3d Kötet. 8vo.—*From the same.*

Mathematicai' Palyamunkák 1 kötet. 8vo.—*From the same.*

A' Felsöbb Analysis Elemei irta lyöry Sändor. I. and II. Füzet. 4to.—*From the same.*

Elmékedések a' Physiologia es Psychologia' Körében irta D. Mocsi Mihali.—*From the same.*

A Puhányok Izomrostjairol, etc. 4to.—*From the same.*

A Hangrendszer Kiszamitasarol, etc. 4to.—*From the same.*

Magyar Akademiai Ertesítö uj folyam. Elsó Kötet. I., II., and III., szam. 8vo.—*From the Academy.*

Index to the Catalogue of a Portion of the Public Library of the City of Boston, arranged in the Lower Hall (with four Supplements). 8vo.—*From the Trustees.*

Eighth and Ninth Annual Report of the Trustees of the Public Library of Boston. 8vo.—*From the same.*

Catalogue of Books in the Upper Hall of the Library of Boston. 8vo.—*From the same.*

Abstracts of the Observations taken at the Stations of the Royal Engineers, from 1853 to 1859. Edited by Colonel Sir H. James, R.E. 4to.—*From the Secretary of State for War.*

Proceedings of the Academy of Natural Science of Philadelphia. 4 parts. 8vo.—*From the Academy.*

Journal of the above. Vol. V., Part 1. 4to.—*From the same.*

Observations on the Genus Unio, etc. By Isaac Lea, LL.D. Vol. VIII., Part 2. 4to.—*From the same.*

Publications of Isaac Lea, LL.D., on Recent Conchology. 3 parts. 8vo.—*From the same.*

Parliamentary Papers on the Burke and Wills Commission. Victoria, 1861–62.—*From Major-General Sir Thomas Pratt, K.C.B., to Rev. Dr Hanna.* Folio.—*Presented by Dr Hanna.*

Bulletin de la Société de Geographie, 5ième série. Tomes II. et III. 8vo.—*From the Society.*

Annales hydrographiques au Dêpot des Cartes et Plans de la Marine. Nos. 311–328. 8vo.—*From the Dêpot.*

Le Vrai Principe de la Loi des Ouragans appliqué d'une manière pratique aux deux hemisphères. Par James Sedgwick. Traduit de l'Anglais. 8vo.—*From the same.*

Description hydrographique de la Côte Orientale de la Corée et du Golfe d'Osaka. 8vo.—*From the same.*

Pilote Française, 1860.—*From the Depôt de la Marine.*

James Horsburgh's Instructions nautiques, 1ere partie. 4to. 1861. —*From the same.*

Renseignements nautiques sur les Côtes de Patagonie. 8vo.—*From the same.*

Instructions nautiques sur les Côtes d'Islande. 8vo.—*From the same.*

Annales hydrographiques. Nos. 333 et 336. 8vo.—*From the same.*

Annuaire des Marées des Côtes de France pour les années 1862 et 1863. 12mo.—*From the same.*

Fortschritte der Physik im Jahre 1859, dargestellt von der physikalischen Gesellschaft zu Berlin. XV. Jahrgang. 8vo.—*From the Society.*

Monatsberichte der königl. preussischen Akademie der Wissenschaften zu Berlin; aus dem Jahre 1861. 8vo.—*From the Academy.*

Abhandlungen der königl. preuss. Akademie der Wissenschaften zu Berlin 1861. 4to.—*From the Academy.*

Schriften der königl. physikalisch-ökonomischen Gesellschaft zu Königsberg. Zweiter Jahrgang 1861. 1te u. 2te Abtheilung. *From the Society.*

Novorum Actorum Academiæ Cæsareæ Leopoldino-Carolinæ Germanicæ Naturæ Curiosorum tomus 29. Jenæ. 4to.—*From the Academy.*

Abhandlungen herausgegeben von der Senckenbergischen naturforschenden Gesellschaft. Viertes Bandes erstes Heft. 4to. —*From the Society.*

Denkschriften der kaiserlichen Akademie der Wissenschaften—(Mathematisch-naturwissenschaftliche Classe.) 20ster Band. 4to.—*From the Academy.*

Jahrbuch der kaiserl.-königlichen geologischen Reichsanstalt, January 1861 to April 1862. 8vo.—*From the Reichsanstalt.*

Natuurkundige Verhandelingen van de Hollandische Maatschappij der Wetenschappen te Haarlem. Tweede Verzameling Zestiende Deel. 1862. 4to.—*From the Association.*

Schriften der Universität zu Kiel aus dem Jahre 1861. Bänder VII. u. VIII. 4to.—*From the University.*

Des Mineralogen und Chemikers Joh. Wep. von Fuchs. 4to.—*From Professor Kaiser.*

Relations des Experiences enterprises par ordre de S. E. M. le Ministre des Travaux Publiques, et sur la demande de la Commission Centrale des Machines à Vapeur, pour déterminer les lois et les données physiques necessaires au calcul des Machines à Feu. Par M. V. Regnault. Tome Second. 4to.—*From the Author.*

Eleventh Number of Meteorological Papers. Compiled by Admiral Fitzroy, F.R.S. 8vo.—*From the Board of Trade.*

Report of the Meteorological Department of the Board of Trade, 1862. 8vo.—*From the same.*

Transactions of the Royal Irish Academy. Vol. XXIV., Part II., Science. 4to.—*From the Academy.*

Contents of the Correspondence of Scientific Men of the 17th Century. Compiled by A. D. Morgan, F.R.S., &c. 8vo.—*From the Author.*

Reports on the Isthmus of Krau. By Captains Fraser and Forlong, April 1861. Folio.—*From the Authors, by Major Scott.*

Revue Orientale et Americaine. Par Léon de Rosny. Paris. 8vo. —*From the Author.*

On the Probable Causes of the Earth Currents. By the Rev. H. Lloyd, D.D. 8vo.—*From the Author.*

Quarterly Reports of the Meteorological Society of Scotland, March and June 1862. 8vo.—*From the Society.*

Notice of the Angwántibo of Old Calabar. By J. A. Smith, M.D. 8vo.—*From the Author.*

Carte Agronomique des Environs de Paris. Par M. Delesse. 8vo. —*From the Author.*

The Bell Rock Light-House; Letter by David Stevenson, F.R.S.E. 8vo.—*From the Author.*

The Essentials of a Healthy Dwelling, and the Extension of its Benefits to the Labouring Population. By Henry Roberts, F.S.A., etc. 8vo.—*From the Author.*

Calendar of the University of Queen's College, Kingston, Canada, Session 1862–3. 8vo.—*From the University.*

Annual Report of the Geological Survey of India, and of the Museum of Geology. Fifth Year, 1860–1. 8vo.—*From the Survey.*

The Description, Composition, and Preparations of the *Sanguinaria Canadensis*, by Geo. D. Gibb, M.D., etc. 8vo.—*From the Author.*

International Exhibition, 1862; Catalogue of the Nova Scotian Departments. 8vo.—*From the Secretary.*

Greenwich Observations, 1860. 4to.—*From the Board of Admiralty.*

The Quarterly Journal of the Geological Society. Nos. 69, 70, and 71. 8vo.—*From the Society.*

Flint Implements in the Drift, being an Account of their Discovery in the Continent and in England. By John Evans, F.S.A., etc. 4to.—*From the Author.*

Annals of the Botanical Society of Canada. Vol. I., Part. III. 4to.—*From the Society.*

Reduction of the Observations of the Deep-sunk Thermometers at the Royal Observatory, Greenwich, from 1846–59. By Professor J. D. Everett, Nova Scotia. 4to.—*From the Author.*

List of Fellows of, and Papers read before, the Royal Institute of British Architects, 1861–2. 4to.—*From the Institute.*

The Theory of Probabilities, by George Boole, F.R.S. 4to.—*From the Author.*

Abstracts of Meteorological Observations in 1860–1. Edited by Sir H. James, R.E. 4to.—*From the Editor.*

Memoirs of the Geological Survey of India: Palæontologica Indica. Edited by Thomas Oldham, LL.D. 4to.—*From the Editor.*

Proceedings of the Society of Antiquaries of London (with Lists). Vol. I., Nos. II.–VII. 8vo.—*From the Society.*

Memoirs of the Royal Astronomical Society of London. Vol. XXX. 4to.—*From the Society.*

Meteorologische Waarnemingen en Nederland en Zijne Bezittingen, etc., 1859–60. Oblong 8vo.—*From the Royal Meteorological Institute of the Netherlands.*

Récherches sur l'Evolution des Araignées. Par M. E. Claparède. 4to.—*From the Society of Arts and Sciences at Utrecht.*

Compte Rendu de la Commission Imperiale Archéologique pour l'Année 1860, et Atlas. S. Petersbourg. Folio.—*From the Russian Government.*

Monday, 15th December 1862.

Professor CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. On the Representative Relationships of the Fixed and Free Tunicata, regarded as two sub-classes of equivalent value; with some general remarks on their morphology. By John Denis Macdonald, Esq., R.N., F.R.S., Surgeon H.M.S. "Icarus." Communicated by Professor Maclagan.

In this paper the author maintains the proposition, that the class Tunicata may be conveniently divided into two sub-classes, viz., the Fixed or Stationary, and the Free or Locomotive, of at least nearly equal value in a zoological point of view, in opposition to the opinion commonly entertained, that the so-called Pelagic Tunicata compose a group only commensurate with the groups of the Compound, the Social and the Simple, into which the Fixed Tunicata have been divided by Milne-Edwards and others.

After some general remarks on the morphology of the class Tunicata, the author proposes the classification, of which the following are the leading subdivisions, and under which he groups and classifies the various genera of Tunicata.

Tunicata.

Sub-class 1st.—Animals fixed or stationary.

I. Branchial membrane closely adherent, or more or less perfectly sac-like; simply areolated or distinctly retiform, the meshes disposed in many transverse series without non-ciliated supporting bars.

1. Gemmæ springing directly from the parent, with a temporary bond of union—Simple Tunicata.
2. Gemmæ springing separately from a definite "ascidiarium" (Hux.), and communicating indirectly through a central common vascular system—Social Tunicata.
3. Gemmæ arising separately from the parent with or without vascular intercommunication, but always immersed in a common test or "ascidiarium"—Compound Tunicata.

Sub-class 2d.—Animals free, locomotive.—Pelagic Tunicata.

II. Branchial membrane sac-like, with transverse slits in single longitudinal series, strengthened by longitudinal non-ciliated rods, apertures terminal or sub-terminal.

III. Respiring by an upper and a lower gill-band, connected with each other laterally, and with the walls of the atrium; having branchial slits, but no supporting longitudinal rods; apertures terminal.

IV. Respiring by a central and inferior gill-band, with free borders and transverse ciliated stripes, but without slits or rods; apertures terminal or sub-terminal.

V. Pharynx ciliated below, without a distinct gill-band; branchial slits reduced to two ciliated openings on the sides of the rectum.

The author concludes his paper with remarks on several of the genera, in reference to the position assigned to them in his classification, and with some details as to the anatomy of Orthocala—the *Salpa pinnata* of authors.

2. On the great Refractor at Elchies, and its powers in Sidereal Observation. By Professor C. Piazzi Smyth, Astronomer-Royal for Scotland.

The telescope here referred to is the largest and best ever erected in Scotland, for exact sidereal observation; and the author having paid a visit last September to its liberal and hospitable owner, J. W. Grant, Esq., of Elchies, Morayshire, had an opportunity of trying its powers on double stars, and describes the results of the trial in his paper.

Out of a list of twenty-nine double stars, there were six cases where one or more new small stars were discovered; and the observations of position and distance on the older members of each group were so trustworthy, as to add valuable information towards elucidating both the proper motion of some *optical* double stars, and the orbital motion of several *binary* ones. In addition to which, several unexpected results were arrived at with reference to cosmical changes in the magnitudes and colours of certain stars.

The following Donations to the Library were laid on the Table:—

Smithsonian Miscellaneous Collections. Vols. I., II., III., and IV. 8vo.—*From the Institution.*

Thirteenth Annual Report of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History, &c. 8vo.—*From the Regents of the University.*

Proceedings of the American Philosophical Society. Vol. VIII., Nos. 64, 65, and 66. 8vo.—*From the Society.*

Annual Report of Brevet Lieutenant-Colonel J. D. Graham on the Improvement of the Harbours of Lakes Michigan, S. Clair, Erie, Ontario, and Champlain, for the year 1860. 8vo.—*From the American Government.*

Manual of Public Libraries, Institutions, and Societies in the United States and British Provinces of North America. By William J. Rhees. 8vo.—*From the Smithsonian Institution.*

Studies in Organic Morphology. By John Warner. 8vo.—*From the Author.*

Fifteenth Annual Report of the Ohio State Board of Agriculture for the year 1860. 8vo.—*From the Ohio Board.*

Annual Report of the Board of Regents of the Smithsonian Institution for 1860. 8vo.—*From the Institution.*

Transactions of the Pathological Society of London. Vol. XIII. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. December 1862. 8vo.—*From the Society.*

Jahresbericht über die Fortschritte der Chemie für 1861. Besorgt von Wilhelm Hallwachs. Erste Hälfte. 8vo.—*From the Editor.*

The Quarterly Journal of the Geological Society. Vol. XVIII., No. 72, Pt. 4. (With Charter, and Bye-Laws, and List of Members.) 8vo.—*From the Society.*

On the Danger of Hasty Generalization in Geology. By Alexander Bryson, Esq., F.R.S.E. 8vo.—*From the Author.*

Report upon the Colorado River of the West; explored in 1857 and 1858 by Lieutenant Joseph C. Ives, by Order of the

Secretary of War Royal 8vo.—*From the American Government.*

Transactions of the Linnean Society of London. Vol. XXIII., Part Second. 4to.—*From the Society.*

Results of Meteorological Observations made under the Direction of the United States Patent Office and the Smithsonian Institution, from the year 1854 to 1859 inclusive: being a Report of the Commissioner of Patents made at the First Session of the Thirty-Sixth Congress. Vol. I. 4to.—*From the Smithsonian Institution.*

Nova Acta Regiæ Societatis Scientiarum Upsaliensis, seriei tertiæ Vol. IV. Fasc. 1., 1862. 4to.—*From the Society.*

Ofversigt af Kongl. Vetenskaps—Akademiens Fördhandlingar. Adertonde Argangen. 1861. 8vo.—*From the Academy.*

Kongliga Svenska Vetenskaps—Akademiens Handlingar. Ny Följd. Tredje Bandet. Andra Häftet. 1860. 4to.—*From the same.*

Meteorologiska Jakttagelser Sverige utgifna af Kongl. Svenska Vetenskaps—Akademien bearbetade af Er. Edlund. Andra Bandet. 1860. 8vo.—*From the same.*

Report on the Physics and Hydraulics of the Mississippi River; upon the protection of the Alluvial Region against Overflow, etc. Prepared by Captain Humphreys and Lieutenant Abbot. 4to.—*From the American Government.*

Transactions of the American Philosophical Society, held at Philadelphia for Promoting Useful Knowledge. Vol. XII. New Series. Part I. 4to.—*From the Society.*

Memoirs of the American Academy of Arts and Sciences. New Series. Vol. VIII. Part I. 4to.—*From the Society.*

Proceedings of the above; from the Four Hundred and Ninety-Sixth to the Five Hundred and Seventh Meeting. 8vo.—*From the same.*

Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt, 1861 and 1862. XII. Band., Nro. 3. Mai, Juni, Juli, August 1862. Wien. 8vo.—*From the Reichsanstalt.*

Die Fossilen Mollusken des Tertiär-beckens von Wien. Von Dr Moritz Hörnes. 8vo.—*From the same.*

Bulletin de l'Académie Impérial des Sciences de St Pétersbourg.

Tome IV., Nos. 3, 4, 5, and 6. 8vo.—*From the Academy.*

Mémoires de l'Académie Impériale des Sciences de St Petersbourg. VII^e. Série. Tome IV., Nos. I. to IX. 8vo.—*From the same.*

Rendiconto delle Sessioni dell' Accademia delle Scienze dell' Istituto di Bologna. Anno Accademico 1859–60, e 1860–1. 12mo.—*From the Academy.*

Memorie dell' Accademia delle Scienze dell' Istituto di Bologna. Tomo X., Fasc. I., II., e III.; e Tomo. XI. 8vo.—*From the same.*

Memorie del Reale Istituto Lombardo di Scienze, Lettere, ed Arti. Vol. VIII., Fasc. 7; e Vol. IX., Fasc. 1. 8vo.—*From the Institute.*

Atti del Reale Istituto Lombardo di Scienze, Lettere, ed Arti. Vol. II., Fas. 15, 16, 17, 18, 19, e 20; e Vol. III., Fasc. 1–4.

Forhandlinger i Videnskabs-selskabet i Christiania. Aar 1861. 8vo.—*From the Society.*

Flateyjarbok en Samling af Norske Konge-Sagaer, etc., 1859, 1860, 1861, 1862. 8vo.—*From the Society.*

Geologiske Undersgelser i Bergens-Omega af Th. Hiatdahl og M. Irgens. 4to.—*From the Authors.*

Beskrivelse over Lophogaster Typicas, af Dr Michael Sars. 4to.—*From the Author.*

Beskrivelse over Aas høiere Landbrugskole af F. A. Dahl. 4to.—*From the Author.*

Fortegnelse over Modeller af Landhusholdnings. Redskaber fra Ladegaard sens Hovedgaard ved Christiania. 8vo.—*From the University.*

Meteorologische Beobachtungen aufgezeichnet auf Christiania's Observatorium. Lieferung I. and II. 8vo.—*From the Observatory.*

Det Kongelige Norske Videnskabers-Selskabs Skrifter 1det 19de Aarhundrede. 4de Binds 2det Hefte. Drontheim. 8vo.—*From the Society.*

Det Svenske Under visningsvaesen. 8vo.

Index Scholarum in Universitate Regia Fredericiana nonagesimo octavo ejus semestri anno MDCCCLII. XVII. Kalendas Februarias habendarum. 8vo.—*From the University.*

Index Scholarum in Universitate Regia Fredericiana nonagesimo nono ejus semestri anno MDCCCLII ab Augusto Mense ineunte habendarum. 8vo.—*From the same.*

Er Norsk det Samme som Dansk? Af K. Knudsen. 8vo.—*From the Author.*

Ueber das Frictions-Phänomen von Herrn Theodore Kjerulf in Christiania. 8vo.—*From the Author.*

Beretning om Fiskeri-udstillingen i Amsterdam 1861.—*From the University of Christiania.*

Beretning om det kongelige Selskab for Norges Vel, etc. i. Aaret 1861. 8vo.—*From the same.*

Syphilisationen udfort i Drammens Sygehuns. Ved Stadslaege F. C. Wildhagen. 8vo.—*From the Author.*

Fortsatte Observationer om Syphilisationem von Prof. W. Boeck. 8vo.—*From the Author.*

La Norvège Pittoresque. Recueil de Vues. Oblong 8vo.—*From the University of Christiania.*

Norges Mynter i Middelalderen, samlede og beskrevne af C. J. Schive. Folio.—*From the same.*

Die Culturpflanzen Norwegens beobachtet von Dr F. C. Schübeler, etc. 8vo.—*From the same.*

Geographical Charts.—*From the same.*

Recherches sur la Syphilis. Folio. Par W. Boeck.—*From the same.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIII., No. 1. 8vo.—*From the Society.*

Journal of the Chemical Society, December 1862.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages, Registered in the Eight Principal Towns of Scotland, November 1862.—*From the Registrar-General.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1862–63. No. 60.

Monday, 5th January 1863.

Professor KELLAND, V.P., in the Chair.

The following Communications were read:—

1. Biographical Account of Professor Louis Albert Necker, of Geneva, Honorary Member of the Royal Society of Edinburgh. By David James Forbes, D.C.L., F.R.S., V.P.R.S. Ed., Principal of the United College of St Salvador and St Leonard, in the University of St Andrews.

Louis Albert Necker, who died at Portree, in Skye, on the 20th November 1861, aged 76, had been for many years a Foreign Honorary Fellow of the Royal Society of Edinburgh.

His relation to the Royal Society, and to Scotland generally, was, however, far different from what belongs to most honorary members. As a youth, his studies had been pursued at the Edinburgh University. He had received almost his first introductions to society amongst the very best circles which the Scottish capital, in the days of perhaps its highest literary and scientific celebrity, could afford; he visited the Highlands, and even the remoter Hebrides, with an admiring enthusiasm which few native tourists have surpassed. In later life he returned with renewed interest to revisit the scenes where he spent his youth. He not unfrequently attended the meetings of the Royal Society, and occasionally contributed to its Transactions; and, finally, having made Scotland the country of his adoption, and passed the last twenty-five years of his life almost entirely on its soil, his remains were laid in the churchyard of the remote village of Portree, which had long become his sole residence.

Under all these circumstances, a slight biography of Mr Necker peculiarly merits a place in the Proceedings of the Royal Society. I shall rather endeavour to convey an idea of what our learned and amiable associate really was, derived from my acquaintance with him personally, and through his writings, than to enumerate all the details of his life, which, as in the case of most literary men, was far from eventful.

Louis Albert Necker was born at Geneva on the 10th April 1786. His father, Jacques Necker, was Professor of Botany, and also a councillor of state and syndic of Geneva. This Jacques Necker was nephew of the financier Necker under Louis XVI., and cousin-german of Madame De Staël. Louis Necker was therefore one generation farther removed from those eminent persons. His mother, Albertine de Saussure, daughter of the illustrious Swiss naturalist, was a person of unusual talent, and of the most amiable disposition. His attachment to her throughout her life was of the tenderest and most constant kind. She died in 1841. She is known to the public by her excellent work called "*Education Progressive*," and also by a biographical notice of Madame de Staël. Necker finished his school studies at Geneva in 1800, and entered the *Académie*, where he followed the various courses of the higher studies for four years. In July 1803, in company with his father, he made his first journey into the Alps, commencing with Chamouni, and extending it to Zermatt. I recollect to have seen in the visitors' book at Chamouni Louis Necker's own record of this visit, entered in a boyish hand.

In 1806 Louis Necker proceeded to Edinburgh (being then twenty years of age), for the purpose of prosecuting his studies at the University, and of improving his mind by foreign travel. This was a practice by no means uncommon amongst the educated Genevese of that date, and one which, I am glad to say, continues at the present time. Those who pursued medicine and the physical sciences have especially resorted to Edinburgh. The result has been a very friendly mutual feeling between the Genevese and the Scotch, which has been constantly experienced not less by those of the one country than of the other. Mutual hospitalities and many valued friendships have been thence derived.

Of such results Necker's was a signal instance. After the age of twenty, Scotland became to him a second fatherland. As became the grandson of De Saussure, he was already conversant with mineralogy and geology; and he could not in all Europe have found a school better fitted to educe his talents than Edinburgh presented at that period. In the University, indeed, under the zealous Jameson, the doctrines of Werner reigned supreme. Yet it was well for a young geologist of that day to become acquainted with his teachings; and in so far as they were overstrained or erroneous, there was an ample corrective in the distinguished school of Huttonians, who then discussed and elucidated the theory of their master, partly in the University, but principally in the hall of the Royal Society, and by their writings. Necker was personally acquainted with Playfair, Sir James Hall, Lord Webb Seymour, Hope, Allan, and others, who met nearly every week at the period of Necker's stay in Edinburgh, to discuss in this Society the theories of geology, and to listen and reply to the less numerous, yet undaunted supporters of Wernerianism, headed by the persevering Jameson. Already, during the winter of 1806–7, Necker had visited the interesting coast of Fife, and the principal islands of the Forth; and under the guidance of Sir James Hall himself had inspected the numerous and interesting geological sections which abound on its southern shore as far as St Abb's Head. At other times he travelled in company with Patrick Neill and others of the Jamesonian school, and had an opportunity of judging impartially the opinions of either party. Of course the discussions of the winter were to be farther pursued in the field during summer; and Necker, nothing loth to judge for himself concerning the facts of which he had become accustomed to hear such conflicting explanations, undertook excursions not only in the geologically interesting neighbourhood of Edinburgh, but to the west of Scotland, and even into the farthest Highlands, then but little visited. The origins of granite and trap were of course the main objects of his search, so far as geology was concerned; and, no doubt by the advice principally of Playfair, who used to call Arran an epitome of the world, one of his early excursions (in May 1807) was to visit that island, which he appears to have studied with scrupulous care, having spent nine days in the northern and most interesting part of the island. He was accompanied by a fellow-student named Shute. He there became a convert to the igneous theory of granite, and seems to have been among the first to direct attention to the granite veins of Tor-nid-neon, afterwards more carefully explored by Mr James Jardine.*

On the 6th August 1807, Necker again left Edinburgh to visit Staffa and the Western Highlands. He travelled by Inverary and Oban, and traversing Mull, enjoyed at the small island of Ulva the hospitality of Mr Macdonald of Staffa, with whom he formed a close friendship, and of whose kindness I have heard him speak warmly even in his later years. From Ulva he made two excursions to Staffa, to the geology and mineralogy of which he of course devoted the utmost attention. He next visited the Island of Coll, where he observed traces of the action of the Gulf-stream in the transported seeds and other products of West Indian origin. He crossed to Tiree, with its ornamental marble; on leaving which he was driven back to Coll by stress of weather, but finally reached Eigg, ascended the Scuir, celebrated for its pitchstone, its fossil wood, and for the cavern which was the scene of a well-known historic massacre. Thence he touched at Rum and Canna, carefully visiting what was most interesting in each; crossed to South Uist, and finally to Skye, reaching Talisker on the 23d September. The advanced season of the year compelled him soon to think of returning southwards. After a stay of a few days only, he left Skye with vivid feelings of regret at having obtained only a glance at its noble scenery and interesting mineralogy. Little did he then think that that island should one day be as familiar to him as his native Switzerland, and should, after more than half a century, afford him a final resting-place! He returned to Edinburgh by Inverness, Elgin, and Blair-Athole, without, however, visiting Glen Tilt.

These particulars have been chiefly gathered from a journal of his Tour in Scotland, by Mr Necker, evidently nearly all written at the time, but (with a procrastination which became habitual with him) not published until 1821 † (fourteen years later), when

* A model of these by Jardine is stated by Necker to have been presented to the Royal Society of Edinburgh. I trust it still may be found in their museum.

† *Voyages en Ecosse et aux Isles Hebrides, par L. A. Necker de Saussure,*

the interest of the details was considerably diminished. Perhaps partly from this cause, the circulation of the work was, I believe, not great, and in this country it is certainly much less known than it deserves to be. It is written, for the most part, with great animation, and conveys a lively impression of the literary society of Edinburgh at that day, and of the state of society in the remoter Highlands and Islands, as well among the higher as the lower classes. It includes many excellent descriptions of scenery, and many accurate details of the mineralogy and geology of the places he visited, written evidently in the manner of De Saussure, whose writings were naturally the object of his life-long admiration. Though admitted to the intimate society of many amiable and accomplished families, he exercised a wise discretion in giving no personal details, and he confined his public references to scientific and literary men, whose attainments and opinions were open to the remark of every one. The caution with which he holds the balance between Huttonian and Wernerian doctrines is almost amusing. But though the decidedly Wernerian views of his illustrious grandfather tended, perhaps, more than anything else to secure his favourable mention of Werner's classification of Rocks, and his adoption of his nomenclature, the Huttonian bias of his mind is everywhere visible; and he does not hesitate to declare, that whatever may be the worth of Hutton's Theory of the Earth in its most wide and speculative sense, yet that the facts of geology have been more correctly and impartially stated by his followers than by their opponents.*

These volumes also show a general acquaintance with other branches of science besides geology, and with literature and art, highly characteristic of the man. Ornithology, in particular, was then and afterwards a favourite study. They contain a great deal on matters connected with the social condition of the country, and its progress in civilisation, and on various questions of the day,

3 vols. 8vo. Geneva, 1821. I may here note, that it is, or was the custom at Geneva, for unmarried men to assume their mother's surname after their own; after marriage, their wife's. Hence, M. Necker is sometimes spoken of as if his family name were De Saussure.

* Mr Cumming Bruce, M.P., recollects that at this period, Necker "used to express his regret that the party spirit then at its height between the Wernerians and Huttonians did not allow either to give due weight to facts which might have made them more tolerant of each other."

which now, of course, have lost much of their interest, but which mark a very intelligent and acquisitive mind. In particular, it is amusing to notice how his Caledonian enthusiasm every now and then breaks forth in defence of Scotsmen and their country in opposition to what he considered to be unjust English prejudices. He repudiates the idea that Scotland's prosperity was in any material degree due to the Union with England; he despises the sneers of Dr Johnson; and he believes all that reasonably could be believed of the genuineness of Ossian's Poems, a portion of which, moreover, he heard recited by a native of Tiree.

It is easy to believe that a young Swiss, highly intelligent, and animated by sentiments so agreeable to Scotchmen, was warmly welcomed into the best circles of Edinburgh. Among the survivors of those who were then intimate with him, I have received a few slight reminiscences from two,—Mr Charles L. Cumming Bruce, M.P., and Mr James Mackenzie.* In the families of these two gentlemen he was ever welcome; and his gaiety, intelligence, gentleness, and love of female society, made him a great favourite. Indeed, the domestic pleasures of that early visit made an impression on his mind which was never eclipsed,—which yet possibly tended to throw a shade of gloom over his more advanced years, when, still solitary in the world, the magnetic influence of early scenes and friendships drew him once and again back to his much-loved Scotland. It was at the house of "the Man of Feeling" especially, that "he met, and was most intimate with, all that was best and most distinguished in the then charming society of Edinburgh, which consisted, among others, of Dugald Stewart, Playfair, Walter Scott, Jeffrey, Dr Hope, and Lord Webb Seymour, with all of whom his happy temper and *naïve* cheerfulness made him a great favourite. When they took their departure, he used to remain discussing their various characters with the accomplished ladies of the family."† Mr James Mackenzie kindly informs me that Necker's chief college companion was an intelligent English medical student named Smith, with whom he lodged at first in St James's Square. Previously (no doubt in the winter 1806–7) he lived *in* the College, in the house of Wilson the janitor.

The travels described in the three volumes I have mentioned

* Writer to the Signet; a son of the author of the *Man of Feeling*.

† From a letter of Mr Cumming Bruce, whom, later, he visited at Oxford.

seem all to have been performed either in the winter of 1806–7, or in the following summer and autumn. There is no doubt that he passed the succeeding winter in Edinburgh, but then, for a time, we lose trace of him. It appears from a passage in his book (vol. ii. p. 67), that he visited Devonshire and Cornwall in 1809 with geological objects. I cannot be sure whether or not he had previously returned to Geneva. I understand that his home journey took place through Holland, and was not free from embarrassment, owing to the war. In 1808 he was elected a member of the *Société de Physique et d'Histoire Naturelle de Genève*, which seems rather to indicate that he returned home in that year. In 1810 he was appointed, under the French *régime*, joint Professor of Mineralogy and Geology at Geneva; and became Honorary Professor (under the Swiss Government) in 1817. In both these capacities he delivered various courses of lectures, as well on geology as mineralogy; and his geological excursions with his students are still advantageously recollected.

In 1813 he visited Auvergne, the Vivarais, and the South of France, for geological purposes, and at the same time the Pyrenees, and probably the coasts of Genoa.* Mr Cumming Bruce's notes give us a glimpse of Necker about this period under a different aspect. "My next *salient* recollection of him," writes Mr C. Bruce, "presents him to me as 'Minister of Police' on my arrival at Geneva in the early summer of 1814, when I arrived there from Italy. The republic had just effected its restoration, and repudiated its annexation to France. I was stopped at the gates to exhibit my passport, when, to my infinite delight, my friend [Necker] presented himself in uniform,† and you may imagine that my baggage was passed with scant investigation. He consigned it to two attendants, with orders to carry it to Cologny, to which (his father's charming villa) he insisted on my accompanying him; and there, in the enjoyment of the kindest hospitality, rendered more and more agreeable by the charm of his charming mother's society, I remained

* *Voyages en Ecosse*, tome i. pp. 45 and 215. See also *Etudes sur les Alpes*, p. 363.

† He was in 1815 captain of a company in the *Contingent Genevois*, under General Bachman. I may here add that he was twice a deputy in the *Grand Conseil* of his Canton, and in 1818 was a representative of Geneva at the Swiss Diet.

during six weeks or two months of my stay on the shores of the beautiful lake. In those days we used to call him *Fouché*, in virtue of his office as Minister of Police. I owed to him at that time my introduction to the society of Coppet, and the kind and sustained friendship of Madame de Staël. There, with Schlegel, Sismondi, Dupont, Sir H. and Lady Davy, Lady Charlotte Campbell and her daughter, Louis and I formed two of the *dramatis personæ* in acting little plays arranged by our hostess from the lesser poems of Byron."*

I find that in 1820 he made an excursion to Italy. Indeed, he not improbably had passed the previous winter there, though I do not know the occasion. At all events he visited Mount Vesuvius in April; and he then made interesting observations on the dykes or injected lavas of Monte Somma, his account of which† still remains classical, and connects itself with his studies of Huttonian geology in Scotland.

In 1821 he at last brought out his work on Scotland, and having thus relieved himself of a task of which he had no doubt long felt the weight, he set himself seriously to what he no doubt considered the main business of his life—the study of the geology of the Alps, in continuation and verification of the labours of his grandfather, De Saussure, whose academic chair he had for some years occupied.‡ He had previously travelled in Switzerland from time to time with geological objects in view, but from and after 1821 (as he himself tells us) he made regularly two annual excursions, one in the early§ part of summer in the lower and outlying parts of the chain, and another towards autumn in the higher Alps. He justly remarks that the importance of the study of the inferior and external parts of the range was at that time not fully appreciated, and still less, perhaps, the excessive fatigue, heat, and even peril, attending the investigation, step by step, of these rugged calcareous mountains, which fully equal in height, even when allowance is made for their elevated bases, the highest mountains of Britain. In all these cases he examined on foot, and step by step, the range of country

* From a letter of Mr Cumming Bruce.

† Mem. de la Soc. de Phys. de Genève, tome ii.

‡ One of his public academical addresses, delivered in 1821, has been preserved (*Bibliothèque Universelle*, 1824).

§ *Etudes Geol. sur les Alpes.* Preface.

within which his special journey was confined, making elaborate notes and drawings on the spot, which he inked in at leisure, thus accumulating a mass of authentic and valuable details, of which unfortunately but a very small part ever saw the light.* The environs of Geneva and the important and intricate country between its lake and the bases of Mont Blanc, formed the most frequent scene of his geological labours. In 1826 he made a special study of the Valley of Valorsine (near Chamouni), with its interesting granite veins and pudding-stones. It may be conceived with what interest he compared the former traces of the vast upheaving forces which raised the Alps, with those which he had sedulously examined nearly twenty years before in the Isle of Arran.

But his researches were far from confined to his own district of Switzerland and Savoy. He had previously visited the Eastern Alps, including the environs of Trieste, and a great extent of country then almost unknown to geologists, extending southwards nearly to Dalmatia, and northwards to Vienna. Family affairs in part, I believe, directed his course to Trieste, and the visit was repeated for some consecutive years. To connect his studies in the East with those in the Western Alps, he undertook in 1828 a special journey, which lasted from May to September, of part of which he published a brief account (*Etudes Geologiques*, Preface, and *Bibl. Univ.*, Oct. 1829). This last is a paper on the interesting hypersthenic syenite of the Valteline. He started by the Tarentaise, Little St Bernard, and Val d'Aoste, by Val Sesia, along the whole series of the Italian lakes to the Vicentin, and thence to Belluno a Pieve di Cadore, from whence he reached Trieste by the Valley of the Tagliamento. He thence traversed Carniola and Carinthia, entering the Tyrol near Fassa, and pursuing his route by the Stelvio and Valteline, until he regained his former track at Como. In 1829, or subsequently, he returned once again with admirable perseverance to the Alps of Carniola, and those of Istria

* As an example, I may mention that soon after M. Favre's interesting paper had appeared in 1848, on the Geology of Chamouni, in which he announces the interesting fact that the summit of the Aiguille Rouge is composed of lias in horizontal strata, being at Portree, I mentioned the fact to M. Necker, who thereupon speedily turned up in his old Alpine notes a section of the Aiguille Rouge clearly expressing the same fact.

and Illyria; yet undertook also researches into the enigmatical fossiliferous deposits of the Tarentaise, to which, about that time, M. Elie de Beaumont had called fresh attention.

I cannot but pause to remark, that had M. Necker resolutely set himself to publish *at that time* his most elaborate and persevering researches on countries even yet so little known to geologists as the Southern and Eastern Alps, he would have obtained a distinguished rank amongst the foremost field-geologists of his day. There is no doubt but that almost to the close of his life he was looking forward to still effecting the publication of what he knew had been too long delayed, yet of which he could not but be aware of the value.

We have now reached the year 1829, when Necker was forty-three years of age, and from this period we may probably trace the commencement of the second and far less happy stage of his life. As one of his attached countrymen observes, in a letter to me, the two phases were so unlike, that they might seem to have belonged to different individuals; the first period marked by the greatest bodily and mental activity, exuberant spirits, and relish for society; the second by comparative indolence, too often by moody reserve, and a painful tendency to misconstrue the kindest intentions of his warmest friends. One of the latter informs me that when he saw him as late as 1824, he was, to use a homely phrase, "blithe as a bee;" and I have no doubt that it was about 1829 that his health began to fail,—partly, one may believe, in consequence of the effects upon a nervous, though wiry constitution, of the very prolonged and laborious pedestrian journeys which he had previously made through countries often inhospitable and sometimes insalubrious. One evidence of the change in his health, was his seeking variety of scene, and a less rigorous winter climate than that of Geneva, by returning once more to his well-remembered Scotland.

My acquaintance with M. Necker commenced at Edinburgh in November or December 1831. The exact date is recalled to me by having first heard from him (then just arrived from London) of the brilliant discoveries which Mr Faraday had communicated to the Royal Society, on the derivation of electric currents from permanent magnets. I can even now recall the spot on which M. Necker first made me acquainted with this grand result. The privilege of making his acquaintance was to me at the time a great one. His favourite sciences were those which then occupied most of my own attention,—geology, meteorology, and general and terrestrial physics. He was perfectly at home in the Alps, which I had already visited, and to which I was about to return. He was as communicative as I was desirous to learn; and having, at that particular period, my time very much at my own disposal, as he also had, we found many congenial subjects of discourse of which we never tired, and innumerable objects for geological rambles in the neighbourhood of Edinburgh, with which, of course, I was familiar, and which were intimately associated in his mind with the precious lessons which he had drawn from the lips of Playfair and of Hall. In addition to this, many of his early friends were also my own. It may therefore be believed that, with his naturally amiable and communicative disposition, we were not long in becoming fast friends. I may say confidently that with few persons have I spent more delightful hours at any period of my life, or been rewarded by a larger amount of instruction, conveyed with a simplicity and grace which were peculiarly his own. M. Necker's appearance at this time was remarkably prepossessing. He was rather short than otherwise; well proportioned and active; his complexion was dark but ruddy; his eyes, of a fine blue, beamed with intelligence; his nose was aquiline, and the upper and lower parts of the face slightly retreating; the mouth firm but sweet; his gait rapid, nervous, and earnest. He spoke English with the utmost fluency, but with a foreign accent far from disagreeable. He had a keen sense of humour (as may be gathered from Mr Cumming Bruce's early recollections), which never forsook him, and he possessed a stock of natural gaiety which flavoured his conversation even long after he was subject to those fits of melancholy from which, in later life, he suffered so severely.

He left Edinburgh for London in February 1832, where I also passed some time in his society. Later in the same year we met at Geneva, where I experienced his hospitality, and had the good fortune to be introduced to his excellent mother. The same autumn he invited me to join him in a tour through part of Switzerland, including the Oberland and Valais. This pleasant tour lasted for a fortnight, and showed the resources of my friend in many new lights. From the commencement of 1832 until his death, almost thirty years later, we maintained a correspondence which, though often recurring at long intervals, was not discontinued. By the aid of these letters I can trace some particulars of his migrations, which might otherwise have escaped me.

In 1833 and 1834 he appears to have been much engaged in the preparation of a treatise on Mineralogy, which had for long occupied his thoughts. He spent the winter of 1834–5 in Paris, carrying it through the press. This was M. Necker's most considerable and most systematic work. It shows to advantage the combination of scientific knowledge which he possessed,—which, as I have already intimated, extended over a wide range of subjects, including not only the Natural History Sciences, but Physics and Chemistry. Such a combination is eminently required by the philosophical mineralogist. His science is unfortunately at present cultivated by few, and profoundly studied by hardly any. Had this not been so, Necker's fame would have been more widely spread than it is. In a very remarkable paper, first published in Jameson's Edinburgh Philosophical Journal for 1832, he treated of "Mineralogy as a Branch of Natural History." He showed that a well characterized mineral is to be regarded as an *individual*, and that such individuals are to be grouped under species, genera, orders, and classes, as in the classification of the organic creation, by having a philosophical regard to *the whole* of the characters and properties which belong to the individuals of each species, in the same way as was done by Cuvier for animals, and by Decandolle for plants. His aim was to conciliate as far as may be the hitherto conflicting systems of classification,—that by Chemical properties alone, and that from External characters alone. His doctrine was (in brief) that those chemical characters are most to be regarded which visibly and palpably affect the external features of the mineral individual; that the indications of ultimate chemical analysis are not, correctly speaking, mineralogical characteristics at all; and that, where chemical and external indications are in apparent contradiction (which is rare), the latter are to be preferred.

Necker applied his principles, which he had derived from a large and wide study of Natural History in its most general sense, with very great ingenuity to the distinction and classification of minerals. His system is detailed at great length, and with much clearness and precision, in his *Regne Mineral, ramené aux Méthodes d'Histoire Naturelle* (Paris, 1835, 2 vols.), to which I have already referred. It is evidently a work conducted with the most patient and conscientious labour. The elaborate tabular views illustrating the system of classification by the totality of the properties on which it is founded, have probably never been exceeded in clearness of detail.

I do not feel entitled to give an opinion as to the success with which Necker applied his principles to the reform of mineralogical classification. But it is admitted by competent judges that he laid down those principles with great success, and in a highly philosophic manner. Dr Whewell in his Philosophy of the Inductive Sciences, has devoted almost a whole chapter* to an analysis of Necker's work, to which he gives high commendation. Professor W. H. Miller, of Cambridge, probably our highest English authority on mineralogy, has expressed to me his approbation both of Necker's paper in the Philosophical Journal, and of his larger work. "They indicate," he says, "on the part of the author, a most philosophic mind. His criticisms on preceding classifications are very just."

I think that the labour—both mental and mechanical—of writing and editing this elaborate treatise, so full of minute details, and of discussions (at least in the introduction) of almost metaphysical subtlety, was perhaps greater than the author's then enfeebled health could well support. Necker was never afterwards quite the same man as before. His nervousness increased painfully, accompanied by fits of absence, and excessive love of seclusion. He considered, probably with justice, that the rigorous winters of Geneva aggravated his sufferings, and returning to Scotland, he passed the winter of 1836–7 in Edinburgh. In the summer of 1837 he returned to Switzerland, and made probably his last journey of any length in the Alps. He crossed the Col of Mont Cervin, studying carefully the geology of that wonderful country, and also the southern portion of the mountains separating Grindelwald from the Valais. In 1838 we find him again in Edinburgh, preparing to pass the winter, which he did at Portobello, near Edinburgh, and close to the seaside, where he hired a small house, and lived in almost complete seclusion. I visited him occasionally; but any society was oppressive to him. His windows looked right out upon the sea,

* Philos. Ind. Sci., book viii. chap. 3. Edit. 1840, vol. i. pp. 500–516.

and he pleased himself by thinking that nothing but the ocean separated him in a right line from Norway. Leaving Portobello in May 1839, he spent part of three months in his old favourite resort, the Isle of Arran. Here he occupied himself with much diligence and zeal in surveying accurately the granitic and trappean formations of the island. The results were presented to the Royal Society of Edinburgh, in April 1840, in an elaborate paper, which embraces a minute tabular description of no less than 149 individual trap dykes in the north-eastern part of the island alone, besides giving indications of many more. It was an occupation well suited to M. Necker's state of health, affording constant, yet moderate occupation of mind, and attraction out of doors, with the advantages of a temperate climate, and removal from any interruption, or anxiety. The wonderful patience and conscientious ability with which this labour was executed is worthy of all commendation; and the really astonishing nature of the phenomena which it chronicles with so much minuteness, exempts it from the suspicion of being a useless or puerile employment. So close a survey introduced M. Necker to many singular mineralogical and geological peculiarities previously overlooked; and having myself since gone over much of the ground with his memoir in my hand, I can testify to its wonderful fidelity. It is impossible to foresee how important this catalogue of dykes may one day prove to the future dynamical geologist.*

We have an interesting chronicle of Necker's life at this time, in a series of letters to his mother, which were printed soon after in the *Bibliothèque Universelle de Genève.*† They commence at Portobello in February 1839, and they unfortunately terminate in September. These letters, now buried in a large periodical work, are charming in themselves, and give a delightful picture of the writer's capacity for intellectual enjoyment. He always presented to his mother the gayer side of his impressions. The little traits of

* In this paper (Trans. Roy. Soc. Ed., vol. xiv.), Necker refers with much interest and satisfaction to his discovery of an outbreak of granite to the north of the head of Glencloy, quite detached from the granitic nucleus of Goatfell. Jameson had already noted syenite near this locality. I am not sure whether Necker recollected having cited Jameson's earlier observation in his own *Voyage en Ecosse,* tom. ii. p. 31.

† Tom. xxv., xxvi., for 1839 and 1840.

his daily life are told with characteristic näiveté, and are interspersed in the most natural manner imaginable with a notice of what he saw interesting in botany, ornithology, mineralogy, or upon other scientific topics, which he evidently felt sure would be neither unintelligible nor uninteresting to his correspondent. In quitting Arran, he adds the significant remark, "Je regrette Arran, où je me suis fait un bien prodigieux." The later part of the season he spent in the Orkney and Shetland Islands, interesting to him, as well from the picture of primitive manners which they present, as from their remarkable geology. This part of his tour is detailed in his letters to Madame Necker; and there is a letter to M. Moricand of Geneva on the geology of the Island of Unst, in a subsequent number of the *Bibliothèque Universelle.* From the Shetlands he proceeded to Skye, where he passed the winter of 1839–40. Here he found so much to interest him geologically, and also found the damp but mild climate to suit him so well, that he was gradually led to adopt Portree as his permanent abode.

During his residence in Skye, in the winter of 1839–40, he was, I believe, actively engaged in preparing for the press the first volume of his *Etudes Geologiques dans les Alpes,* of which no other ever appeared.* He spent the summer of 1840 at Geneva, where the work was no doubt chiefly written. In the autumn he quitted Geneva, with the deliberate purpose of making Portree his future residence. He passed the winter in Paris, seeing his work through the press. I find, from a letter to myself, dated at Edinburgh in April 1841, that Necker was then returning to Skye, having completed the printing of his book, which bears date of 1841.

The *Etudes Geologiques* form the third of Necker's separately published writings. They were probably expected by the author to be, when completed, his best memorial, and the chief contribution to science of a lifetime devoted to its pursuit. But the work as it stands goes but a little way to realise those reasonable hopes. It is but a fragment, and a fragment of which the merits and defects are equally characteristic. We find evidence of patient, clear-sighted investigation into natural operations which would have escaped a less diligent observer, and whose significance a less

* The work itself includes numerous references to his observations in Scotland made in 1839.

intelligent reasoner might have disregarded. It is professedly confined, for the most part, to the superficial formations, and to the basin of the Lake of Geneva. But the author's turn for discursive illustration of his subject ever tempts him to introduce curious, and sometimes important facts, recorded by him in other countries, and in the older rock formations. The work, in fact, oscillates between a memoir on local geology and a systematic treatise; and it does not exactly fulfil the purpose of either. The innumerable references which it contains to forthcoming parts of the intended work give us good room to regret that Necker had not more strictly followed the course pursued by his grandfather, De Saussure, by publishing his geological observations in the order in which they were made, and interspersing them with those contributions to the other parts of physical geography, and those animated descriptions of scenery, in which he, as well as his illustrious relative, peculiarly excelled.

Even in its present fragmentary form there is much to interest the geologist in the isolated volume of studies which M. Necker has left. The followers of Sir Charles Lyell will find in it a fund of admirable observations on the effect of causes still in action; and although the doctrines of glacial operation have made great progress since 1841; and although Necker was systematically disinclined to side with those who attributed to the formerly vast extension of glaciers conspicuous effects both in and out of Switzerland, his information on the distribution of erratics in the basin of the Lake of Geneva is very interesting and suggestive, and many of the facts and difficulties which he propounds are worthy of great consideration.*

As the *Etudes sur les Alpes* was the last, not only of Necker's larger and separate, but even (I believe) of his more occasional printed contributions to science, I may as well advert here to one or two of the latter—his detached memoirs—which I have not already had occasion to mention. There are several on subjects of pure mineralogy, perhaps of no great intrinsic importance. There is a paper in the Transactions of the Royal Society of Edinburgh,

* I have elsewhere pointed out (Edin. Review, April, 1842) some errors into which M. Necker fell in treating of the mechanism of glaciers, a subject to which he appears to have given but little attention.

Vol. XII., on the True and Apparent Dip of Strata; and there is a pleasing and somewhat elaborate paper in the second volume of the Genevese Memoirs on the native birds of the district.* To these I shall merely make this general reference. But I wish to mention three occasional papers, somewhat original in their nature, and which are characteristic of the pleasure which Necker took in cultivating subjects connected with Physical Geography and Natural Philosophy, in an enlarged acceptation, just such as M. Saussure would have relished.

The first of these was an attempt to connect in a general way the great lines of geological stratification over the globe, with the lines of equal magnetic intensity, as traced by Hansteen and General Sabine. This was as early as 1830,† and it is only fair to state, that the knowledge either of the one or of the other class of phenomena was then, at all events, too limited to justify any confident deductions on the subject. The comparison of these lines of direction was not, however, made without considerable research, and the growing interest of the inquiry, and perhaps the increasing probability of its having some physical foundation, induces me to recall attention to Necker's memoir. The recent speculations of Dr Lloyd tend in the same direction, and I think also the observations of MM. Schlagintweit. In Necker's later writings, such as the preface to his *Etudes*, and in his letters to Mad. Necker, we find that he continued to give weight to the theory of the connection of magnetic with geological phenomena.

The next of these papers is contained in a letter addressed to Sir David Brewster, printed in the "Philosophical Magazine" for 1832. It describes a very beautiful optical phenomenon observed by the author in the Alps, when the direct rays of the sun are concealed by a line of forest fringing some rising ground between the spectator and the sun. The outlines of the trees, and even their entire stems, are then seen to shine with a white light of dazzling brilliancy, resembling frosted silver. The effect is not peculiar to

* The memoir on birds seems to have been also printed separately. Necker's kinsman, M. H. de Saussure, a very competent judge, styles it "charmante production devenue très rare, trop peu connue à l'étranger, et qui mériterait une nouvelle édition." Its date is 1823.

† Bibl. Universelle, tom. xliii. 1830.

any season of the year, or to any hour of the day. It is no doubt due to the diffraction or inflection of light acting under rather unusual circumstances, and is the most notable example of the kind to be seen by the naked eye, without any artificial arrangement. I well recollect M. Necker showing me this beautiful appearance in the course of our tour of 1832, and I have often observed it since. The remarkable circumstance is, so far as I recollect, the absence of prismatic colours, which might, however, be anticipated from the infinite variety of dimension of the objects diffracting the light.

The third of these occasional memoirs by M. Necker, having for its subject certain "diverging rays which are seen long after sunset," appeared in the *Annales de Chimie et de Physique* for February and March 1839. It was communicated, I believe, by Arago's request. This paper excited little notice at the time, and is now perhaps nearly forgotten. Yet, though somewhat diffuse in composition, it contains observations and speculations worthy of record. It contains ample and specific descriptions of the second coloration of Mont Blanc, and the exact intervals after sunset at Geneva of the various appearances of illumination presented by the Alps, which have been more vaguely described by several writers. But the more interesting and original part of the paper refers to the production of divergent beams streaking the calm western sky, at a period about 45 minutes after the sun's disappearance. These, no doubt, are most usually caused by detached clouds intercepting the sunlight, and throwing their dusky shadows athwart the vaporous sky. When such is the cause, M. Necker remarked that bad weather usually followed within a short period.* But he also observed that some of these crepuscular phenomena had a more fixed character, and did not indicate a change of weather; moreover, that they recurred (he thought) as often as the sun set in the same position,—that is, every spring and autumn, especially on certain days of February and October, at Geneva.

Hence he began to entertain the idea that the dark rays were shadows of distant mountains lying westward from the spectator,

* This is the foundation of the popular phrase applied to the appearance of "the sun drawing water." See Herschel's Astronomy (Lardner's Encyc.), p. 31.

on the horizon of which the sun was situated when the rays appeared. In the special case mentioned, he believed the Monts Dôme, near Clermont, in France, to originate those rays, and he obtained information from various quarters tending to confirm his idea. From having very often conversed with M. Necker on the subject of his "Rayons crepusculaires," I know that for a number of years he gave this curious inquiry his close attention; and he believed, I think, that from Edinburgh he could see the gigantic shadows of the hills of Arran and Jura.

M. Necker was an honorary member of the Wernerian Society of Edinburgh, and of the Geological Society of London. In the *Proceedings* of the latter (vol. i. p. 392, Feb. 1832) is a short abstract of a paper by him, on the Geological Position of Metalliferous Deposits.

Returning now to the history of M. Necker's later years, I may abridge my record of them within a brief compass. We have seen that he returned from Paris (where he had been printing his "Etudes sur les Alpes,") in April 1841, through Edinburgh, to Portree, in Skye. He was there met by the grievous tidings of the death of the mother to whom he had been so deeply attached. This event occurred at Mornex, near Geneva, on the 13th April, precisely two days before he quitted Edinburgh. It must have been sudden and unexpected, or we may be sure that Necker would not have moved northwards had he perceived her health to be failing. It is easy to conceive, though we have no record of its details, the shock which thus fell upon the amiable recluse. Madame Necker was not only the dearest tie which still linked him to his natural home, but in losing her he lost the beneficial outlet to his sympathies which he had ever found in the sustained and intimate correspondence which he held with her, and of which the printed specimens give us so pleasing an impression. From this time he never again revisited his native country, and his habits became more and more recluse. For some years after his great loss he refused to see almost every one who, with the kindest intentions, sought to interrupt his solitude, and he suspended nearly all correspondence. He rambled occasionally over different parts of the Island of Skye, especially amongst the Cuchullin Hills, and in the environs of Portree and the Storr. But gradually he ceased to absent himself even for a night from home, and confined his excursions within the distance which his pedestrian powers allowed. Once in two or three years, as other engagements permitted, I visited Skye about this period, for the purpose of ascertaining his condition, and of offering such sympathy as he was willing to receive. My friendly overtures were rarely if ever repulsed; and though it was painful to witness the isolation and depression of a person so cultivated and so amiable, there were always intervals in which his old spirits and old interests awoke out of the partial torpor induced by his enfeebled health and monotonous life. Scarcely a day passed during any one of my visits in which we did not walk together to some of the charming localities near Portree, and discuss with renewed interest the scientific problems which his intelligence and quick observation were ever unfolding, whether from the noblest natural object, or the most trivial daily occurrence, in his neighbourhood. It was evidently agreeable to him, even in his sadder moments, to use and listen to his native language, to recall the scenery of his glorious Alps, the achievements and writings of his eminent grandfather, the memory of his accomplished mother, and the cherished reminiscences of his early life in Edinburgh. Nothing was more surprising than to find how few passing events of either public or domestic interest escaped him in his apparent isolation, from which even correspondence was at times almost banished. At this period, however, he read the newspapers with great perseverance, and he seemed never to forget anything that he once read, or to fail in connecting it with what he had previously known. I used to be amazed to find that he occasionally knew more of what was happening in Edinburgh than I myself did; and he tracked with an unfailing instinct the changes which time rapidly produced in the wide connections of his early Scottish friends, many of whom very erroneously believed that he had quite forgotten them. His periodical reading at this time embraced the *Journal des Debats*, the *Caledonian Mercury*, and the *John O'Groat Journal* (a Caithness paper); and from this singular library he managed to extract a wonderful amount of current information, not only public and domestic, but also concerning physical events and changes, and literary intelligence. Of modern books he read very few, but probably occupied his leisure in reviewing the records of his geological tours, and, perhaps, in extending them for the purpose of future publication. He was a very assiduous observer of Meteorological changes, of which he kept a constant record, and by the aid of his barometer, and his great knowledge of atmospheric effects, his cautions became of the most practical value to the fishing population of Portree, by whom, as indeed by all the islanders, he was regarded with much respect and interest, to which the peculiarity of his manner of life, and his extreme shyness towards persons in his own rank of life, no doubt contributed. The prediction of storms was with him for many years a matter of systematic study, and his warnings were at least as much regarded by the Skye sailors as any which Admiral Fitzroy could now furnish. Indeed, one use which he made of his newspaper studies was to trace, by means of the *Shipping Intelligence*, the progress of gales not only over Britain but to the most distant parts of the Atlantic, and he has often discussed with me the results of these interesting, and far from easy investigations. In other respects also he took a sincere interest in the welfare of his poorer neighbours. His kindness was unpretending, and the extent of his liberality will never be known. It is little to say that it was exercised occasionally in ways peculiarly of his own devising, and that he was sometimes the dupe of designing or unworthy petitioners. But in a country, a portion of whose population may be said to be ever on the verge of destitution, the presence of so generous a friend was a public benefit.

From 1851 the state of my own health made renewed journeys to Skye impossible, and through a most unfortunate accident (which I need not explain) our correspondence was for some years interrupted. Before this, however, the intense gloom supervening upon his mother's death had become, in some measure, dissipated. He no longer rejected the visits of his countrymen, or eschewed correspondence as he had once done. The death of his only brother in 1849 affected him considerably, but led him to welcome the younger relatives, who now almost every summer gladdened his solitary chamber. It is cheering to know that the later years of so good a man were blessed with a revival of domestic interests, from which an invincible melancholy, foreign alike to his original disposition and his principles, had for a time debarred him. In the only letter from him of at all recent date which I possess,—it was written in 1859, and was evidently the result of considerable physical exertion,—there is pleasing evidence that neither advancing age, nor expatriation, nor twenty years of solitude and of struggle with constitutional depression, had quenched his sympathy with his friends, or his interest in the cause of science. In it I find a touching enumeration of the losses which he had suffered in the rapidly narrowing circle of his Genevese contemporaries and relatives;—I find also expressions of lively sympathy with the younger generation, and their family connections;—ample proofs that during years of silence and seeming forgetfulness, both his earlier and his later friends in Edinburgh, and elsewhere in Scotland, had never long been absent from his thoughts;—and inquiries, made with an almost tremulous anxiety, as to some of those of whom he had had no recent tidings. Especially did his recollection then turn towards the families of Cumming and of Mackenzie, amongst whom there still survived a few of those friends of 1806, with whom he had shared the intellectual and social enjoyments of his first and happiest Scottish sojourn. I venture to give these details, because his friends were not all aware of the warmth and unalterable sincerity of his attachment, to which, unless an opportunity was directly offered through a letter or a visit, he rarely if ever sought to give expression.

At this period, 1859, he was suffering severely from attacks of rheumatism, which confined him almost entirely to the house. Though enjoying tolerable general health, he became more and more of an invalid. I ought here to record, that throughout the whole of his twenty years' residence at Portree, he was lodged in the house of Mr John Cameron, whose attention and kindness he very highly valued. The knowledge of this circumstance relieved materially the anxiety of M. Necker's friends. Nothing in his last illness requires special notice. He sunk gradually through increasing debility, and without pain, and quietly expired at 7 P.M., on the 20th November 1861, in the seventy-sixth year of his age.

Note on the Family of M. L. A. Necker.

Since the preceding biography was drawn up, I have received from M. Theodore Necker, nephew and nearest surviving relative of Professor Necker, some genealogical particulars which are of sufficient interest to be here briefly recorded. The family of Necker is stated to have been originally Irish, and to have taken refuge in Protestant Prussia during the religious persecutions of Queen Mary of England. Early in the eighteenth century, Charles Frederic Necker, great-grandfather of the subject of our biography, left Custrin in Pomerania for Geneva, being charged with the education of a young German prince. He was a jurist of eminence, and having determined to settle at Geneva, a chair of law was instituted for him in 1724. He died in 1760. His son Louis Necker was Professor of Mathematics at Geneva, and author of several works, while another son was Jacques Necker, the celebrated financier. These brothers both died in 1804. The former was grandfather of Louis Albert Necker, the subject of our biography, and father of Jacques Necker who in 1785 married the daughter of de Saussure. This Jacques Necker retreated with his family to England during the French Revolution, and after his return became Professor of Botany at Geneva. He was remarkable for his unflinching opposition to the French sway. On the Restoration of the Swiss Government he was named one of the first magistrates of Geneva, and died in 1825, very highly respected and regretted. Besides Louis Albert Necker, his eldest son, he had another, Theodore, and two daughters.

Hence the subject of this notice was Professor at Geneva in the fourth generation.

M. Theodore Necker (the nephew of my friend) informs me that among his uncle's papers there remains nothing like a completed work, and little that is available for publication. Through the kindness of the same gentleman, the minerals collected by M. Louis Necker during his residence in Scotland have been presented to the University of St Andrews.

I ought, perhaps, to add (on the authority of M. de Candolle) that the long delay which occurred in the publication of Necker's *Voyage en Ecosse*, to which I have adverted in the preceding notice, was in part due to the detention of his papers in Scotland until after the peace of 1815.

I have been indebted for some valuable information respecting M. Necker's earlier history to the kind communications of Professor Alfred Gautier, a distant connection and attached friend of the subject of this biography.

2. On the Structure and Optical Phenomenon of Decompressed Glass. By Principal Sir David Brewster.

3. Notes on the Anatomy of the Genus Firola. By John Denis Macdonald, R.N., F.R.S., Surgeon of H.M.S. "Icarus." Communicated by Professor Maclagan.

These notes are intended to form an appendix to the author's paper on the anatomy and classification of the Heteropoda, read before the Society last session. He finds the relationship between *Firola* and *Firoloides* even closer than he had supposed, and that, with the exception of gills in the former genus, nearly every anatomical point occurring in one, may be distinctly traced out in the other, only differing in relative characters. The author describes in detail the anatomy of Firola, illustrating his description by a drawing. He concludes this notice by stating his now confirmed conviction of the separation of the sexes in the Heteropoda, of some of which he had obtained specimens which were indubitably females; and he states, in reference to the male sexual organs—as the result of the examination of some hundreds of Heteropoda—that the vas deferens is never traced onwards to the external male organ, but that the penis is imperforate as in many of the Gasteropoda, is far in advance of the spermatic opening, and that these structures are held in communication by a ciliated groove, capable, more or less, of being converted into a canal.

4 On the Zoological Characters of the living *Clio caudata*, as compared with those of *Clio borealis* given in Systematic Works. By John Denis Macdonald, R.N., F.R.S., Surgeon of H.M.S. "Icarus." Communicated by Professor Maclagan.

The object of the author in this paper is to prove the importance of examining, in the living and expanded state, all soft, collapsible, and contractile animals. He describes in detail the anatomy of the genus Clio, illustrating his description by a drawing. He points out the confusion that has occurred in systematic works between the species named respectively *Clio borealis* and *Clio australis ;* and he describes characters by which he thinks that these two species ought to be separated from *Clio caudata* and erected into a new genus; which, however, he declines to designate, being averse to add new names to a list already large.

The following Gentlemen were admitted Ordinary Fellows of the Society:—

Edward Meldrum, Esq.
The Right Hon. Charles Lawson, Lord Provost of Edinburgh.
James Hannay, Esq.
Alexander Peddie, M.D.

The following Donations to the Library were announced:—

Transactions of the Royal Society of Victoria. Vol. V. 8vo.—*From the Society.*

The Canadian Journal of Industry, Science, and Art, November 1862. 8vo.—*From the Institute.*

The Journal of Agriculture, January 1863. 8vo.—*From the Highland and Agricultural Society.*

The Journal of the Chemical Society, January 1863. 8vo.—*From the Society.*

The Cultivation of Cotton in Italy: Report by G. Devincenzi, Member of the Italian Parliament. 8vo.—*From the Author.*

Notices of the Proceedings of the Royal Institution of Great Britain. Part XII., 1861, 1862. 8vo.—*From the Institution.*

Royal Institution of Great Britain, 1862. A list of the Members, Officers, &c., for 1861. 8vo.—*From the same.*

Proceedings of the Royal Society of London. Vol. XII., No. 52. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. No. CXII. 8vo.—*From the Society.*

Journal of the Statistical Society of London, December 1862. 8vo. —*From the Society.*

Transactions of the Linnean Society. Vol. XXIII., Part III. 4to.—*From the Society.*

Magnetical and Meteorological Observations made at the Government Observatory, Bombay, in the year 1860, under the Superintendence of Lieutenant E. F. T. Fergusson, I.N., &c., and Lieutenant P. W. Mitcheson, I.N. 8vo.—*From Her Majesty's Government.*

Compte Rendu de la 45e Session de la Société Suisse des Sciences Naturelles, réunie à Lausanne les 20, 21, et 22 Août 1861. 8vo.—*From the Society.*

Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die Gesammten Naturwissenschaften. Band XIX. 4to. —*From the same.*

Annales de l'Observatoire Physique Central de Russie, publiés par ordre de sa Majesté Imperiale, par A. T. Kupffer. Nos. 1 & 2 (Année 1859). 4to.—*From the Russian Administration of Mines.*

Cercles Chromatiques de M. E. Chevreul. 4to. *From the Author.*

Mémoires de l'Institut Imperial de France. Tome XXXIII. 4to. —*From the Academy of Sciences.*

Supplément aux Comptes Rendus hebdomadaires des Séances. Tome II. 4to.—*From the same.*

Mémoires présentés par divers savants à l'Academie des Sciences, Tomes XVI. et XVII. 4to.—*From the same.*

Carte Geologique des Parties de la Savoì, du Piémont et de la Suisse voisines du Mont Blanc, par Alphonse Favre, Professor de Geologie à l'Academie de Genève.—*From the Author.*

Monday, 19th January 1863.

His Grace the DUKE of ARGYLL, President, in the Chair.

The Council having awarded the Makdougall-Brisbane Prize, for the biennial period ending November 1862, to Dr William Seller, for his "Memoir of the Life and Writings of Dr Robert Whytt," printed in the Transactions, the Prize was presented to Dr Seller by the President.

The following Communications were read:—

1. Notes on the Geology of Lüneburg, in the kingdom of Hanover. By the Rev. Robert Boog Watson.

Lüneburg is the capital of the old Hanoverian duchy of the same name. It stands on the small navigable river Ilmenau, about thirty miles S.E. from Hamburg, and about 150 feet above the sea. The country around is a flat sandy heath, from which the gypseous limestone rock of the Kalkberg rises, not unlike Dumbarton Castle, to a height of 180 feet above the plain. The strata which here present themselves are—

1. Recent sea sand.

2. Boulder sand, sometimes 100 feet thick, full of boulders large and small, of gneiss, chalk, flints, flint-fossils, and great lumps of amber.—Absent from the site of the town and from the Kalkberg, but present at elevations in the neighbourhood considerably greater than either. Lüneburg was not therefore, as it has been described, "a Helgoland in the Boulder Clay sea." (Roth. Zeitschrift der Deutschen Geol. Gesell. 1860.)

3. Miocene clay, with fossils, sometimes from 200 to 300 feet thick.—It rests unconformably on the chalk; but within the town, and round the Kalkberg, where the chalk is absent, it lies directly on the gypsum. It has not been disturbed by intrusion from below, as the underlying strata have been, but its upper surface has been violently torn and abraded during the Boulder Clay period. It often crops out through the overlying sands, and its presence is generally indicated by fine woods of forest trees.

4. Upper white chalk, with flints and characteristic fossils.—Absent from the site of the town and around the Kalkberg, but spreading out all around, appearing on the surface, however, only in one patch on the north side of the town.

5. Triassic clays, limestones, and shales, with fossils.—Present on the surface only in a patch west of the chalk, and intermediate between the chalk and the Kalkberg, but found below the surface in a thin layer over the entire site of the town, and further met with wherever borings have been made through the chalk.

6. Gypsum and anhydrite.—Found wherever borings have been

made sufficiently deep. In the Kalkberg and the Schildstein, a hillock to the west of the Kalkberg, they have penetrated the surface. In general, the gypsum forms but comparatively a thin skin over the unaltered anhydrite; but in the Kalkberg, the whole mass of the rock, which has been quarried to the very heart, is gypsum. The gypsum and anhydrite are a good deal like one another; resemble marble; compact, greyish-white in colour, and slightly translucent. The gypsum especially is full of fissures, one of which has been followed 130 feet deep, filled with dolomite; more commonly they are filled with a gypseous breccia, which in one of the fissures contained the bones of a recent bat (*Vespertilio noctula*). These fissures produce a false appearance of vertical bedding. The crystal Boracite is found in the gypsum and anhydrite. It is only found elsewhere in the precisely similar gypsum rock of Alsberg, at Segeberg in Holstein. Non-crystalline, it appears in the Keuper gypsum of Lüneville in France.

No fossils exist.

The gypsum forms an anticlinal axis, with the Kalkberg for its highest point, sinking away to the east under the town in the form of a narrow round-backed bank, which dips steeply to north and south. Associated with the anhydrite are brine springs almost at saturation point, coming to judge by their temperature from a depth of 400 or 500 feet. These have so exhausted the under surface that great subsidences have occurred.

The points of geological interest connected with this locality are:—

I. That it is far the most instructive, and indeed almost the only place in the great flat of Northern Germany, where the underlying strata have been brought to the surface, these being generally buried deep under sand and clay.

II. That there is here an exhibition of a very peculiar agency by which these strata were elevated, and of the time when this occurred.

One of these inferior strata is anhydrite, a sulphate of lime deposited from water, but deposited without water of crystallization entering into its formation. Later, through exposure to moisture, it has accepted water into chemical combination with the sulphuric acid and lime, and thus changing to gypsum, has expanded to a bulk more than one-fourth greater than before, an increase nearly four times as great as that of water in freezing. This expansion, prevented from developing itself freely, has accumulated at the point of least resistance, and forced up the Kalkberg just like the plug of ice which rises through the fuse-hole of a mortar-shell when filled with water and frozen.

The origin of the sulphuric acid cannot be traced. Heat, pressure, and strong brine have all been proved sufficient to effect the deposition of the sulphate of lime in an anhydrous state.

The expansion through metamorphism must have occurred after the deposition of the chalk, and before that of the miocene clay, the chalk having been disturbed, and the clay thrown down on it after its disturbance.

III. That the age of these gypseous and saline deposits, though a difficult question, can be determined.

No borings have been carried through the anhydrite to show on what it rests. Evidence of age therefore lies in the fossils of the overlying strata, which, resting on the gypsum, have been brought up along with it. These strata are minute in extent, but abound in fossils—chiefly casts. They indicate the Upper Trias, but the particular member of it to which the beds are to be assigned has been keenly debated. Very recently, however, the discovery of five specimens of *Ceratites nodosus* have, in connection with the rest of the evidence, and especially as associated with *Myophoria pes anseris*, given the preponderance in favour of the Lettenkohl. This is a subordinate formation now admitted to exist; but whether to be ranked as the highest of the Muschelkalk or the lowest of the Keuper, or a transition link between the two, is doubtful. Its flora connects it with the Keuper, its fauna with the Muschelkalk. In the Lüneburg beds no vegetable remains have been found, and the want of these renders the relation of these beds to the Keuper more obscure. The absence of such vegetable remains is indeed a characteristic of the Muschelkalk; but this is but a negative resemblance, and its force is counteracted by the absence in the Lüneburg beds of such distinctive fossils of the Muschelkalk as the *Encrinites liliiformis*, *Nautilus bidorsatus*, *Terebratula vulgaris*, &c.

The question then must be determined by the *Myophoria pes anseris* and the *Ceratites*, both of them interesting in themselves from their facility of recognition and from their very limited range in time. The genus Myophoria is confined to the Trias, and the two deep teeth at the hinge in either valve make it easily recognisable from the Trigonia, which has three teeth. The species *Pes anseris* is ribbed, so as exactly to resemble the foot of a goose. It does not last on into the Keuper; it has just barely begun to appear in the latest strata of the Muschelkalk; it abounds in almost incredible numbers in the intermediate Lettenkohl. Now at Lüneburg, the limestone is almost made up of it alone, so abundant is it. This fact therefore connects these beds with the Lettenkohl.

The *Ceratites nodosus* confirms this conclusion. The entire genus is confined to the Trias.* It forms a link both in form and in time between the expiring goniatites and the yet future ammonites. The *Ceratites nodosus* may be very easily recognised by the characteristic feature of the genus, which is, that in each septum all the lobes which point in towards the interior of the shell are toothed, while the projecting rounded saddle between each two lobes is smooth. The species *nodosus* is marked by thick ribs on the sides, radiating outwards, and terminating just at the edge of the back in high knobs or knots; whence its name. The projection of these knobs being on the side of the shell, the back is rendered unusually broad, and has a very square appearance. Minute variations are very frequent, but are not sufficient to constitute more than mere varieties, and the general marks mentioned are unfailing.

The *Ceratites nodosus*, then, thus easily recognised, is confined to the narrowest limits, as it first appears in the upper strata of the Muschelkalk, and disappears finally and for ever in the Lettenkohl, without so much as reaching the Keuper. Wherever found, therefore, it stamps the strata with one of the most definite assay-marks of science; and such was the importance attached to its discovery in the Lüneburg strata, that Von Strombeck, the great Triassic authority of northern Germany, in the absence of the solitary specimen discovered, but unfortunately lost, refused to believe in its existence. Since then, however, five other specimens have been found. They are mere casts, and but broken fragments of an inch or two

* It disappears wholly in the Jurassic, but reappears in a few species (four or five) in the Cretaceous. See Pictet, "Paléontolgie," vol. ii. p. 662. This is therefore an exception to the absoluteness of what is stated above.

in length, and, as is so often the case with ammonites, seem to have lain long in the water after the death of the animal. They have, however, the distinct characteristics of the *Ceratites nodosus*.

These specimens have been the more carefully examined, and the inferences deducible from them the more keenly discussed, from the fact that they have been thought to offer some support to the Darwinian theory of transformation. Von Strombeck and others believe that the latest generations of the *Ceratites nodosus*, as exhibited in the highest strata of the Muschelkalk elsewhere, show a progressive tendency to a certain aberration from the earlier type, as figured by Von Buch in his monograph "über Ceratiten." This aberration, though marked, is not sufficient to constitute, but may be represented as a step towards, a new species. The Lüneburg specimens present this aberration in its widest form, while still obviously belonging to the species *nodosus*. If, therefore, the beds in which they are found can be attributed to the Lettenkohl, then a greater lapse of time is secured. To this lapse of time the change of form may be assigned, and thus some colour may be found for attributing to this same cause the whole of those minute changes of form which the successive species of ceratites present, and which so completely link them on at either end with the antecedent goniatites, and the succeeding ammonites.

As to the question of form. The Ceratites of Lüneburg differs from that figured by Von Buch in this, that in the latter the knobs on the side are included in the first lobe, while in the Lüneburg specimens the back is so much broader that the first lobe fails to reach so far as the knobs, and the second saddle is as it were drawn off the side towards the back, and it therefore, instead of the first lobe, thus includes the knobs. Von Buch's drawings, however, though otherwise most careful, and in this case professedly made from the same specimen, do not agree with one another (see "über Ceratiten," Plate I. fig. 1, and Plate II. fig. 1.) in this very respect of the relation of the knobs to the lobes and saddles; and so, in regard to this particular point, nothing can be made of them. Further, it appears that in all young specimens the back is relatively narrow, and the first lobe extending round the corner of the back at that period of life reaches the knobs on the side; but invariably, as the shell increases with age, the back becomes relatively broader, and then it is only the second saddle instead of the first lobe which includes the knobs. The only peculiarity then of the Lüneburg specimens is precisely what in other cases would be called a dwarfing—*i.e.*, the signs of age appearing in connection with smallness of size; which fact, taken in connection with the rarity of this fossil in the Lüneburg beds, probably points to the existence of climatic or other circumstances unfavourable to the life of this cephalopod.

The other question, that, namely, of the lapse of time,—in other words, whether the Lüneburg strata are Lettenkohl or not,—must be settled on its own merits. Admitting the Lettenkohl as a distinct subordinate formation later than the Muschelkalk, then it appears that the *Myophoria Pes anseris* is rare in the Muschelkalk, abundant in the Lettenkohl, and abundant at Lüneburg; its evidence therefore points to the identity of the Lüneburg strata with the Lettenkohl. On the other hand, the *Ceratites nodosus* is frequent in the Muschelkalk, but hitherto unknown in the Lettenkohl; its evidence therefore, unlike the other, rather connects the Lüneburg beds with the Muschelkalk. In other words, the *Myophoria Pes anseris* proves that these strata are not Muschelkalk but Lettenkohl, while the *Ceratites nodosus* shows that they lie nearer the Muschelkalk than any Lettenkohl strata yet found.

As regards the underlying gypseous limestone, this conclusion determines its age as greater than that of part of the Lettenkohl. That it is much older is not likely; and the existence elsewhere in the Lettenkohl of similar formations, accompanied as here by salt, indicates that the Kalkberg of Lüneberg belongs to the Upper Trias, and probably to the Lettenkohl itself.

Curiously enough, this conclusion dissociates Lüneburg from Germany, where the Lettenkohl is not at all, or but very slightly, saliferous,—the saline deposits of Germany being found in the lower Muschelkalk,—and connects it with France, Switzerland, and England, where it is in the Lower Keuper distinctively that salt is richly present.

2. On the Occurrence of Stratified Beds in the Boulder Clay of Scotland, and on the Light which they throw upon the History of that Deposit. By Alex. Geikie, Esq., F.G.S.

The following Gentlemen were admitted Fellows of the Society:—

The Right Hon. Lord Dunfermline.
William Jameson, Esq., Surgeon-Major H.M. Bengal Medical Staff, and Superintendent of the Botanic Garden, Saharunpore.
William Brand, W.S.
Murray Thomson, M.D.

The following Donations to the Library were laid on the Table:—

Monthly Report of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, December 1862. 8vo. —*From the Registrar General.*

Quarterly Report of the Meteorological Society of Scotland. 8vo. *From the Society.*

Abstracts of the Proceedings of the Geological Society of London. Nos. 88, 89, and 90.—*From the Society.*

Transactions of the Royal Scottish Society of Arts. Vol. VI., Part II. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIII., No. 2. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. No. I., 1863. 8vo. —*From the Society.*

Proceedings of the Royal Society. Vol. XII., No. 52. 8vo.—*From the Society.*

Transactions of the Botanical Society. Vol. VII., Part II. 8vo. —*From the Society.*

The Assurance Magazine, &c., January 1863. 8vo.—*From the Institute of Actuaries.*

The North Atlantic Sea-bed: comprising a Diary of the Voyage on board H.M.S. Bulldog in 1860. By G. C. Wallich, M.D., &c. Part. I. 4to.—*From the Lords Commissioners of the Admiralty.*

Mémoires de la Société de Physique de Genève. Tome XVI., Seconde Partie. 4to.—*From the Society.*

Annual Report of the Board of Regents of the Smithsonian Institution for 1860. 8vo.—*From the Board of Regents.*

Pinetum Britannicum, a Descriptive Account of all Hardy Trees of the Pine Tribe cultivated in Great Britain, with Facsimiles of the original Drawings made for the work. Part I. *Picea nobilis.* By Messrs Lawsons and Son.—*Presented by the Right Hon. Charles Lawson, Lord Provost of Edinburgh.*

Monday, 2d February 1863.

The Hon. LORD NEAVES, Vice-President, in the Chair.

The following Communications were read :—

1. On the Influence of Weather upon Disease and Mortality. By R. E. Scoresby-Jackson, M.D., F.R.S.E., F.R.C.P., Lecturer on Materia Medica and Therapeutics at Surgeons' Hall, Edinburgh.

In the early part of this paper the author adverts to the antiquity of researches into the causal relations of health and mortality. Nevertheless, long as these have been the subject of inquiry, the literature of medical meteorology is meagre in the extreme; and in proportion to the time and labour bestowed upon the many other branches of medical science, this department may justly be regarded as having met with unmerited neglect. Reference is made, however, to the names of many eminent physicians, whose researches into the influence of weather upon the human constitution have contributed not a little to adorn the medical literature of the present century.

It is well known that the influence of external agencies upon health differs materially with locality, so that the author feels himself at liberty to make such investigations into the subject of his paper as he may think sufficient to ascertain approximately the relationship subsisting between the weather and mortality in Scotland, without particular reference to the works of authors on kindred subjects in other countries. It is quite possible that the results evoked by Casper in Berlin, Quetelet in Brussels, Boudin in Paris, Emerson in Philadelphia, Farr or Guy in London, and by Stark in Edinburgh, may differ widely in many of the leading features of the inquiry, and yet the inferences of each be correct in themselves. The author therefore believed that it would be much more to the interest of science to pursue his researches independently of all previous inquiry, divesting himself of all foregone conclusions, and making the facts which he has collected speak for themselves. By following this plan he derives two advantages: *firstly*, that of avoiding a tedious recapitulation of the facts and deductions to be found in other works; and, *secondly*, that of drawing an unbiassed opinion upon the subject, which may the more confidently, on that account, be employed in comparison with results obtained in other localities.

The difficulties attending inquiries into the influence of weather upon mortality are manifold and intricate. All other causes, to which might, altogether or in part, be due the facts observed, must be abstracted and carefully weighed before the true balance of meteorological influence can be justly ascertained; and when this is done, there still remains a deduction to be made for error arising from the unequal distribution of meteorological phenomena even over an area so limited as that of a single city. Whether dependence can be placed upon the accuracy of the returns of the causes of death made to the Registrar-General is another question of serious importance in such investigations. These and many other obstacles arise to bar logical exactness; but where the aim is simply to obtain an approximate knowledge of the subject, the author believes his data are abundantly accurate.

The meteorological data are taken from the collected returns from all the stations of the Meteorological Society of Scotland, as reduced by the Astronomer-royal. The stations have a mean latitude of 56° 30′ N., mean longitude of 3° 4′ W., and a mean elevation of 222 feet nearly.

The mortality tables are constructed from the returns made by the Registrar-General for Scotland respecting the eight larger towns. The period over which the investigations extend is six years—namely, from 1857 to 1862 inclusive. The meteorological data did not admit of extension over a longer period. The author regrets that he is unable to include ozone and electricity in his investigations. With respect to electricity, he has no data applicable to the places and period under examination; and with reference to ozone, he submits, that until the chemistry of that subtile agency is better established, its influence upon the human frame cannot be determined. The grand total of deaths from all causes under consideration during the six years was 143,249, and the average population 867,313. The corrected population for each year is employed as the standard of reference for each year's mortality. The inquiry is led into the influence of weather upon mortality from individual diseases, and the several classes of disease, as well as into the mortality from all causes. A detailed account of the inferences deduced by these investigations would involve the reproduction of a series of tables and diagrams for which the Society's Proceedings are not available, and all of which will be found in the extended paper.

2. History of Popular Literature, and its Influence on Society. By Wm. Chambers, Esq., of Glenormiston.

Having introduced the subject, Mr Chambers referred to the earliest examples of popular literature in the reign of Elizabeth; they were embelished with wood engravings, believed to be executed in Germany. Such was the origin of those very curious tracts known as "chap books," now very rare, and much prized by bibliographic amateurs. The subjects of these books resembled the Folk-Lore of the Germans, and were the embodiment of the superstitions, fancies, and traditions of a much earlier period; the least exceptionable being the ballads of a heroic and tender kind. Next was traced the rise of newspapers, and the importance they began to assume in the reign of Queen Anne, a period also signalised by the popular writings of Steele, Addison, and Defoe. The imposition of the stamp-duty in 1712 checked this sudden rise of popular literature; and various circumstances postponed its reappearance until the reigns of George IV. and William IV., by which time great advances had been made in education and in a general taste for literature,—the writings of Cowper, Burns, Campbell, Wordsworth, Scott, Byron, and others, along with the influence of certain reviews and magazines, having latterly given much impetus to thought. Mr Chambers then spoke of the origin of Chambers' Journal in February 1832, the Penny Magazine in the subsequent March, and other cheap prints, devoted in an especial manner to popularise literature. Finally, he drew attention to the abolition of fiscal duties on the products of the press,—the prodigious copiousness of cheap popular sheets, cheap newspapers included,—and the capacity of modern machinery, moved by steam-power, for their rapid production. On investigation, he found that only a small proportion of the whole was of an immoral, or otherwise objectionable kind; much of the writing in this popular department of literature being by authors of repute, to whom large sums were paid for their services. He estimated that there were not fewer than three hundred millions of newspapers now circulated per annum in the United Kingdom; while the quantity of cheap literary sheets issued per annum amounted to 144,000,000. He concluded by referring to the highly improved tone in all departments of the press, not the least of the beneficial effects of modern popular literature being the extinction of what was worthless and pernicious. On concluding his paper, Mr Chambers laid on the table a quantity of copies privately printed for distribution among the members present.

The following note from Principal Sir David Brewster was read by Professor Tait:—

"I send you, for the Royal Society, six of my best specimens of Decomposed Glass. In presenting them, perhaps you might mention the disappearance of all colour, by introducing a drop of water, and the passage of a prismatic line over each film, owing to the water entering more quickly between some of the elementary films than between others. These may be found by using a balsam that will quickly indurate."

The following announcements were made from the Chair:—

1. The Council have awarded the Neill Prize for the Triennial period 1859–62 to Robert Kaye Greville, LL.D., for his contributions to Scottish Natural History, more especially in the department of Cryptogamic Botany, including his recent papers on Diatomaceæ.

2. The Council have resolved that a Conversazione shall take place in the Society's room, on Wednesday, 25th February, at 8 P.M.

The following Gentlemen were elected Fellows of the Society:—

John Young, M.D., Assistant Geologist, Geological Survey of Great Britain.

David Page, Esq., F.G.S.

The following Donations to the Library were announced:—

Essays from the "Quarterly Review." By James Hannay, Esq., F.R.S.E., Author of "Satire and Satirists," &c. 8vo.—*From the Author.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München. 1862. I. Heft 4, und II. Heft 1. 8vo.—*From the Academy.*

Bulletin de la Société Impériale des Naturalistes de Moscou. Année 1861. Nos. I., II., III., et IV. 8vo.—*From the Society.*

The Journal of the Royal Dublin Society, Nos. 26, 27, 28. 8vo.—*From the Society.*

Historical Sketch of Popular Literature, and its Influence on Society. By Wm. Chambers, Esq. of Glenormiston.—*From the Author.*

Monday, 16th February 1863.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. Sketch of the Recent Progress of Sanskrit Literature. By John Muir, D.C.L., LL.D. (This Paper was given at the request of the Council.)

After giving a sketch of the first beginnings of these studies in India, and their further prosecution in Europe, the author adverted to the relations of Sanskrit with the Greek, Latin, and Teutonic languages, and showed how this affinity established the common origin of the nations by which these languages have been spoken. He then proceeded to give an account of Indian literature, commencing with the hymns and other constituent parts of the Vedas, and then proceeding to the principal systems of Indian philosophy, of which he furnished an outline. He then gave a short statement of the rise and progress of Buddhism, and concluded by merely referring to the later developments of Indian religion and literature, and to the versatility of the Indian intellect as evinced by the variety of its literary productions.

2. On a Pre-Brachial Stage in the Development of *Comatula*, and its importance in Relation to certain Aberrant Forms of Extinct Crinoids. By Professor Allman.

The author described a stage in the development of *Comatula* subsequent to the free stage of the larva, and anterior to that in which it acquires arms. He believed that the subject of the paper was of much interest in affording a key to the nature of certain aberrant forms of extinct *Crinoidea*, such as *Haplocrinus*, *Stephanocrinus*, &c., for the peculiarities of these genera were for the most part exhibited in the young *Comatula*, where they admitted of an easy determination as elements in the composition of the Crinoid.

The following Gentlemen were admitted Fellows of the Society:—

J. G. Wilson, M.D., F.R.C.S.E.
James Matthews Duncan, M.D.
George R. Maitland, W.S.
W. Dittmar, Esq.

The following Donations to the Library were announced:—

Explication de la Carte Geologique des parties de la Savoie, du Piémont, et de la Suisse. Par A. Favre. 8vo.—*From the Author.*

Report of the Commissioners of Patents for the year 1861. Agriculture. 8vo.—*From the American Government.*

Library Catalogue of the Royal College of Physicians. 4to.—*From the College.*

Transactions of the American Philosophical Society. Vol. XII., Part II. 4to.—*From the Society.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München. 8vo.—*From the Academy.*

Proceedings of the Royal Society. Vol. XII., No. 53. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society of London. Vol. VII., No. 1. 8vo.—*From the Society.*

Journal of the Chemical Society. February 1863. 8vo.—*From the Society.*

Victorian Exhibition, 1861. Report on Class III.: Indigenous Vegetable Substances. 8vo.—*From the Government.*

Tenth Annual Report of the Trustees of the Public Library, Boston. November 1862. 8vo.—*From the Trustees.*

Annual Report of the Geological Survey of India for 1861–62. 8vo. —*From the Government.*

Proceedings of the American Philosophical Society. Vol. IX., No. 67. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. February 1863. —*From the Society.*

Memoirs of the Geological Survey of India. 4to.—*From Dr Oldham.*

Memoirs of the Geological Survey of India. II. 1 and 2. 4to.—*From the same.*

Geschichte der Physischen Geographie der Schweiz. Von B. Studer. 8vo.—*From the Author.*

Natuurkunde Verhandelingen van de Hollandsche Maatschappij te Haarlem. XVII. Deel, and XIX. Deel, Eerste Stuk. 4to. —*From the Association.*

Preisschriften gekrönt und herausgegeben von der fürstlich Jablonowski'schen Gesellschaft zu Leipzig. 4to.—*From the Society.*

The American Journal of Science and Arts. No. 102. 8vo.—*From the Conductors.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1862–63. No. 61.

Monday, 2d March 1863.

Principal Sir DAVID BREWSTER, Vice-President, in the Chair.

In presenting the Neill Prize, the Chairman made the following remarks:—

Before presenting the Neill Medal to Dr Greville, in conformity with the decision of the Council, it may be proper for the information of strangers, and even of many Fellows of the Society, to give a brief notice of the bequest to science which was made by the late Dr Patrick Neill.

Although Dr Neill was a member of this Society, he never took an active part in its proceedings, and I believe never communicated any paper to its Transactions. He was one of the founders of the Wernerian Society, and discharged the duties of its Secretary during the thirty years of its existence under the able presidency of Professor Jameson. The Wernerian Society was, indeed, the rival of the Royal Society of Edinburgh, and its seven volumes of Transactions contain many papers by distinguished writers which would otherwise have been communicated to this Society.

Dr Neill's first publication appeared in 1806, and was entitled "A Tour through some of the Islands of Orkney and Shetland." In 1829 he published his "Horticultural Tour in Flanders," and in

1845 his "Fruit, Flower, and Kitchen Garden," which was a republication of the article "Horticulture" in the Edinburgh Encyclopædia. Dr Neill communicated only two papers to the Wernerian Transactions, one entitled "A List of Fishes in the Forth, and Lakes and Rivers near Edinburgh," and another "On the Fossil Remains of the Beaver in Perthshire and Berwickshire."

Dr Neill died in 1851, and bequeathed to the Royal Society of Edinburgh the sum of L.500, "the interest of which was to be applied in furnishing a medal every second or third year to any distinguished Scottish Naturalist, to be adjudicated by the Council of the Society."

In fulfilling this trust, the Council wisely adopted the triennial in place of the biennial period, and the first adjudication of the prize was made to Dr Lauder Lindsay for his researches on the structure of lichens.

The second adjudication was made to Dr Robert Kaye Greville "for his contributions to Scottish Natural History, more especially in the department of Cryptogamic Botany, including his recent papers on Diatomaceæ."

Dr Greville's contributions to Natural History have been both numerous and valuable, and their merits have been recognised by the most distinguished Botanists of the age. His "Scottish Cryptogamic Flora" was published between 1823 and 1828. His "Flora Edinensis" appeared in 1828. His "Algæ Britannicæ, or, Description of Marine and other Inarticulated Plants in Britain belonging to the order Algæ," was published in 1830, and he has inserted in the "Microscopical Journal" no fewer than twelve papers on the Diatomaceæ, an interesting subject which still occupies his attention.

But Dr Greville's services to science have not been limited by his writings. He has been an ardent collector of plants and other objects of natural history; and his complete herbarium of Phanerogamous and Cryptogamous plants, as well as his collection of insects, have been placed in the Museum of our University. He has also made a collection of land and fresh-water mollusca, which is the finest in Scotland.

These various contributions to natural history have been highly appreciated both in this and in foreign countries. In 1824 the

University of Glasgow conferred upon Dr Greville the degree of Doctor of Laws, and many of the Natural History Societies in Europe and America have received him among their corresponding or honorary members.

Though somewhat foreign to the present occasion, the Society will, I trust, excuse me for adding, that Dr Greville has taken an active part in those interesting questions of philanthropy, on the solution of which the happiness and security of society depend. He has felt, as I am sure most of us here feel, that there is something greater than science, and something higher and more enduring than fame; and it is no slight ground of congratulation, that some of those who have been commissioned by their Maker to study His works, and to sound the depths of His wisdom and His power, have shunned the fatal course which others have pursued, of sapping the foundations of that faith and hope which science is so able to sustain.

Dr Greville, In the name of the Council I now beg to present to you the Neill Medal, and to congratulate you on this honour, which you have so well merited.

The following Communications were read:—

1. Letter from Sir D. Brewster relative to the specimens of Topaz with Pressure Cavities presented by him to the Museum of the Society.

Dear Professor Balfour,—In vol. xvi. of the "Transactions of the Royal Society of Edinburgh," I have described and given drawings of the pressure cavities which I discovered in topaz; and in vol. xxiii., just published, I have pointed out the geological relations of these cavities.

As the specimens of topaz containing them are so rare that I have found only *five* out of many hundreds which I have examined;—as the existence of such cavities with a polarising structure around them, proving that the topaz was in a soft or plastic state, will hardly be admitted by those who believe that the topaz was formed by aqueous deposition;—and as it is quite possible that other specimens containing such very minute cavities may never be found, even when diligently searched for, I think it right to present to the Society for preservation the *five* topazes in which the cavities were found.—I am, ever most truly yours.

(Signed) D. Brewster.

Allerly, *Feb.* 7, 1863.

2. On the Polarization of Rough Surfaces, and of Substances that reflect White or Coloured Light from their Interior. By Sir David Brewster, K.H., F.R.S.

3. On a Clay Deposit with Fossil Arctic Shells, recently observed in the Basin of the Forth. By the Rev. Thomas Brown, F.R.S.E.

The author having stated the circumstances which led to his discovering this bed with its fossils near the harbour at Elie, referred to a drawing of the section, and explained the position and contents of the different strata.

Specimens of the shells were exhibited, as named by Dr Otto Torrell of Lund, who had supplied important information as to their distribution. They are all, without exception, now living in the Arctic Seas. A majority of them are exclusively Arctic. Several are new to the British glacial deposits—viz., *Thracia myopsis*, *Pecten groenlandicus*, *Crenella decussata*, *C. lævigata*,* *Turritella erosa*,† and a new *Yoldia* found in Spitzbergen in 80° north latitude.‡ It was shown how strongly this evidence goes to prove the former existence of a Boreal or Arctic climate in Scotland.

The shells seem also to indicate some considerable rise in the level of the land. They are deep-water species—some of them very markedly so. Four distinct series of facts appear to show that they have not been washed up and transported, but are lying in the clay-bed where they originally lived. As the deposit is now rather above high-water mark, the fair inference would seem to be

* "Most probably, but much injured."

† "Almost certainly this species, yet cannot be positively asserted."

‡ The other species are—*Saxicava rugosa*, large form, *Tellina proxima*, *Astarte compressa*, *Leda truncata*, *L. pygmæa*, *Natica groenlandica*, large form. Fragments also occur which seem to belong to *Cyprina Islandica* and *Mya truncata*.

that the whole sea-bed of the Firth must have been considerably raised.

Reference was made to the discovery of the glacial beds of the Clyde by Mr Smith of Jordanhill. They had been looked for on the Forth, but without success. Dr Fleming struck the first trace of them at Tyrie, but it was faint, there being only two or three specimens of the shells, and these he was led to think not indigenous. In the Elie clay the same two species occur rather abundantly, along with others, all evidently in the clay-bed where they had lived. The group is so characteristic that there need be no question now as to the occurrence of the true old glacial beds with Arctic shells in the basin of the Forth.

Various reasons were stated for holding that this bed is very closely connected with the boulder clay, being not improbably a sea-formation contemporaneous with some portion of that deposit.

It was shown, that the facts brought to light in this section give us some glimpse into the circumstances under which the period of Arctic cold passed away.

The submerged forests of the Fifeshire coast were referred to in connection with the information which this section seems to furnish as to the somewhat obscure question of their true stratigraphical position.

4. On the Remarkable Occurrence of Graphite in Siberia. By Thomas C. Archer, Esq.

The author in this paper gives the localities of three large mines of this mineral. The first situated in the Semipalatinsk district, Western Siberia, between 47° and 50° N. Lat., and in 80° E. Long. from Greenwich, on the Kirghesian Steppe. The locality of the mine is remarkably barren, and upon digging down a few feet, the graphite is found lying in a continuous stratum which has been ascertained to extend over a space of 2100 acres. This immense deposit belongs to Messrs Samsonof and Mamontof of Sernopol, and is worked for commercial purposes.

The second deposit is of a similar character as to its stratification; but instead of being covered with a bed of peaty soil, as in the case of the former, it has overlying it, a stratum of spathose iron ore of a very peculiar texture, being close grained and black, and breaking with a remarkable conchoidal fracture. This mine is situated in Eastern Siberia, on the Lower Tunguska, about 240 miles from its confluence with the Ye-nee-sey, its geographical position being between 50° and 65° N. Lat., and in 102° E. Long.

The bank of the river for 1960 feet is formed entirely by a section of the graphite stratum, varying from 35 inches to 5 feet in thickness, and above it, often receding several feet, the stratum of spathose-iron ore, also about 5 feet in thickness. These beds of graphite and iron ore being washed by the river floods, are quite bare for from 30 to 105 feet inland, where a bank begins to rise, formed by the detritus of a mountain side; one of the chain of Alexyef, which itself is placed about 1800 feet from the shore. This mountain is composed of gneiss, and it has not been ascertained whether either of the strata above mentioned pass into the mountain, but they have been traced nearly to the base by borings, and have been found to extend, without varying very much in thickness, over a space of about 1960 square feet, computed to contain 12,000,000 cubic feet of graphite.

The author believes that no similar beds or strata of graphite have ever been discovered, this mineral usually being in imbedded masses, rarely very large, or in large nodules in *pockets* formed in trap and other igneous rocks.

The third mine described—namely, that of M. Alibert—is of this character. It is also in Eastern Siberia, at the foot of Mount Balagool, 98° 30″ E. Long., by 52° 20″ N. Lat., 200 miles west from Irkutsk. Mount Balagool is composed chiefly of sienite, and it is by laborious operations that the graphite is raised to the surface. The mines are worked by the half-wild Buriates of the district; but the quality of the graphite is so remarkably fine that it amply repays the labour, L.1200 worth having being raised in the first four months.

The author called attention to these mines, because, from their vastness, as compared with other graphite deposits, they assume a geological importance, and are rendered peculiarly interesting by the facts lately stated by Dr Pauli respecting the development of plumbago in the process of manufacturing caustic soda on a large scale.

The following gentleman was admitted a Fellow of the Society:—

Rev. Robert Nisbet, D.D.

The following Donations to the Library were announced:—

Proceedings of the British Meteorological Society. Vol. I. Nos. 1–4. 8vo.—*From the Society.*

List of Members of the British Meteorological Society. 1862. August.—*From the same.*

Catalogue of Books in the Library of the British Meteorological Society. August, 1862. 8vo.—*From the same.*

Eleventh Report of the Council of the British Meteorological Society for the year 1861. 8vo.—*From the same.*

The American Journal of Science and Arts. January, 1863. 8vo.—*From the Conductors.*

Proceedings of the American Philosophical Society. Vol. IX. No. 68. 8vo.—*From the Society.*

The Journal of Agriculture. March 1863. 8vo.—*From the Highland and Agricultural Society.*

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. No. XXXII. 8vo.—*From the Registrar-General.*

Supplement to the above. 8vo.—*From the same.*

Denkschriften der kaiserlichen Akademie der Wissenschaften. Philosophisch-historische Classe. Zwölfter Band. 4to.—*From the Academy.*

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften. XXXIX Band. ii, iii, iv, u. v, Heft; u. XI Band. i. u. ii, Heft. (Philosophisch-historische Classe.) 8vo.—*From the same.*

Sitzungsberichte der kaiserlichen Akademie der Wissenschaften Mathematisch-naturwissenschaftliche Classe XLV Band, iii, iv, u. v, Heft (Erste Abtheilung), u. v, Heft (Zweite Abtheilung); u. XLVI Band. i, u. ii, Heft (Zweite Abtheilung). 8vo.—*From the same.*

The Plants Indigenous to the Colony of Victoria, described by

Ferdinand Mueller, Ph.D., M.D., &c. Vol. I. Thalamifloræ. 4to.—*From the Author.*

Maps of the Ordnance Survey of Scotland. With Catalogue.—*From Colonel Sir Henry James.*

Monday, 16th March 1863.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Polarization of the Atmosphere. By Sir David Brewster, K.H., F.R.S.

2. Concluding Note on the Star Observations at Elchies. By Professor C. Piazzi Smyth.

In the former paper, read in December 1862, the author had detailed the points of interest that had been found in discussing the angles of position, distances, and magnitudes of certain double stars which he observed at Elchies with Mr Grant's fine telescope in last September; and he now treated similarly the observations of the *colours* of the stars then and there observed. The chief point to notice being, that in certain cases the colours undergo periodical variations; with the star "95 Herculis" in twelve years, almost exactly within the tenth part of a year, if older records can be trusted to implicitly; and such periodical change the author considered a new feature in this branch of astronomy, and one of a most important and hopeful character for observers to follow up in future.

The paper concluded with a well-merited tribute of praise to Mr Grant of Elchies, for his services to science, in planning, causing to be made, and then erecting, his large equatorial telescope; and with sincere condolence for his subsequent long illness, "which alone is the cause that he himself has not been the first to contribute to a learned Society observations, and perhaps discoveries, made by himself with the said telescope."

3. On a new fossil *Ophiuridan*, from Post-pliocene strata of the valley of the Forth. By Professor Allman.

I am indebted to one of our University students, Mr Peter Lawson, for a specimen of a star-fish, which he informed me had been found, along with many others, in a deposit of brick-clay near Dunbar. The interest of this fact was a sufficient inducement to cause me at once to visit the locality where the star-fish was obtained, and where, by the kindness of Mr France, the proprietor of the brick-works, I succeeded in obtaining good specimens of the fossil.

Notwithstanding some very marked characters, which might possibly be regarded as possessing higher than specific value, I prefer referring the star-fish of the Dunbar brick-clay to Müller and Troschel's genus *Ophiolepis*, rather than encumbering the existing nomenclature with a new and doubtful generic name. The species, which is very distinct from every other described member of the genus, may be defined by the following diagnosis:—

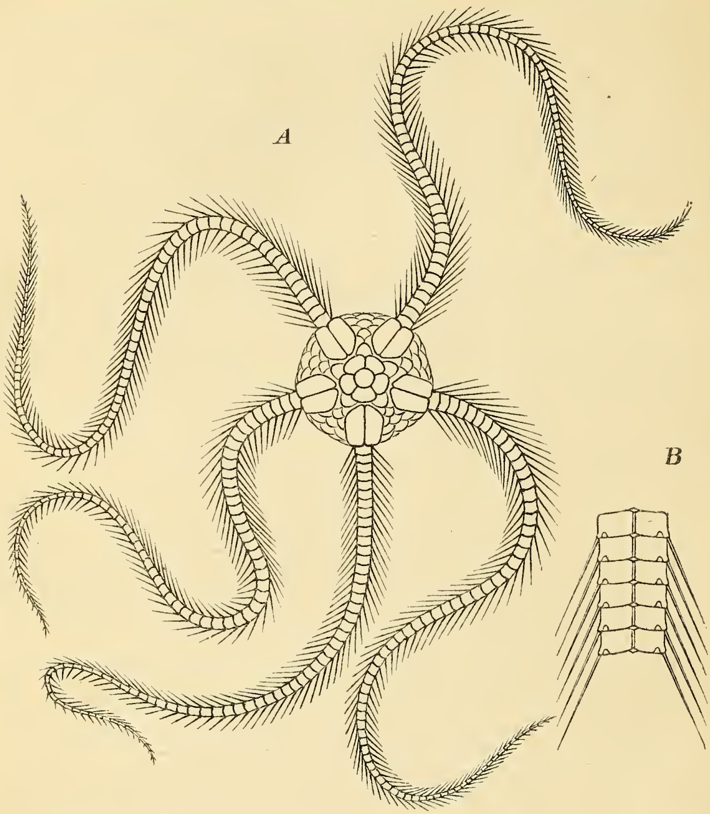
Ophiolepis gracilis (mihi), nov. spec.

Upper surface of the disc covered with imbricated plates, a single circular plate occupying the centre, and with the radial shields large, and having their opposed edges in contact for their entire length. Dorsal shields of the arms about twice as broad as long near the disc, and thence with their breadth gradually decreasing in proportion to their length, until towards the distal extremity of the arm they become longer than broad; they cover the whole dorsal surface of the arm, and have their adoral and aboral margins transverse and parallel. Ventral shields of the arms very minute, and allowing the lateral shields of one side to meet those of the opposite side in the inferior median line of the arm. Aboral edge of each lateral shield with a notch for the exit of a cirrus. Spines about once and a-half as long as the breadth of the arms. Arms about five times as long as the diameter of the disc, and gradually tapering to a fine point.

The size of the largest specimens obtained is about four inches from tip to tip of the arms.

One of the most remarkable features in the present species is the rudimental condition of the ventral shields of the arms; these shields being much smaller than in *Ophiolepis ciliata* (Mül. and

Fossil in brick-clay of the Post-pliocene age, near Dunbar, Scotland.



Ophiolepis gracilis—(A) viewed from the dorsal side, slightly enlarged; (B) ventral wall of one of the arms still more enlarged viewed from within; showing the lateral shields slightly separated from one another along the mesial line, where the minute ventral shields are introduced between their angles. The apertures for the exit of the ambulacral cirri are seen near the outer edges of the lateral shields.

Trosch.), where they are exceptionally small among the *Ophiuridæ*, and where the lateral shields bear only short papilliform spines instead of the long, highly-developed spines of *O. gracilis*. It was only after having sought in vain for the ventral shields in some dozens of specimens that I succeeded in detecting them in a single instance. In this case they appeared in a view of the internal surface of the ventral wall (fig. B) as very minute rhombic plates lying along the mesial line, where they were interposed between the angles of the lateral shields. It is quite possible that the ventral plates are more fully displayed upon the outer surface of the wall, but in no case did I find this surface sufficiently exposed to enable me to obtain a view of them; while the inner surface, on the contrary, was frequently well exposed by the disappearance in the fossil of the dorsal shields, and of the series of vertebra-like ossicles, which, in the living *Ophiuridæ* occupies the axis of the arms. In most of the specimens sufficiently well preserved to afford a view of the ventral walls of the arms, the lateral shields were seen to be slightly separated from one another along the ventral suture, leaving here a distinct but narrow fissure, which was not interrupted even by the intervention of the minute ventral plates, which had in almost every case disappeared. In some instances, however, the lateral shields escaped displacement, and the two series were then in contact with one another along the line of suture. The notch for the exit of the cirri or tentacular ambulacra, situated on the aboral edge of every lateral plate, is very distinct, and is completed into an entire aperture by the adoral edge of the plate next in succession. The spines along the sides of the arms are long and slender; in no case, however, could I satisfy myself that more than a single spine was borne by each lateral shield; but the condition of the specimens does not justify our thus limiting the number of those spines. Neither was I able to discover in the specimens any evidence of scales over the apertures for the cirri.

The deposit in which *Ophiolepis gracilis* occurs is a fine dense tenacious blue clay of Post-pliocene age. It is situated upon the shore of the Firth of Forth, about two miles to the west of Dunbar, and is largely worked for the manufacture of bricks. It lies low; and were it not for an artificial embankment, would be flooded at high tide.

In this deposit, at about five feet from the surface, is a horizontal bed, where the star-fishes are found. They occur in great numbers upon the surface of the bed, which is occasionally separated from the bed above it by a thin parting of fine sand. They are remarkable for their unmutilated condition, lying there with their slender arms, even to the extreme points, in the position which they must have naturally held during life, thus showing an entire absence of that spontaneous dismemberment which is so characteristic of the *Ophiuridæ* when dying under any prolonged irritation, and indicating some sudden cause of deprivation of life, such as we may suppose to result from an irruption of fresh water into the part of the sea inhabited by them.

None of the specimens I obtained, however, were sufficiently well preserved to enable me to make out all their characters as completely as I could have wished, the nature of the clay in which they were imbedded being apparently not suited to the preservation of the more delicate structures. The oral surface of the disc, especially, was in no case retained so perfectly as to allow of the mouth or the disposition of the plates of this part of the animal being observed. It was only in some instances that traces of the spines were visible, and then almost the only indications left were their impressions in the surrounding clay.

It is a curious and interesting fact, that not only did all the specimens found belong to a single species, but that not a vestige of a shell, or of any other organism, could be detected in any part of the clay which I had an opportunity of examining.

The following gentlemen were admitted Fellows of the Society:—

The Hon. Lord Ormidale.

Joseph D. Everett, M.A., Professor of Mathematics and Natural Philosophy, King's College, Windsor, Nova Scotia.

The following donations to the Library were announced:—

Almanaque Náutico para 1864, calculado de órden de S. M. en el Observatorio de marina de la ciudad de San Fernando. Cadiz. 1862. 8vo.—*From the Director of the Observatory.*

Proceedings of the Linnean Society. Vol. VII., No. 25. 8vo. —*From the Society.*

The Canadian Journal of Industry, Science, and Art. February, 1863. 8vo.—*From the Canadian Institute.*

Proceedings of the Horticultural Society. March 1863. 8vo.—*From the Society.*

Transactions of the Historic Society of Lancashire and Cheshire. New Series. Vol. II. 8vo.—*From the Society.*

Proceedings of the Royal Institution. Vol. I. 8vo.—*From the Institution.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIII. No. 4. 8vo.—*From the Society.*

Abstracts of the Proceedings of the Geological Society of London. No. 91. 8vo.—*From the Society.*

The Journal of the Chemical Society. Nos. II. and III. 8vo.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland. February, 1863. 8vo.—*From the Registrar-General.*

Journal of the Statistical Society of London. March 1863. 8vo. —*From the Society.*

Pilote Francaise.—*From the Depôt de la Marine.*

Monday, 6*th April*, 1863.

Professor KELLAND, Vice-President, in the Chair.

Mr J. D. Marwick presented, through Professor Smyth, specimens of lead from the roof of the lower storey of Nelson's Monument, on the Calton Hill, injured by lightning.

The following Communications were read :—

1. Accompanying Note to Portions of Lead from the Roof of the Lower Storey of Nelson's Monument, injured by Lightning on the evening of 4th February 1863. By Professor C. Piazzi Smyth.

The portions of sheet-lead above mentioned had attracted my attention on the days following the 4th of February, when engaged in repairing some damage which had then occurred to the electric wires connecting the Nelson Monument and the Observatory; and finding that plumbers (employed by the Town-Council) were removing the old lead and substituting new in its place, and being also encouraged by Professor P. G. Tait, who with me visited the spot, to believe that the markings which had been discovered were electrically of unusual interest, I lost no time in applying to Mr J. D. Marwick, town-clerk, for those portions of the leaden covering which contained the marks in question, with the view of presenting them to the Royal Society.

Mr Marwick was as obliging as prompt in responding to such a request, and sent me the required specimens next day, accompanied by the enclosed memorandum written by Mr H., assistant to Mr Cousin, city-architect.

10*th February* 1863.

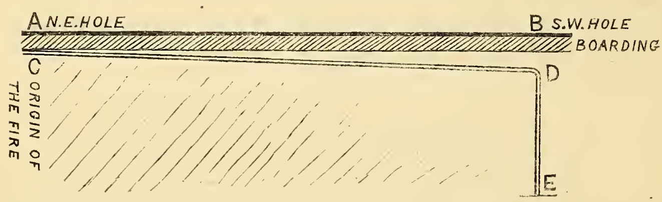
" The accompanying pieces of lead were taken from the north-west side of the lead platform on the roof of the lower part of Nelson's Monument.

" The distance between the holes was about nine feet six inches.

" Both holes were immediately over a block-tin gas-pipe, which is here carried under the lead and boarding of the platform, and which was found melted the whole length between the two holes, and a foot beyond the north-east hole.

" These holes in the lead were evidently *directly* caused by the burning gas from the pipes underneath.

Fig. 1.



" The sketch shows section through the platform between the two holes A and B. CD shows the gas-pipe under and between them.

" From this sketch we might naturally expect a hole melted in the lead at A, the pipe being here at its highest level immediately under the boarding, only one inch from the lead.

" The pipe between C and D would very quickly be melted by the burning gas, as it lies horizontally and can be more easily acted on by a flame issuing from it.

"At D the pipe dips vertically about eighteen inches.

"It is evident that the *vertical* length of pipe DE would not be readily melted by the strong flame burning at D.

"The boarding and lead at B, immediately over D, would therefore be exposed to the flame of the gas for a much longer time than any part between A and B. And here we might expect what we find, a large piece of the boarding burnt, and the larger of the two holes in the accompanying pieces of lead.

"How the gas was at first ignited remains to be shown.

"H."

The above memorandum gives an excellent matter-of-fact description of what chiefly remained to be seen at the time when it was written, but it does not mention what had much struck me several days previously, when I first caught sight of the small and neat oblong hole in the roof at A; and, on subsequently pulling up the leads, which at that time had not been disturbed at that place since the storm, I found the under surface of the metal strangely burred and scored around the aperture, and also perceived small globules of melted lead, driven away apparently by some radiating force from the hole, until caught and jammed between the remaining uninjured lead and its wooden surface of support.* Neither does the memorandum account for the first igniting of the gas, but expressly says, that what may have caused that "remains to be shown."

This is in truth the most important part of the whole affair, and which I will now endeavour to describe.

The evening of the 4th of February 1863 ushered in one of the most violent storms of thunder and lightning that has been experienced in Edinburgh, and perhaps in most parts of Scotland, for many years, and its violence was all the more remarkable, inasmuch as the month of February is near the minimum of the year for

* These globules had very imperfect adhesion, and had mostly dropped off when the plate was presented to the Royal Society; but some few of the more distant ones still remained, and all the others had left marks, usually of a yellowish colour, showing their former positions, sizes, and shapes.

electrical manifestations in the shape of thunder-storms. This point, not yet generally acknowledged, is indicated pretty certainly by the following numbers, extracted from the Registrar-General's printed Reports for Scotland; they are, in fact, the deductions prepared for that officer at the Royal Observatory, Edinburgh, from the schedules of fifty-five observers of the Meteorological Society of Scotland, and give, for the means of three years, as follows:—

	Number of Stations at which Lightning was seen.	Mean Number of Times at each Station.
January, . . .	34	4
February, . . .	11	2
March, ...	42	3
April, ...	24	4
May, ...	86	5
June, ...	85	7
July, ...	91	7
August, . . .	54	3
September, . .	31	3
October, . . .	50	8
November, . .	30	4
December, . .	37	4

The storm, then, was anomalous in its season of occurrence, and in its violence; also, as it would appear from the newspaper accounts, by the regularity and broad spread of its passage over the country from west to east, occurring nearly an hour earlier at Greenock than at Aberdeen or Edinburgh. In Glasgow and its neighbourhood several buildings were struck, a tall chimney and a church entirely ruined; a lodging-house of operatives injured in every floor; and a large number of the telegraph instruments of the Private Telegraph Company thrown out of order, and one clerk rendered senseless.

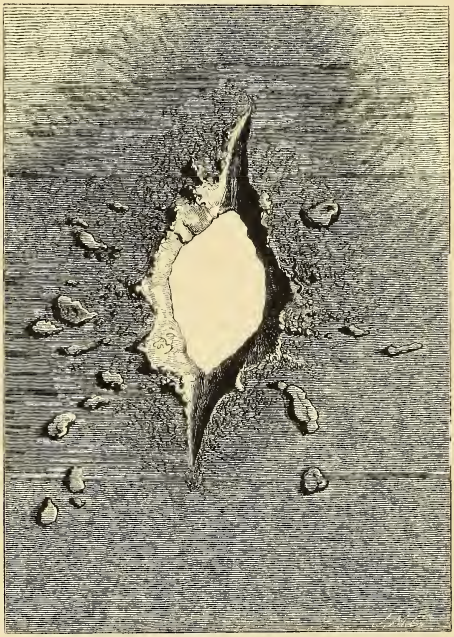
This storm began in Edinburgh about 7^h P.M., and lasted nearly an hour; it came with very strong west wind, and accompaniments of rain and hail; and it was described to me by Mr Wallace, who was on the Calton Hill at the time, as being most remarkable for the slanting, almost horizontal, direction of the lightning, as well as its greenish-blue colour. The thunder was at the same time deafeningly loud, and on one occasion apparently coincident with the flash; shaking the house he was in (the old Observatory Tower), and giving the idea that either that building, or the Royal Observatory, must have been struck. Going out immediately to see what might have happened, he met the servant at the door, who spoke of the flash of lightning having entered the lowest room of that tower, "gone half way across the floor," and left an overpowering smell of "brimstone" behind; and also called his attention to Nelson's Monument, about 200 yards east-south-east of them, being apparently on fire, because sparks were issuing from the roof of one of the low rooms at its foot, on the western side.

Now, at the winter period of the year, it seems that the tenant there (Mrs ———) finding the above monumental building very cold, prefers to live in a wooden house close by, and on the evening of the 4th of February she was in that house ill and in bed; but when the particular flash occurred which had been so much noticed by Mr Wallace and the Observatory servant, it seemed close to her also, filled her house with the brimstone odour, and so firmly impressed her with the belief that the Monument had been struck, that she sent out her servant "to see if the time-ball was still at the top of the building;" believing that if mischief had occurred anywhere from lightning, it would be near the summit of the structure. The answer, however, brought back was, that the time-ball was quite safe, but that sparks were coming out of the roof of the low west room. The policeman of the hill was likewise on the ground almost immediately after the flash, and testified both to the then sudden appearance of sparks issuing from the roof of the uninhabited room, and its accompaniment, by the traditional sulphurous smell in the air of strong lightning, or "ozone."

The door of the Monument was then speedily opened, access to the roof obtained, and the new-lit fire, caused by the burning of gas and wooden rafters, speedily extinguished. In this manner the gas, no doubt, after it was set on fire, did much mischief to both leaden roof and wooden rafters, especially at the place on the sketch marked B, which contains big and rather confused holes; but if any one still asks what first set the gas on fire, I think there is equally little doubt that we may answer "it was that particular slanting flash of local and ozone-producing lightning which excited the residents on the hill so much at the time."

We may probably also assume that the lightning struck at the point A. I had already been directed to that point from the

Fig. 2.



The hole at "A," as it appears on the under surface of the lead; carefully drawn full size by Mr J. M. Corner, wood-engraver.

similarity of the hole there, to a lightning hole in sand, but could not imagine why the fluid should have pierced a hole through a good conductor, viz., a sheet of lead. On mentioning this difficulty to Professor Tait, he remarked, "that if the hole was due to the immediate action of the spark, I might be quite sure that there was a conductor below, which the lightning was trying to get at and pass off by," and *after* that opinion had been so expressed, the lead was lifted at the place (it had previously only been raised at B), and the gas-pipe was found precisely there at its closest point of approach anywhere to the roof, as may be seen clearly represented in the assistant architect's subsequent and independent drawing.*

However anomalous, therefore, the case may appear at first, some theoretical principles are remarkably borne out by it; and that the foot of the building should have been struck, and not the top, seems to follow from the low, level and almost horizontal direction in which the lightning was sensibly observed to come, and with the wind and rain,—causing thereby the windward foot of the tall building to become for that occasion the shortest passage for the fluid to reach the ground by.

In such a case, though, it may be suggested, that the long horizontal wire extending through a length of 4000 feet between the Nelson Monument and the castle for the service of the time-gun, should have been most abundantly charged by induction. That is true; and there is little doubt but that the said wire was copiously filled, and might have produced dangerous effects, had it not been furnished at either end with large copper plates in close proximity to many pronged conductors ending in wet earth, which led away innocuously the greater part of the charge. Enough however still remained to do some singular damage to the electrically controlled clocks at either end of the line. Thus, the members of one of the bundles of permanent magnets, near the pendulum-bob of the castle clock, had their poles changed and their new attraction made rather stronger than their old; the members of a similar bundle in the Observatory window-clock had their poles partially changed; and in the interior of the Normal Mean Time clock one of the gold contact points was partially fused, and spattered on its steel spring, which was blued at that part as though by heat.

The gold contact point thus treated, it will be understood, was in direct metallic connection at the instant with the long open-air wire; and the magnets that were altered were in indirect connec-

* Professor Tait has also remarked, and it seems well worthy to be noted as a memorandum for any future occasion, that it would have been advisable to have preserved the boarding at "A," as well as the lead; for the manner of action and of piercing through wood by lightning is very different to the burning action of flame; and thick wooden planking *was* everywhere interposed between the gas-pipe and the leaden roof.

tion, or rather, in inductive position, for they were surrounded at the time by the wire coil of the pendulum-bob, whose composing wire is a connected continuation of the long open-air wire.

To this it only remains to add, that these lightning-made magnets at the Castle clock, when duly replaced in the bundle suitably with their new poles, have given the most steady and satisfactory results in working the control of the clock ever since.

2. Note on the Anatomical Type in the Funis Umbilicalis and Placenta. By Professor Simpson.

3. On Earth-Currents during Magnetic Calms, and their Connection with Magnetic Changes. By Balfour Stewart, Esq., M.A., F.R.S. Communicated by Professor Tait.

In two previous communications made by the author to the Royal Society of London, it had been endeavoured to show that earth-currents and auroræ, which occur simultaneously with magnetic storms, are secondary currents due to the small but abrupt changes in the magnetism of the earth which such storms denote. Earth-currents also occur during periods of magnetic calm, but they can then be rendered visible only by means of a delicate galvanometer.

Such has been constructed by Mr C. V. Walker, who has by its means registered those earth-currents which occurred during the three last months of 1851, a period of magnetic calm.

The object of the present communication is to discuss those observations of Mr Walker in connection with the simultaneous changes which took place in the values of the declination and the horizontal force component of the earth's magnetism, these changes being furnished by means of continuously acting magnetographs at Kew Observatory. By this method Mr Walker's observations were divided into three classes,—

1*st class.* Observations during moments of magnetic calm.
2*d* „ Observations during minor magnetic disturbances.
3*d* „ Observations during greater magnetic disturbances.

In the first of these classes a law of hours was manifestly observed, the values of the earth-currents for the hours of the night being extremely small. But in the second, and especially in the third class, the law of hours was observed to fail; and in the latter of these classes the peculiar action of disturbances was very manifest, the tendency of such disturbances being to create very strong earth-currents at the moment of their occurrence; and it is noticeable that these earth-currents were as often positive as negative.

It was remarked by the author, that the very great strength of those earth-currents, which take place at the moments of disturbance, is in favour of the theory of induction, since the peculiarity of a disturbance is not so much *a very great* as *a very rapid and abrupt* departure of the magnet from the normal position; and since, on the theory of induction, the corresponding earth-current will be due to abruptness of magnetic change, we thus obtain an explanation why the currents which accompany disturbances are so very powerful, and also why these are as often positive as negative.

With regard to the first class of earth-current observations, or those which occurred during magnetic calm, the author believed the daily range indicated by these observations to be the induction effect of the daily magnetic change, on which hypothesis the small value of the currents for the night hours might be accounted for by the corresponding fact that during these hours the magnetic change is exceedingly small.

4. Note on a Pictish Inscription in the Churchyard of St Vigeans. By Professor Simpson.

Dr Simpson considered the inscription to be "Drosten, Son of Voret, of the family of Fergus."

5. On some Kinematical and Dynamical Theorems. By Professor W. Thomson. (Abstract by Professor Tait.)

In the course of investigations which the author had been led to make in connection with a Treatise on Natural Philosophy which he and Professor Tait are about to publish, he met with some remarkable theorems, which appear to be new and of considerable importance. As the details of the investigations will soon be published, a very brief sketch only is given here.

I. *Twist* of a wire. If a straight wire, of uniform section, have a side line of reference traced on its surface parallel to its axis; and if a perpendicular to this line from any point of the axis be called a *transverse*, the amount of torsion or twist of the wire, when bent into any form, may be determined by the following construction:—

Parallel to the tangent to the axis of the wire, at a point moving along it, let a radius of an unit sphere be drawn, cutting the spherical surface in a curve. From points of this curve draw parallels to the transverses at the corresponding points of the bar. The excess of the change of direction from one point to the other in the curve, above the increase of its inclination to the transverse, is equal to the twist in the corresponding part of the wire.

From this some very curious consequences follow, of which one is as follows:—If a wire be bent along any curve on a spherical surface, so that a side line of reference lies all along in contact with the sphere, it acquires *no twist;* so that when an apple (supposed spherical) is peeled, there is no twist in the peel.

Again, if an infinitely narrow ribband be laid on a surface along a geodetic line, its twist is at every point equal to the tortuosity of its axis.

II. Given any material system at rest, and subjected to an impulse of any given magnitude and in any specified direction, it will move off so as to take the greatest amount of kinetic energy which the specified impulse can give it.

Cor. If a set of material points be struck independently by impulses, each given in amount, more kinetic energy is generated if the points are perfectly free to move each independently of all the others than if they are connected in any way.

III. Given any material system at rest. Let any parts of it be set in motion suddenly with given velocities, the other parts being influenced only by their connections with those which are set in motion, the whole system will move so as to have less kinetic energy than belongs to any other motion fulfilling the given velocity conditions.

6. Note on a Quaternion Transformation. By Prof. Tait.

The following paper gives an idea of the nature of the physical applications of quaternions to which I referred in a previous note (*Proceedings*, April 1862), but which other avocations have, as yet, prevented me from developing into a form and bulk suitable for publication in the Society's Transactions. The equations I now give form the *basis* of the investigations in question, which I hope to present to the Society in detail on some future occasion.

I. If the vector of any point be denoted by

$$\rho = ix + jy + kz, \qquad (1)$$

there are many interesting and important transformations depending upon the effects of the quaternion operator

$$\triangleleft = i\frac{d}{dx} + j\frac{d}{dy} + k\frac{d}{dz} \qquad (2)$$

upon various functions of ρ. When the function of ρ is a scalar, the effect of $\triangleleft$ is to give the vector of most rapid increase. Its effect on a vector function is indicated briefly in my former note.

II. I shall commence with one or two very simple examples, which are not only interesting, but, as we shall see, very useful in subsequent transformations.

$$\triangleleft \rho = \left(i\frac{d}{dx} + \&c.\right)\left(ix + \&c.\right) = -3 \qquad (3)$$

$$\triangleleft T\rho = \left(i\frac{d}{dx} + \&c.\right)\left(x^2 + y^2 + z^2\right)^{\frac{1}{2}} = \frac{ix + jy + kz}{(x^2 + y^2 + z^2)^{\frac{1}{2}}} = \frac{\rho}{T\rho} = U\rho \qquad (4)$$

$$\triangleleft (T\rho)^n = n(T\rho)^{n-1} \triangleleft T\rho = n(T\rho)^{n-2}\rho \qquad (5)$$

and, of course,
$$\triangleleft \frac{1}{(T\rho)^n} = -\frac{n\rho}{(T\rho)^{n+2}} \qquad (5)^1$$

whence,
$$\triangleleft \frac{1}{T\rho} = -\frac{\rho}{T\rho^3} = -\frac{U\rho}{T\rho^2} \qquad (6)$$

and, of course, $\lhd^2 \frac{1}{T\rho} = - \lhd \frac{U\rho}{T\rho^2} = 0 \ldots\ldots (6)^1$

Also, $\lhd \rho = -3 = T\rho \lhd U\rho + \lhd T\rho \,.\, U\rho = T\rho \lhd U\rho - 1,$

$$\therefore \lhd U\rho = -\frac{2}{T\rho} \ldots\ldots (7)$$

III. By the help of the above results, of which (6) is especially useful (though obvious on other grounds), and (4) and (7) very remarkable, we may easily find the effect of $\lhd$ upon more complex functions.

Thus, $\lhd S\alpha\rho = -\lhd(\alpha x + \&c.) = -\alpha \ldots\ldots (8)$

$$\lhd V\alpha\rho = -\lhd V\rho\alpha = -\lhd(\rho\alpha - S\alpha\rho) = 3\alpha - \alpha = 2\alpha \ldots\ldots (9)$$

Hence $\lhd \frac{V\alpha\rho}{T\rho^3} = \frac{2\alpha}{T\rho^3} - \frac{3\rho V\alpha\rho}{T\rho^5} = -\frac{2\alpha\rho^2 + 3\rho V\alpha\rho}{T\rho^5} = \frac{\alpha\rho^2 - 3\rho S\alpha\rho}{T\rho^5} \ldots\ldots (10)$

Hence $S\,.\,\delta\rho \lhd \frac{V\alpha\rho}{T\rho^3} = \frac{\rho^2 S\alpha\delta\rho - 3S\alpha\rho S\rho\delta\rho}{T\rho^5} = -\frac{S\alpha\delta\rho}{T\rho^3} - \frac{3S\alpha\rho S\rho\delta\rho}{T\rho^5}$

$$= -\delta \frac{S\alpha\rho}{T\rho^3} \ldots\ldots (11)$$

This is the principal transformation alluded to in the title of this note. By (6) it can be put in the sometimes more convenient form

$$S\,.\,\delta\rho \lhd \frac{V\alpha\rho}{T\rho^3} = \delta S\,.\,\alpha \lhd \frac{1}{T\rho} \ldots\ldots (12)$$

And it is worthy of remark that, as may easily be seen, S may be put for V in the left hand member of the equation.

We have also

$$\lhd V\,.\,\beta\rho\gamma = \lhd\{\beta S\gamma\rho - \rho S\beta\gamma + \gamma S\beta\rho\} = -\gamma\beta + 3S\beta\gamma - \beta\gamma = S\beta\gamma. \quad (13)$$

Hence, if ϕ be any linear and vector function of the form

$$\phi\rho = \alpha + \Sigma V\,.\,\beta\rho\gamma + m\rho, \ldots\ldots (14)$$

then $\lhd \phi\rho = \Sigma S\beta\gamma - 3m = \text{scalar} \ldots\ldots (14)^1$

Hence, an integral of

$$\lhd \sigma = \text{scalar constant, is } \sigma = \phi\rho. \ldots\ldots (15)$$

If the constant value of $\lhd \sigma$ contain a vector part, there will be terms of the form $V\epsilon\rho$ in the expression for σ, which will then express a distortion accompanied by rotation.

Also, a solution of $\lhd q = a$ (where q and a are quaternions) is $q = S\zeta\rho + V\epsilon\rho + \phi\rho$.

It may be remarked also, as of considerable importance in physical applications, that, by (8) and (9), $\lhd(S + \frac{1}{2}V)\alpha\rho = 0$, but I cannot enter at present into details on this point.

IV. In this brief note, I shall not give any more of these transformations, which really present no difficulty; but I shall show the ready applicability to physical questions of one or two of those already obtained, a property of great importance, as it may now be asserted that the next grand extensions of mathematical physics will, in all likelihood, be furnished by quaternions.

Thus, if σ be the vector-displacement of that point of a homogeneous elastic solid whose vector is ρ, we have, p being the consequent pressure produced,

$$\lhd p + \lhd^2 \sigma = 0 \qquad (16)$$

whence $S\delta\rho \lhd^2\sigma = -S\delta\rho \lhd p = \delta p$, a complete differential.... $(16)^1$

Also, generally, $p = kS \lhd \sigma$,

and if the solid be incompressible

$$S \lhd \sigma = 0 \qquad (17)$$

Thomson has shown (*Camb. & Dub. Math. Journal*, ii. p. 62), that the forces produced by given distributions of matter, electricity, magnetism, or galvanic currents, can be represented at every point by displacements of such a solid producible by external forces. It may be useful to give his analysis, with some additions, in a quaternion form, to show the insight gained by the simplicity of the present method.

Thus, if $S\sigma\delta\rho = \delta\frac{1}{T\rho}$, we may write each equal to $-S\delta\rho\lhd\frac{1}{T\rho}$. This gives

$$\sigma = -\lhd\frac{1}{T\rho}$$

the vector-force exerted by one particle of matter or free electricity on another. This value of σ evidently satisfies $(16)^1$ and (17).

Again, if

$$S\,.\,\delta\rho \lhd \sigma = \delta \frac{S\alpha\rho}{T\rho^3}, \text{ either is equal to}$$

$$-S\,.\,\delta\rho \lhd \frac{V\alpha\rho}{T\rho^3} \text{ by (11).}$$

Here a particular case is

$$\sigma = -\frac{V\alpha\rho}{T\rho^3},$$ which (*Quarterly Math. Journal*, vol. iii. p. 338) is the vector-force exerted by an element α of a current upon a particle of magnetism at ρ.

Also, by (10), $\lhd \frac{V\alpha\rho}{T\rho^3} = \frac{\alpha\rho^2 - 3\rho S\alpha\rho}{T\rho^5}$, and the same paper shows that this is the vector-force exerted by a small plane current at the origin (its plane being perpendicular to α) upon a magnetic particle, or pole of a solenoid, at ρ. This expression, being a pure vector, denotes an elementary rotation caused by the distortion of the solid, and it is evident that the above value of σ satisfies the equations $(16)^1$, (17), and the distortion is therefore producible by external forces. Thus the effect of an element of a current on a magnetic particle is expressed directly by the displacement, while that of a small closed current or magnet is represented by the vector-axis of the rotation caused by the displacement.

Again, let

$$S\delta\rho \lhd^2 \sigma = \delta \frac{S\alpha\rho}{T\rho^3}.$$

It is evident that σ satisfies $(16)^1$, and that the right-hand side of the above equation may be written

$$-S\,.\,\delta\rho \lhd \frac{V\alpha\rho}{T\rho^3}.$$

Hence a particular case is

$$\lhd \sigma = -\frac{V\alpha\rho}{T\rho},$$ and this satisfies (17) also.

Hence the corresponding displacement is producible by external forces, and $\lhd \sigma$ is the rotation axis of the element at ρ, and is seen as before to represent the vector-force exerted on a particle of magnetism at ρ by an element α of a current at the origin.

It is interesting to observe that a particular value of σ in this case is

$$\sigma = -\tfrac{1}{2} \lhd \, S\alpha U\rho - \frac{\alpha}{T\rho},$$

as may easily be proved by substitution.

Again, if

$$S\delta\rho\sigma = -\delta \frac{S\alpha\rho}{T\rho^3},$$

we have evidently

$$\sigma = \lhd \frac{S\alpha\rho}{T\rho^3}.$$

Now, as $\frac{S\alpha\rho}{T\rho^3}$ is the potential of a small magnet α, at the origin, on a particle of free magnetism at ρ, σ is the resultant magnetic force —and represents also a possible distortion of the elastic solid by external forces, since $\lhd \sigma = \lhd^2 \sigma = 0$, and thus $(16)^1$ and (17) are both satisfied.

The following Gentlemen were duly elected Fellows of the Society:—

The Hon. George Waldegrave Leslie.
The Hon. Charles Baillie (Lord Jerviswoode).
James Sanderson, Esq., Surgeon-Major Madras Medical Staff.

The following Donations to the Library were announced:—

Abhandlungen herausgegeben von der Senckenbergischen naturforschenden Gesellschaft. Vierten Bandes zweite Lieferung. 4to.—*From the Society.*

Proceedings of the Geological Society of London. Nos. 95 and 96. 8vo.—*From the Society.*

Les Grandes Usines de France. 4 Parts. 8vo.

Natural History of New York. Vol. III., Part 6, on Palæontology. 2 Vols. 4to.—*From the American Government.*

Natural History of New York. Part 5, on Agriculture. 4to.—*From the same.*

Ἱπποκράτους καὶ ἄλλων ἰατρῶν παλαιῶν λείψανα. Edidit Franciscus Zacharias Ermerins. Volumen Secundum. Trajecti ad Rhenum, 1862. 4to.—*From the Dutch Government.*

Verslagen en Mededeelingen der Koninklijke Akademie van

Wetenschappen. Afdeeling Natuurkunde. Dertiende et viertiende Deel. 8vo.—*From the Academy.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Letterkunde. Zesde Deel. 8vo. —*From the same.*

Jaarboek van de Koninklijke Akademie van Wetenschappen gevistigd te Amsterdam voor 1861. 8vo.—*From the same.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. Achste Deel. 4to.—*From the same.*

Journal of the Asiatic Society of Bengal. New Series. No. 113. 8vo.—*From the Secretaries.*

Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herring on the Coasts of Scotland. Folio.—*From the British Government.*

The Quarterly Journal of the Geological Society. No. 73.—*From the Society.*

Transactions of the Linnean Society of London. Volume XXIV. Part 1. 4to.—*From the Society.*

Materiaux pour la Carte Geologique de la Suisse publiés par la Commission Geologique de la Société Helvetique des Sciences Naturelles aux frais de la Confederation. Première Livraison. With Chart. 4to.—*From the Society.*

Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider i Aaret 1861. 8vo.—*From the Society.*

Det Kongelige danske Videnskabernes Selskabs Skrifter femte Raekke. Naturvidenskabelig og Mathematisk Afdeeling. Femte Binds andet Hefte. 4to.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XII. No. 54. 8vo.—*From the Society.*

Instructions Nautiques sur les mers de l'Inde, par James Horsburgh; traduites de l'Anglais par M. le Predour. II^e^. Partié. 4to.—*From the Depôt Général de la Marine.*

Annuaire des Marées des Côtes de France pour l'an 1864 par M. Gaussin. 12mo.—*From the same.*

Publications du dépôt des Cartes et Plans de la Marine. Nos. 37–43 et 46–49. 8vo.—*From the same.*

Seventy-Fifth Annual Report of the Regents of the University of the State of New York. 8vo.—*From the University.*

Fifteenth Annual Report of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History. 8vo.—*From the same.*

Scheikundige Verhandelingen en Onderzoekingen uitgegeven door G. J. Mulder. Derde Deel. Tweede Stuk. 8vo.—*From the Author.*

Monday, 20th April 1863.

Principal FORBES, Vice-President, in the Chair.

The following Communications were read :—

1. On the Conservation of Energy. By Professor Tait. (Abstract.)

(*This Lecture was given at the request of the Council.*)

What Matter or Force may be, we have not as yet the slightest idea. Matter is only known to us by the forces it exerts or resists. It is possible that there may be but one species of ultimate parts (molecules or atoms ?) of matter ; but in the present state of chemical science, it is more philosophical to reason as if the ultimate parts of the various elementary bodies are distinct. However this may be, a particle of hydrogen, oxygen, sodium, or gold, exerts certain definite forces upon other particles; which forces, we have every reason to believe, will remain for ever unchanged, unless the so-called element should at some future time be decomposed.

Now, for such elementary particles, change of position (grouping) or motion (relative) is the only affection we can conceive ; and we must endeavour to deduce, from the relation between forces and the motions they produce, all the phenomena of nature, except perhaps some of those exhibited in living structures.

All that is necessary for such an inquiry has been most distinctly laid down by Newton in his Axiomata, and the Scholia appended to them. A brief resumé of what Newton has there done will lead us easily and naturally to the Conservation of Energy—though stated for visible motions only, and without reference to the energies of heat, electricity, &c.

I. The motion of a body is uniform if no force act on it.

II. Change of motion is proportional to the force producing it, and takes place in the direction in which the force is exerted.

From this it follows at once, that force is measured by the *rate of change of motion* it produces; in other words, by the product of the mass, and the acceleration of its velocity..

This, combined with purely geometric ideas as to motion in the abstract, leads directly to the parallelogram of forces, and through it to the subjects of the Statics and Kinetics of a *single* particle. In order to extend our investigations to a *body*, or a system of bodies, we require the additional law,

III. To every *action* there is an equal and opposite *reaction.*

Newton shows that there are *two* ways in which this *action* may be measured, the third law being true for either. These lead to two classes of important dynamical theorems.

(*a*) Mutual pressures, tensions of rods and cords, attractions, stresses in solids or liquids, &c. &c., form one class of Actions and Reactions. We have thus, as immediate consequences, "Conservation of Momentum," and "Conservation of Areas." From this point of view, we have also the general statement, by what is commonly called "D'Alembert's Principle," of the equations of equilibrium and motion, and therefore the mathematical expression of the circumstances of any dynamical problem.

(*b*) But Newton goes farther, and points out *another* kind of action and reaction, ruled by the third law. His words are,—*si æstimetur agentis actio ex ejus vi et velocitate conjunctim, et similiter resistentis reactio æstimetur conjunctim ex ejus partium singularum velocitatibus et viribus resistendi ab earum attritione, cohæsione, pondere, et acceleratione oriundis; erunt actio et reactio . . . . . sibi invicem semper æquales.* The Actio here spoken of, the product of a force by the rate of motion of its point of application, is now known as the *rate of doing work*, or the horse-power of the prime mover. We notice amongst the various forms of the corresponding Reactio, the *rate of losing work* by the resistances, such as friction, cohesion, and weight; but we also have as a reaction, the resistance due to the *acceleration* of the various parts of the system; and in this statement (made by

Newton with reference to machines and their visible motions only, but now extended to all the phenomena of physical science) consists the "Conservation of Energy."

It would be easy to give the general investigation, but for an elementary lecture like this a very simple example will suffice,—the case of a particle moving in a straight line, and acted on by a force whose direction coincides with the line of motion.

If s be the space passed over in time t, and v the velocity, geometrical ideas lead at once to

$$v=\frac{ds}{dt} \quad\text{..............................(1)}$$

The *second* law of motion (above) gives, if F be the force, and m the mass of the particle,

$$F=m\frac{dv}{dt} \quad\text{..............................(2)}$$

This is the ordinary equation of motion.

But Newton's second form of action and reaction, as connected by the *third* law, gives at once for the action of the force $F\frac{ds}{dt}$, and for the reaction of the particle due to acceleration we have $m\frac{dv}{dt}$ multiplied by v. Hence

$$F\frac{ds}{dt}=mv\frac{dv}{dt} \quad\text{..............................(3)}$$

which, as we see by (1), is merely the equation (2), with the additional factor v, or $\frac{ds}{dt}$, in each member.

While the integrated form of (2) is

$$m(v-v_0)=\int_{t_0}^{t}Fdt \quad\text{..............................(2)}^1$$

showing that the momentum, or quantity of motion is increased in any interval by the product of that interval by the average value of the force, the integral form of (3) is

$$\frac{m(v^2-v_0^2)}{2}=\int_{s_0}^{s}Fds \quad\text{..............................(3)}^1$$

expressing that the *change of vis viva* is measured by the amount of *work done by the force.* What is expended in *work* is therefore stored up as *vis viva.* (This is given generally for a single particle by Newton; *Principia*, Section VIII., Prop. XL.)

A simple case is that of a weight raised, or falling, in a vertical line. Here the work expended in raising it is so many foot pounds, each being the work employed to raise one pound a foot high. And in fact, by the ordinary formulæ for projectiles,

$$v^2 = 2gs,$$

$$\text{or } \frac{mv^2}{2} = mg.s = W.s,$$

or the *vis viva* acquired by falling through a space s, is equal to the work lost in falling, or required to restore the body to its original position. Now, the raised weight, in *virtue of its position*, has a power of doing work which it does not possess when lying on the ground; this is an example of what is called *Potential Energy.* As it loses this in falling, it gains an exact equivalent in *vis viva*, which is what is called *Kinetic Energy.* In this example we see that the *sum of the potential and kinetic energies is constant;* and the same is true in other common cases, such as the potential energy of a drawn bow and the kinetic energy of the arrow, the potential energy of compressed air in the reservoir of an air-gun and the kinetic energy of the bullet, and so on. It is true even in such a case as the potential energy of a distorted tuning-fork and the kinetic energy of the sound it produces, if we include in the latter the *vis viva* of the vibrations communicated to surrounding bodies.

It is easy to give a general proof, that if the particles of any system act each on another with forces which are in the direction of the line joining them, and dependent on the mutual distance only, in such a system the *sum of the potential and kinetic energies cannot be altered except by external forces; and therefore, if the introductory statements about matter be true, and physical phenomena such as heat, electricity, &c., be referred to motion of matter, there can be no alteration in the sum of the energies of the universe.* This is the general statement of the Conservation of Energy.

From this we at once deduce a proof of the impossibility of procuring perpetual motion (*i.e.*, a machine which not only keeps up its motion but does external work) by means of any of the known forces of nature; and *vice versâ*, taking this impossibility for granted, we may show that the forces exerted by two material particles on each other must be in the direction of the line joining the two, and must depend on their distance *only*.

The first of the physical energies, distinct from visible motions, which was shown to be subject to the law of "conservation," was Heat. Bacon, Locke, and others, long ago regarded heat in a material body as a species of motion; but it was not proved to be so till a comparatively recent period, when Davy showed it conclusively by melting pieces of ice by rubbing them together in an enclosure cooled below the freezing point. Davy says, "The immediate cause of the phenomenon of Heat is motion, and the laws of its communication are the same as the laws of the communication of motion." Take, in connection with this, Newton's second form of Action and Reaction, and we have the Dynamical Theory of Heat; requiring, of course, experimental data to connect the two forms of Energy quantitatively. Rumford, by measuring the heat produced in boring cannon, and comparing it with the work expended, made a near approach to the value of the mechanical equivalent of heat—*i.e.*, to an answer to the question, "How much work is required to produce a given amount of kinetic energy in the form of heat?" Other thinkers and experimenters made more or less accurate and useful advances, but in a very small way, till Joule, about twenty years ago, made the experimental treatment of the subject his own. He showed by varied yet accordant experiments, that 772 foot pounds of mechanical energy are equivalent to the additional kinetic energy which a pound of water must acquire to raise its temperature from 60° F. to 61° F. He has extended his experimental work to others of the physical energies, and arrived at many most startling results, several of which I intend to show to-night.

The science of Thermodynamics, in which Carnot and Clapeyron made great steps before the immateriality of heat was generally recognised, has, since Joule's experiments were made, received enormous developments from Clausius, Rankine, Thomson, and others; and Helmholz, in an admirable essay (*Ueber die Erhaltung* *der Kraft*) published in 1847, has extended most ingeniously the application of the principle of "conservation" through the whole range of physics, bringing out, from the principles already stated in this discourse, the explanation of electrodynamic induction, &c., besides various laws of transformation of energy, already empirically determined from experiment.

[The lecturer then performed an extensive series of experiments, involving transformations of various forms of energy, pointing out in each case the separate portions into which the original energy was broken up. It is not necessary to describe these experiments here.]

It will be seen that in all these experiments heat has been pointed out as the ultimate form taken by the original energy. This is a general law of nature,—*All energy ultimately becomes heat*. Also heat, by conduction, radiation, or convection, tends ultimately to be uniformly diffused through the matter in the universe; and when uniformly diffused, cannot be made available for the production of any other form of energy, since, for the transformation of heat into any other form of energy, bodies of *different* temperatures are required. Uniformly diffused heat, then, as far as we can see at present, is the inevitable ultimate transformation of all the energy, potential or kinetic, in the universe.

[The lecturer went on to consider at some length the gravitation theory of the origin of the sun's energy, and various connected subjects, which are to a certain extent already popularised.]

2. On Fagnani's Theorem. By H. F. Talbot, LL.D.

3. On the Theory of Parallel Lines. By H. F. Talbot, LL.D.

The following Address to His Royal Highness the Prince of Wales was adopted, and ordered to be forwarded to the Duke of Argyle for presentation:—

TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

May it please your Royal Highness,—

We, the President and Fellows of the Royal Society of Edinburgh, desire humbly to approach your Royal Highness with the expression of our dutiful and heartfelt congratulations on your Royal Highness's marriage.

Ever ready to rejoice at whatever affords a prospect of increased happiness to your Royal Highness, and a further security for the continued sway of a Royal House which has conferred on this realm so many benefits and blessings, we hail with especial interest and gratification the union of your Royal Highness with a daughter of an ancient nation, distinguished at all times for noble and generous qualities, and which holds a high place among the countries of Europe in literature and science ; and above all, we regard it as an unspeakable boon that the Royal Lady whom we now welcome to our shores is endowed with all those virtues and attractions which are best calculated to bless and adorn domestic life, to assist in cheering the widowed solitude of our beloved Sovereign, and to sustain in unsullied lustre the honour and dignity of the British Court.

We earnestly hope and pray that this auspicious alliance may be productive of all the happiness with which we desire to see it attended.

The following Gentlemen were elected Fellows of the Society :—

Charles Cowan, Esq.
John Alexander Smith, M.D.

The following Donations to the Library were announced :—

Proceedings of the Royal Geographical Society of London. Vol. VII. No. 2. 8vo.—*From the Society.*

Quarterly Report of the Meteorological Society of Scotland, for the quarter ending 31st December 1862. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIII. No. 5. 8vo.—*From the Society.*

Notice sur la vie et les travaux de P. L. A. Cordier, Membre de l'Institut, &c. &c. 8vo.—*From the Author.*

Proceedings of the Royal Horticultural Society. April. 8vo.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages, registered in the Eight Principal Towns of Scotland. March. 8vo.—*From the Registrar-General.*

Journal of the Chemical Society. April. 8vo.—*From the Society.*

Proceedings of the British Meteorological Society. Vol. I. No. 5. 8vo.—*From the Society.*

Die Fortschritte der Physik im Jahre 1860. XVI. Jahrgang. I. und II. Abtheilung. 8vo.—*From the Physical Society of Berlin.*

Memoirs of the Geological Survey of India. II. 3. 4to.—*From Dr Thomas Oldham.*

The American Journal of Science and Arts. Vol. XXXV. No. 104. 8vo.—*From the Conductors.*

Atti dell' Imp. Reg. Istituto Veneto di Scienze, Lettere ed Arti dal Novembre 1861 all' Ottobre 1862. Tomo VII., serie iii., dispensa 4–10; e tomo VIII., serie iii., dispensa 1–3. 8vo. —*From the Institute.*

Bulletin de la Société de Géographie, cinquième série. Tome IV. 8vo.—*From the Society.*

On the Forces concerned in producing Magnetic Disturbances (Proceedings of the Royal Institution of Great Britain). Balfour Stewart, Esq., F.R.S. 8vo.—*From the Author.*

Catalogue of the Minerals containing Cerium. By Dr William Sharswood. 8vo.—*From the Author.*

Description of a New Genus (Trypanostoma) of the family Melanidæ, and of forty-five New Species, &c. By Isaac Lea, LL.D. 8vo.—*From the Author.*

Proceedings of the Academy of Natural Sciences of Philadelphia. Nos. VII.–XII. 8vo.—*From the Society.*

Journal of the Academy of Natural Sciences of Philadelphia. New Series. Vol. V., Part 3. 4to.—*From the Academy.*

Mémoires de l'Académie des Sciences de l'Institut Imperial de France. Tome XXXIII. 4to.—*From the Academy.*

Cercles Chromatiques de M. E. Chevreul. 4to.—*From the Author.*

On the Law of Expansion of Superheated Steam. By W. Fairbairn, LL.D., and Thomas Tate, Esq. 4to.—*From the Authors.*

Bakerian Lecture. Experimental Researches to determine the Density of Steam at Different Temperatures, and to determine the Law of Superheated Steam. By William Fairbairn, Esq., LL.D., and Thomas Tate, Esq. 4to.—*From the Authors.*

Biblical Natural Science, being the Explanation of all References in Holy Scripture to Geology, Botany, Zoology, and Physical Geography. By the Rev. John Duns, F.R.S.E. Parts 1 to 4. 8vo.—*From the Author.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1863–64. No. 62.

Eighty-First Session.

Monday, 23d November 1863.

Dr Christison, V.P., in the Chair.

The following Council were elected:—

President.

His Grace The DUKE of ARGYLL, K.T.

Vice-Presidents.

Sir David Brewster, K.H.
Dr Christison.
Professor Kelland.
Hon. Lord Neaves.
Principal Forbes.
Professor Innes.

General Secretary,—Dr John Hutton Balfour.

Secretaries to the Ordinary Meetings.

Dr Lyon Playfair, C.B.
Dr George James Allman.

Treasurer,—David Smith, Esq.

Curator of Library and Museum,—Dr Douglas Maclagan.

Councillors.

E. W. Dallas, Esq.
Rev. L. S. Orde.
Professor Tait.
A. Campbell Swinton, Esq.
Dr William Robertson.
Dr E. Ronalds.
T. C. Archer, Esq.
W. F. Skene, Esq.
A. Keith Johnston, Esq.
Rev. Dr Stevenson.
Dr Stevenson Macadam.
Hon. Lord Jerviswoode.

Monday, 7th December 1863.

Professor Innes, one of the Vice-Presidents, delivered the following Opening Address :—

Gentlemen,—The opening of our Session requires that I should lay before you the state and prospects of our Society, which I hope may to some extent be considered the criteria of the state and prospects of the sciences which it cultivates.

The Society has lost since the commencement of last Session by death, six Fellows, viz.,—Robert Allan, Esq., Beriah Botfield, Esq., Dr James Keith, Dr David Boswell Reid, Professor Connell of St Andrews, Professor Mitscherlich of Berlin; and by resignation, two, the Rev. G. V. Faithfull and D. R. Hay, Esq.

In room of whom the Society has elected twenty-five new Fellows, viz.,—Professor Blackie, William Brand, Esq., W.S., Robert Campbell, Esq., advocate, Dr Hugh F. C. Cleghorn, India, Charles Cowan, Esq., W. Dittmar, Esq., Dr J. Matthews Duncan, the Right Hon. Lord Dunfermline, Professor Everett, Nova Scotia, James Hannay, Esq., William Jameson, Esq., India, Hon. Lord Jerviswoode, Charles Lawson, Esq., Hon. G. Waldegrave Leslie, G. R. Maitland, Esq., W.S., Edward Meldrum, Esq., Rev. Dr Nesbit, Hon. Lord Ormidale, David Page, Esq., Dr A. Peddie, James Sanderson, Esq., Deputy-Inspector of Hospitals, Dr John A. Smith, Dr Murray Thomson, Dr J. G. Wilson, Dr John Young.

Our roll, therefore, stands thus :—The number of Fellows in 1862 was 258, of which we have lost by death 6, by resignation 2 = 8, leaving 250. To which add the new Fellows, 25, making the whole number of the Fellows of our Society 275, a larger number than has appeared on the list for many years.

I am enabled, chiefly through the active kindness of our Secretaries, to offer a few notices of the members we have lost, during the past Session.

Robert Allan, son of Mr Thomas Allan, a banker in Edinburgh, a Fellow of the Society, and for many years Curator of its Museum and Library, and well known as an early and successful collector of a fine cabinet of minerals, was born in 1806, and educated at the High

School and University of Edinburgh. He inherited his father's taste for minerals, and while still a youth followed out the study in extended travels in company with Professor Haidinger, who introduced him to the acquaintance and to the cabinets of all the chief foreign mineralogists—among others, Berzelius and Mitscherlich.

Mr Allan passed advocate in 1829, but never practised, and was admitted a Fellow of this Society in 1832. He was also a member of the Geological Society of London.

Mr Allan published in 1834 a Manual of Mineralogy, the classification founded on the external character or natural historical arrangement.

In 1837 he edited a fourth edition of "Phillips' Mineralogy," in which he added notices of 150 new minerals.

On his return from an excursion to the volcanic district of Italy and Sicily, Mr Allan presented to this Society a set of specimens of volcanic rocks of the Lipari Isles, with a descriptive notice, an abstract of which is in our Transactions, of date 16th January 1831.

He communicated an account of a visit to the Geysers and Hecla to the British Association at Glasgow, in 1855.

Mr Allan died in consequence of a fall in his garden.

Beriah Botfield was of a Shropshire family, in which county his grandfather, Thomas Botfield, made his large fortune as a manager and lessee of the Dawlay Collieries. Thomas's third son inherited Norton Hall, near Daventry, in Northamptonshire, and lived the life of an English sporting squire. He married Charlotte, daughter of William Withering, M.D., F.R.S., the author of "The Botanical Arrangement of British Plants." The only child of that marriage was Beriah, the subject of the present notice, who, in addition to his father's property, inherited the estates of both his uncles, and had become before his death a man of very large fortune.

Beriah was born 5th March 1807, and succeeded his father in 1813. He was educated at Harrow and Christ Church, where he took his Bachelor's degree in 1828.

After leaving Oxford he made a tour in the Highlands of Scotland, a journal of which he printed for private circulation,—printed at Norton Hall, 1830, 12mo.

He was High Sheriff of Northamptonshire in 1831.

In 1840 he was elected Member for Ludlow, and again in 1841.

In 1847 he was beaten by the Whig candidate.

In 1857 he was solicited to stand again, and he sat in Parliament for Ludlow for the rest of his life.

Mr Botfield was a member of the Royal Society of London, the Royal Geographical Society, Royal Institution, Society of Arts, of the Antiquaries of London, Scotland, and Copenhagen, of the Royal Irish Academy, l'Institut d'Afrique, and of all the principal Societies in the Kingdom, and of a great number of literary Clubs,—as the Roxburghe, Bannatyne, Maitland, Spalding, Surtees, Abbotsford, Camden, Percy, Ælfric, Hakluyt, Cheetham; to most of which he gave valuable contributions, his part being generally to defray the expense.

In addition to these, and some smaller tracts printed for private circulation, Mr Botfield published "Notes on the Cathedral Libraries of England," from a personal examination, 1849; "Prefaces to the First Editions of the Greek and Roman Classics, and of the Sacred Scriptures," 1861. Large 4to.

Another work, for which he was making collections when he died, and which would have been of great interest and value, was intended to illustrate the history of the old monastic libraries of England. A collection of the extant catalogues and inventories of these was already in type, to which he meant to add the catalogues of other Middle Age libraries. His collections, made for these objects will, it is feared, be lost to the world by his death. He had previously edited (in 1838), for the Surtees Society, catalogues of the Library of Durham Cathedral, at various periods.

In 1858, Mr Botfield printed, for private circulation, *Stemmata Botevilliana*, a large volume illustrating the descent and antiquities of all the Bottevilles, Thynnes, and Botfields.

He was a liberal collector of pictures, and was also known as a zealous book-hunter.

Mr Botfield married Isabella, daughter of Sir Baldwin Leighton, Bart., but left no family; and has entailed a considerable part of his property on the second son of the Marquis of Bath, in respect of a very old but perhaps real connexion between his family and the Thynnes.

James Keith, second son of William Keith of Corstorphine Hill, accountant in Edinburgh, was born 29th November 1783, and was educated at the High School and University of Edinburgh. He was apprentice to Messrs Bell, Wardrope, and Russell; went to London in 1804, and attended the London Hospital and Guy's. Was surgeon of the Berwickshire Militia for two or three years, which he resigned on entering into partnership with Dr Andrew Wardrope, which connection terminated by Dr Wardrope's death in 1822.

Mr Keith took the degree of M.D. in the University of Edinburgh in 1804, and he became a Fellow of the College of Surgeons in 1810. He was physician to the Deaf and Dumb Institution for many years. From the extreme shyness of his disposition, his worth and ability were known only to a limited circle of intimate friends. He died 12th May 1863. His widow and two sons survive—William Alexander, M.A. Oxon., and Charles Maitland.

David Boswell Reid was the second son of Dr Peter Reid, physician in Edinburgh. His mother, Christian Arnot, was the eldest daughter of Hugo Arnot of Balcormo, advocate and antiquary, well known to the last generation by his book on the history of Edinburgh and his collection of Scotch criminal trials—and perhaps still better by the extraordinary attenuated, almost skeleton, figure of the old gentleman preserved to us in Kay's Portraits. Dr Peter Reid (whose mother was a Boswell of the Balmuto family) was the editor of Dr Cullen's "First Lines of the Practice of Physic," 1802. A new edition was published, with supplementary notes, in 1810. He was also the author of a little duodecimo volume, entitled "Letters on the Study of Medicine and on the Medical Character, addressed to a Student," Edin., 1809. Besides the subject of my present notice, Dr Peter Reid had two sons,—Dr William, a lecturer in Edinburgh on the practice of Medicine, and Dr Hugo, well known as the author of several popular works, the last of which is a modest and temperate memoir of his distinguished brother, to which I beg to acknowledge my obligation.

David Boswell Reid was educated at the High School and University of Edinburgh. At the former, Mr Pillans, the rector, has mentioned him as "among the head boys of the Rector's class."

While a medical student he became a member of the Royal Medical Society, of which he was chosen senior president in 1826–27, his junior being James Kay, now Sir James Kay Shuttleworth.

In 1827, Mr David Reid commenced a course of practical chemistry, which was very useful and very popular. He aimed at enabling each student to familiarise himself, by experiments made under the directions of a teacher, with the properties of the chief chemical substances, and the phenomena attending their action on each other.

After much approval in his extra-mural lecture-room, he joined Dr Hope in the College, and was again quite successful in the object of his course. But the Professor and Assistant had some misunderstandings, which led Mr Reid to leave the College, and renew his independent lectures, which were highly appreciated—attended by all classes,—the young ambitious student,—the veteran philosopher and man of science,—the man of intelligence feeling the want of science. On his benches met Dr Chalmers and Sir John Leslie, Professors George Joseph Bell and Pillans, Dean Ramsay and Mr Combe.

After the burning of the Houses of Parliament, and in contemplation of a new building, when a committee of the Commons was inquiring on the subject of its ventilation and acoustics, Dr Reid was examined as a witness, from having devoted much attention to those subjects, and having shown excellent examples of his skill, first in his own lecture-room, and, later, in the great temporary edifice, erected 15th September 1834, in the High School ground, for the Edinburgh dinner to Lord Grey, at which 2768 persons were present, and 240 ladies in the gallery, and each individual speaker was distinctly heard.*

The result of his examination was, that Dr Reid was employed to direct the ventilation and acoustics of the temporary House of Commons in 1836. It is not pretended that his plans gave universal satisfaction to the 700 members, each of whom had a different notion, and of course a peculiar constitution of body to be suited. But, after ten years' experience, in 1846, a fair committee of the House reported as to "the great improvement effected," and "concurred in the general opinion in its favour."

* The Pavilion was 113 feet in length by 101 feet in breadth.

In 1840 arrangements were made for Dr Reid settling in London, and, while taking charge of ventilating the temporary House of Commons, superintending also the ventilation of the new building then in progress. This brought Dr Reid necessarily into close contact with the architect of the new palace, Mr Barry, and unfortunately they did not agree. The difference got worse and worse, till in 1845 they were no longer on speaking terms, and every detail of such extensive operations had to be settled by correspondence,—a state of things which could not be allowed to last. The quarrel broke out in some strong expressions of Dr Reid,—a prosecution for libel by Mr Barry,—a pretty general attack on Dr Reid by the public press, and a Reply by him to "The Times" newspaper [1845–47].

In 1852 a negotiation was entered into, by which the Government proposed to secure Dr Reid's services permanently, and to throw the ventilation of the whole buildings of the Houses under his charge,—one part of which, the House of Lords, had hitherto been managed by Mr Barry on a different system,—but "these negotiations were abruptly broken off." In fact, Dr Reid was turned off, after sixteen years successful service, and, as his brother tells us, "a small sum was given to him as some compensation for the loss which he had sustained. His friends who knew his whole career, and the proceedings connected with his removal to London, to take the charge of ventilating the Houses of Parliament, were of opinion that the sum awarded was totally inadequate to compensate for the sacrifices he had made."

Dr Reid went to New York in 1855. He delivered lectures in the Smithsonian Institution there, and at Boston. In the beginning of this year (1863), he received the appointment of Inspector of Military Hospitals, but soon after, while engaged in an official journey, he died suddenly at Washington, on 5th April 1863.

Dr Reid's system of ventilating great buildings, where crowds habitually assembled, consisted in forcing in a current of air by means of a powerful engine—the air being previously washed to free it from dust and to give it the requisite moisture. Some of his experiences are curious.

"The house is heated to 62° before it is opened, and maintained in general at a temperature between 63° and 70°, according to the velocity with which the air is permitted to pass through the house. This velocity is necessarily regulated by the numbers present, the temperature to which the air can be reduced in warm weather, and the amount of moisture which it may contain when the quantity is excessive. Some members are much more affected by an excess or deficiency of moisture than by alterations of temperature. In extremely warm weather, by increasing the velocity, air even at 75° may be rendered cool and pleasant to the feelings."

He goes on to say—"The temperature may always be advantageously increased and the velocity diminished before the usual dinner hour. After dinner, other circumstances being the same, the temperature should be diminished, the velocity increased, and the amount of moisture in the air reduced. During late debates, as they advance to two, three, four, or five in the morning, the temperature should be gradually increased as the constitution becomes more exhausted, except in cases where the excitement is extreme."

Next to the Houses of Parliament, Dr Reid's greatest and most successful undertaking of ventilation was the St George's Hall at Liverpool, in which immense building, on some occasions, there have been as many as 4500 persons for about ten hours; the air during all that time having been supplied to all that multitude in a pure state, and in a comfortable and agreeable condition as to temperature and moisture.

Dr Reid superintended while in this country the arrangements for ventilating the royal yacht, "The Victoria and Albert," and the steamships used in the expedition to the Niger, in both instances to the entire satisfaction of his employers; and since going to America, he was employed in the ventilation of a Russian frigate, "The Grand Admiral," built at New York

Arthur Connell, eldest son of Sir John Connell, Judge of the Admiralty Court, and author of a well known work on the Law of Scotland respecting Tithes, entered the High School of Edinburgh in 1804, and the University of Edinburgh in 1808, where he studied under Playfair, Leslie, Dugald Stewart, and Hope. From Edinburgh Mr Connell went to Glasgow College, where he studied under Jardine and Young, and, having obtained a Snell exhibition, went to Balliol College, Oxford, in 1812.

In 1817 Mr Connell passed advocate at the Scotch Bar, but he had from boyhood a remarkable turn for science, especially botany and chemistry, and he ultimately devoted himself exclusively to the latter science.

In 1840 he was presented to the Chair of Chemistry in the University of St Andrews.

In 1843 Mr Connell was candidate for the Chemistry Chair at Edinburgh, vacant by the death of Dr Hope, and though not successful, produced a collection of testimonials of the highest character. Most of these were the more worthy of attention as not made for the occasion and so in some degree influenced by private friendship. They are for the most part notices in the published works of eminent chemists and in scientific journals, of Mr Connell's chemical labours, and the papers in which these were announced and described.

Having failed in this object of his ambition, Mr Connell continued to study and teach his favourite science at St Andrews till 1856, when the fracture of a limb, and its effects upon a constitution already long enfeebled, completely incapacitated him from active duty.

Mr Connell became a member of this Society in 1829, from which time till 1843 he contributed to the Transactions, or published in the pages of the "Edinburgh Philosophical Journal," memoirs to the number of 29.

His chief merit lay in his skill and unrivalled accuracy as a mineral analyst. To him we are indebted for several new mineral species—for the discovery in the minerals Brewsterite and Harmotome of the earth barytes in combination with silicic acid—that earth previously having been found combined only with the sulphuric and carbonic acids; while his ascertaining the constitution of the mineral Greenockite, *on one grain* of the substance, displayed a dexterity seldom if ever surpassed.

Mr Connell also engaged in somewhat more ambitious researches on the voltaic decompositions of alcohol, ether, and other liquids, and has presented us with an instrument for ascertaining the dew point, superior in several respects to that generally used.

Mr Connell was of a very retiring nature, modest, gentlemanly, and gentle in disposition. He expired peacefully on 31st of October last.

EILARD MITSCHERLICH, born 7th January 1794, at Neurede, in the Grand Duchy of Oldenburgh, where his father was a minister of the Lutheran Church, was educated at Heidelberg and Paris, and studied afterwards at Göttingen. His first objects of study were language and ethnology. Later in life he devoted himself more to natural science, and especially chemistry. He assisted Berzelius at Stockholm for some years.

In 1821 he was appointed Professor of Chemistry in the University of Berlin, and attached to the Friedrich Wilhelm Institut. His lectures were held in high estimation, and attended by numerous classes of students.

In 1828 he was elected an Honorary Member of this Society, and in 1829 was awarded a Medal by the Royal Society of London for his discourses "regarding the laws of crystallization and the properties of crystals."

In 1852 Mitscherlich was elected an Associate Member of the Institute of France. His great European reputation is founded on his studies on crystallization and some ingenious adaptations of instruments for practical chemistry. His text-book—*Lehrbuch der Chemie*—has gone through a great many editions.

Mr Mitscherlich died in the present year.

His experiments and disquisitions tended to establish the rule that bodies crystallizing in the same shape (isomorphous) have an analogous chemical composition—throwing great light on chemical classification, and giving us one of the greatest generalizations (after the Atomic theory) which chemistry has gained by the researches of philosophers.

When I have laid before you these slender memorials of our deceased brethren, I may claim to have discharged the real duty of my office to-night. If indeed I were worthy to fill the chair in which your favour has placed me,—if I had, like some of our distinguished Fellows, a knowledge of all science, or even a special acquaintance with any *one*,—it would be my duty to submit to you a survey, or at least some outline, of the progress of science among us and among our neighbours. But for such a task you know me to be ill qualified. I should not venture to speak in the language of science anywhere, and least of all in the presence of the men whom I now see around me.

There are subjects, however, in which scientific men and men of no science feel an equal interest—which must engage the attention of every person of common intelligence.

Among these is the great step recently made in African geography—the discovery of the head of the Nile. No other geographical discovery can ever compare with this. It is not the solution of a puzzle in the Geographical Society. It is removing the "*Impossible*"—the very type of impossibilities—from our books. It is opening to the whole world the mystery which was a mystery even to the initiated. Poets have lost a topic! What philosophers and historians guessed and speculated about, is now written down plain on the map. That is now clear which has been wondered at since men began to ask the meaning of anything. We have lost the oldest subject of curiosity in the world!

A grave, prosaic mind loses its equanimity, and gives way to the charm of romance at the thought of the veil being raised that has for so many thousands of years covered the head of the great mysterious river which was worshipped of old—not more for its beneficent overflowings, regular as the seasons, yet unaccountable, than because of its unknown, unapproachable source.

I do not mean that the facts which our travellers have brought to light run counter to the conclusions of former geographers. On the contrary, I think the body of history on the one hand, the speculations of science on the other, had prepared the world for such a discovery. Glancing at the ancient, I mean the classical authorities, without arraying them before you, I may say that among innumerable fables and much unphilosophical reasoning, they almost concur in giving the Nile its source in a mighty lake—some say two immense lakes—fed by periodical rains,—fed also, say some, by subterraneous streams flowing from the west (these subterraneous rivers were favourites with the wonder-loving naturalists of old). This great lake was further believed to lie at the foot of lofty, snow-covered mountains, named the Mountains of the Moon. Herodotus indeed demurs to the snow. The Reservoir Lakes become immeasurable marshes in some of the accounts. Indeed I should despair of producing a *catena* of witnesses for any single point of the statement; but such as I have described was nearly the mind of ancient Greece and Rome, speaking on the information obtained in Egypt.

It is more remarkable to find a similar shadow of the truth from a different quarter, and perhaps of an earlier date. The ancient inhabitants of India seem to have felt the same interest, and to have had an equal glimmering of the course of the Nile. In a well-known paper by Mr Wilford, in the Asiatic Researches, we have a sort of abstract of the ancient Indian belief concerning the Nile, drawn from the Purānas and other Hindu or Sanscrit books.

The name of the river in those most ancient books is *Kali*, black. (Though Homer names the river *Aegyptus*, it was known to ancient Greeks as Μελας.) According to the same authorities, that famous and holy river takes its rise from the lake of the gods, thence named Amara or Deva, Saróvera in the region of Sharma or Sharmasthan, between the mountains of Ajagara and Sitanta, part of Soma-giri, or the Mountains of the Moon, the country round the lake being called Chandristhan or Moon-land. The Hindus believed in a range of snow-covered hills in Africa.

From thence the Kali flows into the marshes of the Padma-van, and through the Nishada Mountains into the land of Barbara; whence it passes through the mountains of Hemacáta; then entering the forests of Tapas (or Thebais) it runs into Kantaka-desa, or Mitha-sthan, and through the woods emphatically named Aranya and Atavi into Sanchabdhi (or our Mediterranean).

From the country of Pushpaversha, it received the Nanda or Nile of Abyssinia, the Asthimati or smaller Krishna, which is the Takazzi or little Abay, and the Sanchanaga or Mareb.

The Ajagara Mountains, which run parallel to the eastern shores of Africa, have at present the name of Lupata, or the back-bone of the world. Those of Sitanta are the range which lies west of the lake Zambre or Zaire, words not improbably corrupted from Amara or Sura. This Lake of the Gods is believed to be a vast reservoir which, through visible or hidden channels, supplies all the rivers of the country.

The Hindus, for mythological purposes (says Mr Wilford), are fond of supposing subterranean communications between lakes and rivers, and the Greeks, we know, had the same leaning.

We really had made little progress beyond these ancient guesses, till in the year 1858 Captains Speke and Burton saw and sailed upon the great lake Tanganyika, 600 miles from the coast at

Zanzibar. The lake is narrow, but 300 miles long, and 1800 feet above the level of the sea. Very soon after, Captain Speke alone had the glory to see and bear witness to the great inland sea which he has named Victoria. Having only seen this mighty lake, and being obliged to leave it unexplored, Captain Speke made haste to return to it, and this time in company with his old comrade and brother-in-arms Captain Grant, and through toils and dangers which men like these love almost for their own sake, they, together, reached in 1861 the Victoria Lake, which Speke had discovered three years earlier.

It happened (and such coincidences are frequent in science) that at the very time when Speke and Grant were fixing the bearings and heights of the great lake and its mountains, Baron von Decken and Mr Thornton measured and estimated the altitude of *Kilima Nearo*, one of a mountain range to the eastward of our travellers' route, at 20,000 feet, while the snow line descended below 16,000.

At present our information is necessarily meagre, but on the testimony of these two veteran travellers, furnished as they were with instruments for observation, we have some actual certainty, and room for infinite speculation.

The Victoria Sea of fresh water is about 150 miles square. The equator line runs through it, though nearer its north shore. Its waters are 3563 feet above the sea level. It is skirted, if not quite surrounded, by ranges of mountains of 10,000 feet high. Without farther evidence, independent even of the high authority of Captain Speke's opinion, we receive as certain that in the Victoria great lake is the source, or rather the great reservoir of the Nile, for of course the lake is fed by numerous streams, in fact by a stream from every valley among the surrounding mountains, and then it follows that the White Nile, not the Blue Nile as Bruce believed, is the chief of the two streams that join at Kartom, lat. 15° 30′.

Thus was the mystery cleared up that had defeated the ingenuity and enterprise of philosophers and travellers, of kings and Cæsars, since the days of Herodotus.

Captain Speke thinks very highly of the country he has explored in a commercial and agricultural view. He found the people not all savage, but capable of intelligent interest and quite awake to kindness and friendship. But the country is everywhere thinly peopled, and productive much beyond the wants of the population. Along the equator, at heights varying from 6000 to 12,000 feet, the travellers found a delicious climate, with abundance of water, and no excessive heat, full of cattle and corn. In the kingdom of Karagwé (lat. 1° 40′, elevation 5100 feet), the temperature for five months ranged from 60° to 70° at 9 morning. From what they could learn of the country to the westward of the lake, it preserves the same character for several hundred miles, and I know that Captain Speke believes there is a continuance of that which he calls the *Fertile Zone* almost to the coast of the Atlantic. He tells his friends he has "discovered a great fertile zone there, caused principally by the Mountains of the Moon, situated close to the equator, in the midst of the continent of Africa. These are great rain condensers. Round them are the sources of several rivers, the Nile on one side, the Tanganyika and the Congo on the other. The rains falling all round make that a fertile zone—the most fertile in the world. There is nothing in India or China to equal it."

It is in that direction the indefatigable traveller proposes to make his next expedition, and let us hope that in two years more we shall welcome Captain Speke returning from the mouths of the Congo.

I know not whether to congratulate or condole with the Society upon another advance in science, or whether that is to be called an advance which some consider a double trespass, a breaking down of the boundaries between geology and archæology, and overleaping the ancient landmarks which divided natural science from sacred history.

Certain well-known discoveries of hand-shaped weapons and implements, found along with the remains of some extinct animals, in undisturbed beds of a very ancient alluvial deposit both in France and in England, led the antiquary, whose department is limited to the human period, to seek to extend that period into what had hitherto been the exclusive province of the geologist; and the geologist again, driven to admit that these flint spear-points have been shaped by man's hand, and used upon (or among) the *Elephas primigenius*, the *Rhinoceros*, and other extinct animals whose teeth and bones now bear them company, has to seek for an extension of the period hitherto allotted for the operations and deposits which the race of man has witnessed.

This only brought out more palpably what geologists had for some time taught—had taught indeed almost as early as geology took the dimensions of a science—that the globe itself was immeasurably older than the age assigned for man.

That period—the creation of man—the age of man on the globe—had been early, and nearly unanimously fixed, by calculations based upon the data afforded by the Mosaic books.

Such calculations were necessarily more or less conjectural, founded on interpretations of archaic forms of language, and of words which might have different meanings. Numbers and figures were to be read in varying manuscripts, often from faulty copies; and although great men like Newton had satisfied themselves that the received age of the world and its inhabitants was the true one, new facts, of a science unknown to Newton, had shaken that opinion, and it seemed probable that the Biblical scholar, the student of sacred history, in the view of geological facts, would, in the first place, abandon the position that the age of the creation, the antiquity of the earth, was to be determined by the interpretation of the Mosaical books; and, *secondly*, that he would not shut his eyes to new evidence offered upon the questions, whether the Mosaical books intended to affirm the age of man upon the globe, and whether the interpreters of those books had accurately and precisely and definitely ascertained their meaning and intention in that matter.

I should perhaps do better in using the terms of the latest authority on this subject, which comes with "Oxford" on its title page to vouch its orthodoxy, and with the sound sense of our friend Dr Hannah to commend it to our acceptance:—*

"It is surely mere misapprehension to suppose that the revelation with which Moses was really entrusted could traverse the path of the modern geologist, or contain any thing that would either confirm or contradict his readings of those buried rocks. From whichever side the error comes, we are bound to shake ourselves free from it, not by saying with some that God cared not though His instruments should make mistakes on scientific subjects, but by pointing out that there can be no error where there is no assertion, and that a purely theological revelation contains no assertion which falls within the proper sphere of science."

* Dr Hannah's Bampton Lectures. Oxon., 1863.

I say then the two parties, the scientific inquirer and the Mosaical scholar, both earnest for truth, would have come to some understanding, not surely to conceal or shut out the truth, but to give each full license to inquire and experiment, and to draw all legitimate inferences from facts discovered; for after all, the disputes between theologians and geologists relate rather to inferences from facts than to the reality of the facts themselves. The theologian infers certain truths from the words of the first chapter of Genesis; the geologist infers certain notions from what he sees in an open quarry. The inferences are mutually contradictory; but as the theologian and the geologist are both capable of drawing false inferences, such inferences may be contradictory and neither may be true. A new light on the meaning of the word "Day" in the Mosaic language might end the controversy; so might some evidence that the best instances of hand-formed flint implements found in ancient drift were fictitious and fraudulent.

We must suppose that a candid student of the Divine books will take what help is in his power for explaining their difficulties, and, be sure, he will not neglect the testimony of the rocks—the history of creation written in other letters but by the same Author. So a candid geologist, who reflects that the purpose of Moses was clearly not to teach natural philosophy, but to inculcate and enforce the worship of the true God, will acknowledge that the order of creation given in Genesis does agree marvellously with the inverse order of the fossils actually found—plants, marine or aquatic animals, birds, mammals, man.

I say these disputants might have come to terms—explaining the Scripture history of the creation by the help of a careful and reverent study of the created universe. But a third party has lately rushed among the combatants, and now fight with two-edged weapons. These are theologians too—at least they are churchmen, and Hebraists, and mighty arithmeticians; but, with a singular view of their duty to their Church, they cavil at the foundations of its history and doctrine, and think it necessary to tell the world so. These critics insist, that no interpretation, construing of a phrase, word, or numeral of the Mosaical books shall be admitted—that all shall stand or fall together; and then, having picked out some words, especially some numbers, which they judge erroneous—

though not affecting a single point of doctrine or morals, or the essentials of history—they say the books ascribed to Moses are devoid of authority, and must be abandoned!

That is not the way in which we are accustomed to read any ancient history; and, though different canons are used for criticising the inspired writers from those applied to other historians, yet, as to the mere text, the books of Moses are entitled beyond others to a fair and liberal construction, as the most ancient books in the world, and as having passed through an infinite number of transcriptions and translations.

But I must declare my entire concurrence with Dr Hannah, that "it is a dangerous and mistaken policy to raise these disputes to adventitious importance, by treating them as though they necessarily involved the issue of our highest interests."

For the persons of tender conscience, who feel themselves constrained "to build up those scattered fragments of difficulty into a coherent edifice of doubt," they would themselves surely feel easier, as it would be a relief to the world, who are judging in the quarrel, if they could cease to be members of a Church which founds so confidently on the Mosaical history. They would *assail* with more satisfaction if they had not promised to *defend*.

For the geologist, if my voice were wanting to encourage him, I would bid him go forward, cautiously, reverently, yet without fear. Let him test the evidence with all care before publishing a discovery. He must consider he has everything to prove, and he should assert nothing without evidence, and take nothing for granted. We want proof of the antiquity of the Drift-deposit, and of the fossils contained in it belonging to the extinct animals named. We want proof that the flints are hand-wrought, and not chipped accidentally in the rolling drift. Much more, we desire proof that they *were* found there, and not *placed* to be found by some cunning quarryman. It is not only the flint instrument but its manufacture, its chipping into shape, that must be tested. Is the fracture of the flint such that it might have been made many thousand years ago?

Farther, the geologist should publish to the world the evidence of his facts; for the inquiry is one that concerns the public, and in which the public take an interest. But why should I intrude my advice upon men who have shown they know well what is required at their hands in a momentous inquiry? Nine of the most eminent geologists of France and England met in friendly conference at Paris, and, later, at Abbeville, to compare specimens, to test the evidence, to do everything for ascertaining the truth; and they published the *procès-verbal* of their proceedings in the "Natural History Review" of last August, with the sanction of Dr Falconer's name, and others equally well known. It seems hardly to be doubted, that numerous frauds have been perpetrated upon the naturalists. When specimens are well paid for, they become plentiful, both in England and in France, but there may be means of detecting the impositions, and these means our geologists are using with all care. The iron horse-shoe, lately put forth among the primeval relics, has been, as I understand, withdrawn; the bones of elephant and other animals, bearing marks of human hands, are not yet accepted by these naturalists. As to the Abbeville jaw-bone of a man, whose jaw must have ceased chewing long before the flood, there is but one opinion in England, which I am informed by Mr Evans is also gaining ground in France—that the whole thing was an impudent imposition. Mr Prestwich, who was once a believer, published his recantation in the last Quarterly Journal of the Geological Society.

It may be permitted me, perhaps, as one of the public, to offer one more advice to the naturalist. He must take care not only that his reasoning is logical, his inferences cautious and careful, but he will do well to avoid even the appearance of disputing for victory. Science has no enemies if its votaries do not raise them up by indiscretion and intemperance.

I have to apologise for occupying so much of your time, and for venturing rashly beyond the boundaries of my own line of study.

The following Gentlemen were duly elected Ordinary Fellows:—

Alexander Crum Brown, M.A., M.D., D.Sc.
Alexander Wood, M.D., F.R.C.P.E.

The following Donations to the Library were announced:—

Abhandl. der königl. Gesellschaft der Wissenschaften zu Gœttingen. 9ter u. 10ter Bände 1860–2. 4to.—*From the Society.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ naturæ Curiosorum. Vol. XXVI, pars posterior, 1858. 4to.—*From the Society.*

Sitzungsberichte der kaiserl. Academie der Wissenschaften zu Wien—Mathematisch-naturwissenschaftliche Klasse. Jahrgang, 1862, Bände XLVI.–VII.; und Philosophisch-historische Klasse, Bände XL.–I, nebst Register zu Bänden XXXI.–XL.—*From the Academy.*

Denkschriften der kaiserl. Academie der Wissenschaften—Mathematisch-naturwissenschaftliche Klasse. XXIter Band. 4to. —*From the same.*

Società reale di Napoli: rendiconto dell' academia delle Scienze fisiche e mathematiche. Anno Imo. fascicoli 1–8. Anno IIdo. fascicoli 1–3; e rendiconto delle scienze morali e politiche. Anni 1862–3. 4to.—*From the same.*

Positiones mediae stellarum fixarum in zonis regiomontanis a Besselio inter + 15° et + 45° declinationis observatarum ad annum 1825 redactæ, etc. auctore Maximiliano Weisse. 4to. —*From the Imperial Academy of St Petersburg.*

Observations metéorologiques faites à Nijné-Taguilsk, années, 1861–2. 8vo.—*From the Russian Government.*

Transactions of the Zoological Society of London for 1861. Part III.; and 1862, Parts I., II., and III. 4to.—*From the Society.*

Proceedings of the same. Vol. IV., Part 7; and Vol. V., Parts I. and II. 8vo.—*From the same.*

Philosophical Transactions of the Royal Society of London for 1862. Parts I. and II. 4to.—*From the Society.*

Proceedings of the same for 1863. 8vo.—*From the same.*

Extension of the Triangulation of the Ordnance Survey into France and Belgium, &c. By Col. Sir H. James, R.E., &c. 4to.—*From the Author.*

Memoirs of the American Academy of Arts and Sciences. New Series. Vol. VIII., Part II. 4to.—*From the Society.*

Proceedings of the same. Conclusion of Vol. V. and commencement of Vol. VI.—*From the same.*

Journal of the Academy of Natural Sciences of Philadelphia. Vol. V., Part III. 4to.—*From the Academy.*

Proceedings of the Boston Society of Natural History. Vol. VIII., 1861–2. Vol. IX. 1862–3. 8vo.—*From the Society.*

Boston Journal of Natural History. Vol. VII. Nos. 1, 2, and 3. 8vo.—*From the same.*

Proceedings of the American Philosophical Society. Vol. IX., No. 69. 8vo.—*From the Society.*

Catalogue of the Library of the same. Part I. 8vo.—*From the same.*

Transactions of the same. Part III., Art. IV., "Intellectual Symbolism." By P. E. Chase, M.A. 4to.—*From the same.*

Astronomical and Meteorological Observations at the U. S. Naval Observatory during 1861. 4to.—*From the Observatory.*

Annual Report of the Trustees of the Museum of Comparative Zoology. 1862. 8vo.—*From the Trustees.*

Report of Lieut.-Col. J. D. Graham on Mason and Dixon's Line. 8vo.—*From the Author.*

Observations on the Genus Unio. By Dr Isaac Lea. Vol. IX. 4to.—*From the Author.*

Discussion of the Magnetic and Meteorological Observations at Gerard College Observatory from 1840–5. Second Section, comprising Parts IV., V., and VI. Horizontal Force. By Dr A. D. Bache. 4to.—*From the Author.*

Appendices XVI. and XXIII. to the above. 4to.—*From the same.*

Report of the Superintendent of the U.S. Coast Survey for 1859 and 1860. 2 vols. 4to.—*From the same.*

Ohio Agricultural Report for 1861. Second Series. 8vo.—*From the Smithsonian Institution.*

Annual Report of the Regents of the Smithsonian Institution for 1861. 8vo.—*From the same.*

On the Syllogism. No. V. By A. De Morgan, F.R.A.S. and C.P.S., &c. 4to.—*From the Author.*

Archaeologia. By the Society of Antiquaries of London. Vol. XXXIX. 4to.—*From the Society.*

Proceedings of the Royal Institution of Great Britain. Nos. 37 and 38. 8vo.—*From the Institution.*

Scheikundige Verhandelingen, tweede Deel, tweede Stuk door G. J. Mulder. 8vo.—*From the Author.*

Muir's Sanscrit Texts. Vol. IV.—*From the Author.*

Beobachtungen des Mars um die Zeit der Opposition, 1862, von Dr A. Winnecke. 4to.—*From the Author.*

Observations de la grande Nebuleuse d'Orion faites à Cazan et à Poulkova. Par O. Struve. 4to.—*From the Author.*

Proceedings of the Medico-Chirurgical Society of London. Vol. IV., Nos. 3 and 4. 8vo.—*From the Society.*

Atti dell' imp. reg. Istituto Veneto di Scienze, Lettere ed Arti dal Novembre 1862 all' Ottobre 1863. Tomo ottavo; Serie terza. Dispense quarta-nona. 8vo.—*From the Institute.*

Du Climat de Genève. Par E. Plantamour. 4to.—*From the Author.*

Résumé Météorologique de l'Année 1861 pour Genève et le Grand S. Bernard. By the same. 8vo.—*From the same.*

Biblical Natural Science. By Rev. John Duns. Parts VI.–XIII. 8vo.—*From the Author.*

Traforo dell' Alpi tra Bardonèche e Modane, 1863. 4to.—*From the Italian Government.*

Mémoire sur la loi du réfroidissement des Corps Sphériques, etc. Par J. Plana, Turin. 4to.—*From the Author.*

Memoirs of the Geological Survey of India, II. 4, and II. 5. 4to. —*From Dr Oldham.*

Catalogus Lichenum quos in Provincia Sondriensi et circa Novum Comum collegit, etc. Presbyter Martinus Anzi. 8vo.—*From T. C. Archer, Esq.*

Annales hydrographiques, Nos. 350–5. 8vo.—*From the Dêpôt de la Marine.*

Bulletin de la Société de Géographie. 8vo.—*From the same.*

Cartes de la Pilote Française.—*From the same.*

Proceedings of the Nat. Hist. Society of Dublin. Vol. III., Parts I. and II. 8vo.—*From the Society.*

On the Generative System of *Helix aspersa et hortensis.* By Dr H. Lawson. 8vo.—*From the Author.*

Jahrbuch der kaiserl. königl. Geologischen Reichs Anstalt. XII. No. 4, and XIII. Nos. 1 and 2. Mit General Register der ersten 10 Bände. 8vo.—*From the Archivar of the Reichs-Anstalt.*

Bibliothèque de M. le Baron de Stassart léguée à l'Academie Royale de Belgique. 8vo.—*From the Academy.*

Sveriges Geologiska Undersökning. 1–5. With Maps. 8vo.—*From the Swedish Government.*

Proceedings of the Royal Horticultural Society. May to November 1863. 8vo.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XXXI. 4to.—*From the Society.*

Annales de l'Observatoire Royal de Bruxelles. Tome XV. 4to.—*From M. Quetelet.*

Note sur les Résultats fournis par une enquête relative à l'authenticité de la découverte d'une machoire humaine et des haches en silex dans le terrain diluvien de Moulin-Quignon. Par M. Milne-Edwards. 4to.—*From the Author.*

Ueber die Saurodipterinen, Dendrodonten, Glyptolepiden u. Cheirolepiden des Devonischen Systems von Dr C. H. Pander. With 17 Plates. 4to.—*From the Russian Government.*

Monatsberichte der königl. Preuss. Akademie der Wissenschaften zu Berlin. Aus dem Jahre 1862. 8vo.—*From the Academy.*

Mittheilungen der naturforschenden Gesellschaft in Bern. Nos. 497–530. 8vo.—*From the Society.*

The Westminster Confession of Faith critically compared with the Holy Scriptures and Found Wanting. By James Stark, M.D., &c. 8vo.—*From the Author.*

Pinetum Britannicum. Part IV. Abies Hookeriana; Abies Pattoniana. Folio.—*From Charles Lawson, Esq.*

Journal of Agriculture; July and October 1863. 8vo.—*From the Highland Society.*

Report on the Madras Military Fund, containing New Tables of Mortality, Marriage, &c., from 1808 to 1858. 8vo.—*From Samuel Brown, Esq.*

Proceedings of the Royal Meteorological Society. Vol. I., Nos. 6–8. 8vo.—*From the Society.*

Journal of the Proceedings of the Linnean Society. Vol. VII., Nos. 26, 27. 8vo.—*From the Society.*

The Canadian Journal of Industry, Science, and Art. Nos. 44–47. 8vo.—*From the Society.*

Journal of the Royal Dublin Society. No. 29. 8vo.—*From the Society.*

Journal of the Geological Society of Dublin. Vol. X. Part I. 8vo.—*From the Society.*

Monthly Returns of the Births, Deaths, and Marriages Registered in the Eight Principal Towns of Scotland for 1863. 8vo.—*From the Registrar-General.*

Quarterly Returns of the above Registered in the Divisions, Counties, and Districts of Scotland for 1863. 8vo.—*From the same.*

Quarterly Reports of the Meteorological Society of Scotland for 1863. 8vo.—*From the Society.*

Nyt Magazin for Naturvidensskaberne. Twelfth Volume, Parts I.–III. 8vo.—*From the Editors.*

Norsk-Forfatter Lexicon, 1814–56. Af Jens E. Kraft. Sjette Heft. 8vo.—*From the Editor.*

Norske Vaegtlodder fra fjortende aarhundrede beskrevene. Af C. A. Holmboe. 4to.—*From the Author.*

Taxidermi. For the use of the University of Christiania. 8vo.—*From the University.*

Peter Andreas Munch. Ved Paul Botten Hansen. 8vo.—*From the Author.*

Fredie Aars-Beretning om Fantesolket. Ved Eilert Sundt. 8vo. —*From the Author.*

Udsigt over Mineral Cabinett Opstilling og Storrelse. Af givet som Indberetning for 1861 fra Bestzreren. 8vo.—*From the same.*

Forhandlinger i Videnskabs-Selskabet i Christiania Aar, 1862. 8vo.—*From the Society.*

Ægyptische Chronologie. Von J. Lieblein. 8vo.—*From the Author.*

Det Kongelige Norske Frederiks Universitets Aarsberetning for Aaret 1861. 8vo.—*From the University.*

Aperçu des différents Méthodes de Traitement employées à l'hôpital de l'Université de Christiania contre la Syphilis constitutionelle. Par J. L. Bidenkap. 8vo.—*From the same.*

Committee-Beretning Angaaende Syphilisationen ved Steffens, Egeberg et Voss. 8vo.—*From the same.*

Det Kongelige Frederiks Universitets Halvhundredaars-fest. Sept. 1861. 8vo.—*From the same.*

Schriften der Universität zu Kiel. Aus dem Jahre 1862. Band IX. 4to.—*From the University.*

Abhandlungen der philosoph.-philologischen Classe der königl. bayerischen Akademie der Wissenschaften. 9ten Bandes 3te Abtheilung. 4to.—*From the Academy.*

Mathematisch-physikalische Classe von derselben. 9ten Bandes 3te Abtheilung. 4to.—*From the same.*

Denkrede auf Joh. Andreas Wagner, von Dr C. F. P. von Martius. 4to.—*From the same.*

Rede in der öffentlichen Sitzung der k. Akademie der Wissenschaften am 28 März 1863. Von Justus Freiherrn von Liebig. 4to.—*From the same.*

Ueber die deutschen Einheits-bestrebungen in 16 Jahrhundert, von dem königl. Universitäts Professor Dr Cornesius. 4to.—*From the same.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München, 1862, II. Heft. 3, 4, and 1863, I. Heft. 1–3. 8vo.—*From the same.*

Berichte über die Verhandelungen der königl. sächsischen Gesellschaft der Wissenschaften zu Leipzig; mathematisch-physische Classe, 1862, und philologisch-historische Classe, 1862. 8vo. *From the Society.*

Die Schlacht von Warschau, 1856. Von Joh. Gust. Droysen. No. 4. 8vo.—*From the same.*

Ueber den Bau von Angiopteris. Von G. Mettenius. 8vo.—*From the same.*

Transactions of the Botanical Society, Vol. VII. Part III. 8vo.—*From the Society.*

Phenomena attending the Fall of Meteorites on the Earth. By W. Haidinger, For. Mem. R.S. L. and E., &c. 8vo.—*From the Author.*

Du Progrès dans les langues par une direction nouvelle donnée aux travaux des Philologues et des Academies. 8vo.—*From the Author.*

Scientific Papers. By John Hogg, M.A., F.R.S., &c. 8vo.—*From the Author.*

On the Origin and Distribution of the Regum or Black Cotton Soils of India. By Captain A. Aytoun. 8vo.—*From the Author.*

On the Phenomena of the Glacial Drift of Scotland. By Archibald Geikie, Esq. 8vo.—*From the Author.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tomes XIII. et XIV. 8vo.—*From the same.*

Mémoires Couronnés, etc., publiés par l'Académie Royale de Belgique. 8vo.—*From the same.*

Annuaires de l'Académie de Belgique. 1863.—*From the same.*

Annuaire de l'Observatoire Royale de Bruxelles. Par M. A. Quetelet. 16mo.—*From the Author.*

Bolide observée dans la soirée du 4 Mars 1863. Par M. A. Quetelet. 8vo.—*From the same.*

Etoiles filantes. Orages des mois d'Août et Septembre 1862. Direction des Courants électriques dans les corps des animaux. Par M. A. Quetelet. 8vo.—*From the same.*

Sur les étoiles filantes. Par E. Herrick et Ad. Quetelet. 8vo.—*From the same.*

Différence des temps entre Bruxelles et Vienne pour les époques critiques des Plantes et des Animaux. Par M. A. Quetelet. 8vo.—*From the same.*

Sur les Nébuleuses, etc. Par M. A. Quetelet. 8vo.—*From the same.*

Aurora boréalis du 14 au 15 Décembre 1862. Par M. A. Quetelet. 8vo.—*From the same.*

De la Variation annuelle de l'inclinaison et de la déclinaison magnetique, etc. Par M. A. Quetelet. 8vo.—*From the same.*

Climat de la Belgique. Par M. A. Quetelet. 4to.—*From the same.*

Etoiles filantes de période du 10 Août 1863. Par M. A. Quetelet. 8vo.—*From the same.*

On Time-Boundaries in Geological History, &c. By J. D. Dana, Esq. 8vo.—*From the Author.*

System der deutschen Katarakten insbesonders Bayern's. u. s. w. Von Dr Joh. Gistl. 8vo.—*From the Author.*

Systema Insectorum secundum Classes, Ordines, Genera, Species, scripsit Dr Joh. Gistl. Tome I., Fasc. I. 8vo.—*From the same.*

Mélanges Mathématiques et Astronomiques, tirés du Bulletin de l'Académie Impériale des Sciences de S. Petersbourg. Tome III. $\frac{20 \text{ Juin}}{2 \text{ Juillet}}$ 1862. 8vo.—*From the Academy.*

Bulletin de la Société Impériale des Naturalistes de Moscou. Nos. II., III., & IV. 8vo.—*From the Society.*

Suez Canal. Report of John Hawkshaw, F.R.S., to the Egyptian Government. 8vo.—*From the Author.*

Reise der œsterreichischen Fregatte Novara um die Erde. Nautisch-physikalischer Theil. IIte. Abtheilung. 4to.—*From the Austrian Government.*

Correspondenz-blatt des Vereins für Naturkunde zu Presburg. I. Jahrgang. 1862. 8vo.—*From Prof. E. Mack.*

Fifteenth Annual Report of the Regents of the University of the State of New York, on the Condition of the State Cabinet of Natural History. 8vo.—*From the U.S. Government.*

Report of the Commissioner of Patents for 1860. Vols. I. and II. 8vo.—*From the U.S. Government.*

Address to the Royal Physical Society of Edinburgh on the Opening of the Ninety-second Session. By Alexander Bryson, Esq. 8vo.—*From the Author.*

Klein on Foretelling the Weather in Connection with Meteorological Observations. Translated from the Dutch by Dr Adriani. 8vo.—*From the Translator.*

Catalogue des Objets d'Antiquité etc. de Feu, M. Jomard. 8vo.—*From the Author.*

Proceedings and Transactions of the Meteorological Society of Mauritius. Vol. V. 8vo.—*From the Society.*

Annual Report of the Yorkshire Philosophical Society for 1862. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XXVI. Parts II. and III. 8vo.—*From the Society.*

Nederlandsch Kruidkundig Archief onder redactie van W. F. R. Suringar en M. J. Cop. Vifde Deel. Derde Stuk. 8vo.—*From the Editors.*

Schriften der königl. physikalisch-ökonomischen Gesellschaft zu Königsberg. Dritter Jahrgang 1862, 1e u. 2te Abtheil. 4to. —*From the Society.*

Resultate magnetischer u. meteorologischer Beobachtungen auf einer Reise nach dem östlichen Sibirien in den Jahren

1828–30. Von Prof. Hansteen u. Lieutenant Due. 4to.—*From the Authors.*

Proceedings of the Royal Physical Society of Edinburgh. Sessions 1858–62. 8vo.—*From the Society.*

Transactions of the Pathological Society of London. Vol. XIV. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society. No. 76.

Compte Rendu de la Commission impériale archéologique pour l'année 1861 (avec un Atlas). 4to.—*From the Russian Government.*

Greenwich Observations for 1861. 4to.—*From the Astronomer-Royal.*

Edinburgh Astronomical Observations. Vol. XII. 8vo.—*From Prof. Smyth.*

Jahresbericht über die Fortschritte der Chemie, etc. Von H. Kopp u. H. Will, für 1861. 2te Hälfte. Giessen 1863. 8vo.—*From the Editors.*

Mémoires de Société impériale des Sciences naturelles de Cherbourg. Tomes VI.–VIII. 8vo.—*From the French Consul.*

Proceedings of the Royal Geographical Society. Vol. VII. Nos. III., IV., and V. 8vo.—*From the Society.*

Monday, 21*st December* 1863.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read:—

1. On the Morphological Relationships of the Molluscoida and Cœlenterata and of their leading members, *inter se*. By John Denis Macdonald, R.N., F.R.S., Surgeon of H.M.S. "Icarus." Communicated by Professor Maclagan.

2. On the External Anatomy of a New Mediterranean Pteropod. By John Denis Macdonald, R.N. Communicated by Professor Maclagan.

3. On the Limits of our Knowledge respecting the Theory of Parallels. By Professor Kelland.

The Author has in this paper traced to its consequences the assumption, as if it were an axiom, of the proposition "That the angles of a triangle are together less than two right angles." The results as regards the theory of parallels are such as to imply that such lines would have most of the properties of equal circles exterior to one another.

Professor Tait reminded the Society that, at the close of last session, he and Balfour Stewart, F.R.S., of the Kew Observatory, had deposited with the Secretary a sealed packet containing the coincident results of certain investigations which they had separately carried on from totally distinct points of view, and which appeared to lead to a new principle in Natural Philosophy.

Experimental attempts at verifications of this principle have since been made by them in various ways, and others are in progress. Meanwhile, the authors desire to put on record that it appears probable, from their experiments, that the viscosity, &c., of air are not the only causes of the increased radiation from a moving body. (Compare Joule and Thomson, *Phil. Trans.* 1860.) A vacuum apparatus now in course of construction, will, it is hoped, lead to decisive results.

The following Gentlemen were elected Fellows of the Society:—

Andrew Wood, M.D., F.R.C.S.E.
Robert William Thomson, Esq., C.E.

The following Donations to the Library were announced:—

Monthly Return of the Births, Deaths, and Marriages Registered in the Four Principal Counties of Scotland. October 1863. 8vo.—*From the Registrar-General.*

Journal of the Royal Geographical Society. No. 32. 8vo.—*From the Society.*

Transactions of the Linnean Society. Vol. XXII., Part II. 4to.—*From the same.*

Journal of the Chemical Society. No. 12. 8vo.—*From the same.*

Transactions of the Royal Society of Literature. Vol. VII., Part III. 8vo.—*From the same.*

American Journal of Science and Arts. No. 108. 8vo.—*From the Editors.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1863–64. No. 63.

Monday, 4th January 1864.

Professor KELLAND, Vice-President, in the Chair.

The following Communications were read:—

1. On the great Drift-Beds with Shells in the South-west of Arran. By the Rev. Robert Boog Watson, B.A., F.R.S.E., Hon. Mem. Naturw. Ver. Lüneburg.

These beds, as examined by the author, lie in the Torlin or Kilmorie Burn basin, in the Scoradale or Slidry Water basin (more strictly in the first north or north-west tributary of each, reckoning upwards from the sea), and in the Clachan Glen,—all in the south-west of Arran. They are of great extent and depth; at certain points they contain boreal shells in considerable numbers. They are divisible into two classes, (1.) underlying fine dark sands and clays; and, (2.) overlying coarse red clay with striated stones, probably boulder clay.

They are interesting, because,

1. They present, in a striking form, proof of the immense destruction of the surface of the land.

2. They afford unusually good sections, from the rock on which they rest, upwards.

3. They throw some light on the formation of the boulder clay.

4. They present sea shells, at one point land plants, and also at one point a later lake basin.

The special information they give is,—

1. That *all* the latest geological changes have not materially affected the relations of hill and valley.

2. That the valleys were largely excavated by ice.

3. That the ice covered the land till it was submerged.

4. That the depression of the land below the sea was continuous, and ultimately attained 1000 feet at least.

5. That the depression was, at one point at least, sudden.

6. That this sudden fall did not begin later, at least, than the time at which the present 90 feet line above the sea-level reached the level of the sea.

7. That this sudden subsidence could not have amounted to less than 200 feet.

8. That it could not have much exceeded 300 feet.

9. That under obvious limitations, the beds which lie *nearest the sea-level and deepest below the surface*, are the *oldest*, and that those are *contemporary* which occupy the *same relative position to the sea-level and the underlying rock.*

2. On the Agrarian Law of Lycurgus, and one of Mr Grote's Canons of Historical Criticism. By Professor Blackie.

3. On the Occurrence of Amœbiform Protoplasm and the Emission of Pseudopodia in the Hydroida. By Professor Allman.

The author described the contents of the small tubular appendages, named Nematophores by Busk, which are developed upon certain definite points of the hydrosome in the *Plumularidæ*. These contents were shown to consist of a granular protoplasm, with occasionally a cluster of large thread-cells embedded in it.

The protoplasm has the property of emitting pseudopodia, which are very extensile and mutable in shape, and exactly resemble the pseudopodial prolongations, whose occurrence among the *Rhizopoda* is so eminently characteristic of this group of *Protozoa*. The contents of the nematophores, indeed, except alone in the presence of thread-cells, are indistinguishable in structure, and in the phenomena presented by them from the sarcode or protoplasm, which forms the substance of an amœba, a difflugia, or an arcella.

The following Gentleman was elected a Fellow of the Society:—

James David Marwick, Esq.

The following Donations to the Library were announced:—

Journal of the Statistical Society of London. December 1863 (with General Index). 8vo.—*From the Society.*

Monthly Notices of the Astronomical Society. Vol. XXIV., No. 1. 8vo.—*From the Society.*

Monthly Return of Births, Deaths, and Marriages Registered in the Four Principal Counties of Scotland. November 1863. 8vo.—*From the Registrar-General.*

Abhandlungen herausgegeben von der senckenbergischen naturforschenden Gesellschaft. Vierten Bandes, dritte u. vierte Lieferung. 4to.—*From the Society.*

Historia e Memorias da Academia real das Sciencias de Lisboa. Classe de Sciencias Moraes, Politicas e Bellas Lettras. Nova Serie. Tomo II., Parte II. 4to.—*From the Academy.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München. Jahrgang 1863, I. (Doppel) Heft IV. 8vo. —*From the Academy.*

Kongliga Svenska Vetenskaps-Akademiens Handlingar. Ny Följd, Fjerde Bandet, Fórsta Häftet. 1861. 4to.—*From the Academy.*

Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar. Nittonde Årgången. 1862. Meteorologiska Jakttagelser i sverige utgifna af kongl. Svenska Vetenskaps-Akademien, bearbetade af Er. Edlund. Fredje Bandet. 1861. Oblong 8vo.—*From the same.*

The Canadian Journal of Industry, Science, and Art. No. 48.—*From the Editors.*

Transactions of the Royal Scottish Society of Arts. Vol. VI. Part III. 8vo.—*From the Society.*

The Journal of Agriculture. January 1864. 8vo.—*From the Highland and Agricultural Society.*

The Journal of the Royal Geographical Society. Vol. XXXII. 8vo.—*From the Society.*

Jahrbuch der kaiserlich-königlichen geologischen Reichs-Anstalt. 1863. XIII. Band. 8vo.—*From the Austrian Government.*

Mémoires de l'Académie Impériale des Sciences de St. Petersbourg. VII[e] Série. Tome IV., Nos. 10 et 11. 4to.—*From the Academy.*

Bulletin de l'Academie Impériale des Sciences de St. Petersbourg. Tome IV., Nos. 7–9. Tome V., Nos. 1 et 2. 4to.—*From the Academy.*

Tables of Heights in Sind, the Punjab, North-western Provinces, and Central India, determined by the great Trigonometrical Survey of India, Trigonometrically and by Spirit-Levelling operations. 8vo.—*From the Director of the Survey.*

Monday, 18th January 1864.

His Grace the Duke of ARGYLL, President, in the Chair.

The following Communications were read :—

1. Description of the Lithoscope, an instrument for distinguishing Precious Stones and other bodies. By Sir David Brewster, K.H.

The Instrument was exhibited.

2. On the Temperature of certain Hot Springs in the Pyrenees. By R. E. Scoresby-Jackson, M.D., F.R.C.P.

In the year 1835, Principal Forbes very carefully observed the temperatures of certain springs in the Pyrenees, with the view of ascertaining to what extent changes of temperature occur in them. Observations previously made were, for several reasons, of uncertain worth, and Principal Forbes was desirous of then fixing "data for future observers with a degree of accuracy hitherto unattempted."

The author having determined to spend his autumn holidays in the Pyrenees, believed that a careful repetition of such observations, after the lapse of twenty-eight years, would afford results of some interest. He furnished himself with accurate thermometers made for the purpose, and, during the month of August, carefully observed the temperatures of several of the springs visited by Principal Forbes in 1835. In the tables which are distributed through the paper, the temperatures of the springs are given as recorded by different observers at various periods between the years 1835 and 1863. From these records it would appear that whilst there is perhaps in no instance a general or permanent change of temperature, neither is there in any an undeviating temperature. It is probable that the temperatures of the springs in the interior of the globe have undergone no change, and that the changes observable upon the surface of the earth are due to superficial causes, such as external temperature, the infiltration of cold surface water, &c. To a certain extent, an allowance must be made for inaccuracies; for it is scarcely to be supposed that all the observers dipped their thermometers exactly at the same points, nor does the author know that in all cases the instruments employed were without errors.

3. On Human Crania allied in Anatomical Characters to the Engis and Neanderthal Skulls. By Wm. Turner, M.B., Senior Demonstrator of Anatomy in the University.

The Author compared the above crania with various human skulls which had come under his observation. He exhibited a skull brought by Mr Henry Duckworth, F.G.S., from St Acheul near Amiens, which in its general contour presented a striking resemblance to the Engis skull. The St Acheul skull was somewhat smaller, being probably that of a female. It might almost have been regarded as a reduced copy of the Engis skull. There was no evidence that the skull from St Acheul was of an earlier date than the Gallo-Roman period of French history. The Neanderthal skull was compared with several modern crania, mostly British, especially with reference to the projection of the supra-orbital ridges, the retreating forehead, and the slight convexity of the occipital region. He exhibited several skulls which were closely allied to it in one or other of these features. It was shown also that the Neanderthal skull, although below the European mean in its internal capacity, yet exceeded the dimensions of some normal modern European crania which had been carefully measured—its large transverse parietal diameter compensating for the brain space lost by the retreating forehead and flattened occiput.

As the history and geological age of the Neanderthal skull were both unknown, and as many of its most striking anatomical characters were closely paralleled in some modern European crania, the Author considered that great caution ought to be exercised in coming to any conclusion, either as to the pithecoid affinities or psychical endowments of the man to whom it originally appertained.

4. Notice of a Simple Method of Approximating to the Roots of any Algebraic Equation. By Edward Sang, Esq.

M. Lagrange, on applying the method of continued fractions to the resolution of numerical equations, discovered that, for those of the second degree, the quotients recur periodically. From this, combined with the previously well known fact that all periodic chain fractions belong to quadratics, he inferred that periodicity is exclusively confined to equations of this order.

In January 1858, I showed to the Royal Society that the series of approximating fractions obtained by M. Lagrange can be continued in the opposite direction, and that the convergence then is to the other root; and enunciated the general theorem, that if any two fractions be assumed, and if a progression be formed from them by combining fixed multiples of their members, this progression, which I called *duserr* or two-headed, may be continued in either way, and gives on the one hand the one, on the other hand the other root of a quadratic.

This would seem to confirm Lagrange's view of the limited application of periodicity.

However, we may observe that our attention has been restricted to one kind of periodicity; there may be recurrences of higher orders which may belong to equations of higher degrees. Thus if, instead of beginning with two fractions, we had assumed three, and formed the progression by combining specified multiples of the last, the penult and the antepenult, the terms of the progression would approach to some limit which, not being the root of a quadratic, may be the root of a cubic or of some higher equation ; such a progression may be extended backwards, giving an approximation to another root; and we may still farther complicate the recurrence by using four, five, or any number of fractions.

While engaged in examining the nature of such progressions, and seeking for a demonstration of some general properties which they seemed to possess, I came upon a very simple theorem, which gives great facility in the search for the roots of equations.

If we put an algebraic equation in the usual form—

$$ax^n + bx^{n-1} + \ldots\ldots px + q = o,$$

multiply each term by its exponent; thus,

$$nax^n + \overline{n-1}\, bx^{n-1} + \ldots\ldots p + 0,$$

and divide the expression so obtained by the original polynome, developing the quotient according to the descending powers of x, the resulting series takes the form

$$n + \mathrm{A}x^{-1} + \mathrm{B}x^{-2} + \mathrm{C}x^{-3} + \mathrm{D}x^{-4} + \text{\&c.};$$

or if we develop the quotient according to the ascending powers of x, and change the signs, we have, writing from right to left,

$$+ \text{ \&c. } + \delta x^4 + \gamma x^3 + \beta x^2 + \alpha x,$$

and these two series conjoined make a duserr progression; thus,

$$+ \text{\&c. } + \delta x^4 + \gamma x^3 + \beta x^2 + \alpha x + n + \mathrm{A}x^{-1} + \mathrm{B}x^{-2} + \mathrm{C}x^{-3} + \mathrm{D}x^{-4} + \text{\&c.},$$

approaching on either side to a geometrical progression, the common ratio of which is a root of the equation; that is to say, if we divide the coefficient of any term by that of the term to its left, we shall have an approximation to a root more and more close the farther we proceed along the series. The approximation on the right hand is to the root farthest from zero, that on the left hand to the root nearest to zero.

If the equation $2x^3 - 11x^2 + 13x - 3 = 0$ were proposed, we should form from it the expression $6x^3 - 22x^2 + 13x - 0$, and, by division, thence form the progression

$$3 + \frac{11}{2.x} + \frac{69}{2^2.x^2} + \frac{509}{2^3.x^3} + \frac{3937}{2^4.x^4} + \frac{30901}{2^5.x^5} + \frac{243657}{2^6.x^6} + \text{\&c.},$$

which shows that the fractions

$$\frac{11}{2\cdot 3}, \frac{69}{2\cdot 11}, \frac{509}{2\cdot 69}, \frac{3937}{2\cdot 509}, \frac{30901}{2\cdot 3937}, \frac{243657}{2\cdot 30901}, \text{ \&c.}$$

converge to the greatest root of the equation. Or, performing the division from the right hand, observing to change the signs, we have

$$+\text{ \&c.} + \frac{898034}{3^6}x^6 + \frac{91913}{3^5}x^5 + \frac{9367}{3^4}x^4 + \frac{964}{3^3}x^3 + \frac{103}{3^2}x^2 + \frac{13}{3}x,$$

showing that the fractions

$$\text{\&c.}, \frac{3\cdot 91913}{898034}, \frac{3\cdot 9367}{91913}, \frac{3\cdot 964}{9367}, \frac{3\cdot 103}{964}, \frac{3\cdot 13}{103},$$

converge to the least root of the equation.

In this case we have the duserr progression,

$$\text{\&c.}, \frac{9367}{3^4}, \frac{964}{3^3}, \frac{103}{3^2}, \frac{13}{3}, 3, \frac{11}{2}, \frac{69}{2^2}, \frac{509}{2^3}, \frac{3937}{2^4}, \text{ \&c.},$$

of which the centre term 3 is the index of the order of the equation, and of which if we take any four consecutive terms, which we may denote by P, Q, R, S, we have the equation

$$2S - 11R + 13Q - 3P = 0,$$

by help of which we can readily continue the progression either way; thus,

$$S = \frac{3P - 13Q + 11R}{2}, \; T = \frac{3Q - 13R + 11S}{2}, \text{ \&c.}$$

for the progress to the right hand; or,

$$\text{\&c.}, O = \frac{13P - 11Q + 2R}{3} \quad P = \frac{13Q - 11R + 2S}{3},$$

without the necessity of going through the details of the division.

If we denote by r_1, r_2, r_3, &c., the roots of the equation, the coefficients of the powers of x in the duserr progression are the sums of the powers of r_1, r_2, &c. inverse of the power of x; that is to say,

$$A = \Sigma (r^1);\; B = \Sigma (r^2);\; C = \Sigma (r^3), \text{ \&c.; while}$$
$$\alpha = \Sigma (r^{-1});\; \beta = \Sigma (r^{-2});\; \gamma = \Sigma (r^{-3}), \text{ \&c.}$$

Now if we have a number of unequal quantities, r_1, r_2, r_3, and take their successive powers, the power of the largest of them may be made to exceed the sum of the corresponding powers of all the others in any required proportion, so that if R denote the greatest of all the roots, the ratio $R^m : \Sigma(r^m)$ may be brought, by taking m sufficiently great, as nearly to a ratio of equality as we desire; of necessity, the ratio $R^{m+1} : \Sigma(r^{m+1})$ will be still more nearly that of equality; wherefore the quotient

$$\frac{\Sigma(r^{m+1})}{\Sigma(r^m)}$$

may be made to approximate to the value of R within any prescribed degree of nearness.

Similarly, on taking the successive inverse powers, those of the greater diminish much more rapidly than those of the smaller quantities; wherefore we may continue the progression towards the left hand until the sum $\Sigma(r^{-m})$ may have to the $-m^{\text{th}}$ power of the least root, ρ, a ratio differing from that of equality as little as may be desired, in which case the two ratios

$$\Sigma(r^{-m-1}) : \Sigma(r^{-m}), \text{ and } \rho^{-m-1} : \rho^{-m}$$

will be nearly alike; that is to say, the quotient $\frac{\Sigma(r^{-m})}{\Sigma(r^{-m-1})}$ will differ from the smallest root, ρ, by an imperceptible quantity.

The chief use of this approximation will probably be found in practice to be to give a starting point for the more rapid methods already known, which methods are only rapid when the root has to be approached from a small distance. Yet, having obtained a pretty close approximation, s, to some root, we have only to make the substitution $x-s=y$, to obtain a new equation, having one root very small in comparison with the others, and to which, therefore, the approximation by this method will be very rapid.

When the root R is positive, the signs of the quantities A, B, C, &c. become continuous and +; if R be negative, they must be alternate; and it is to be observed that if the coefficients of the even powers of x become negative, the root must be imaginary. Also, if there should be two roots, R and $-R^1$, nearly equal to each other, the coefficients of the odd powers will become small in comparison with those of the even powers, in which case it may be convenient to take

$$\sqrt{\left\{\frac{\Sigma(r^{m+2})}{\Sigma(r^m)}\right\}}$$

as the formula for approximation.

5. Notice of the State of the Open-Air Vegetation in the Edinburgh Botanic Garden, during December 1863. By J. H. Balfour, A.M., M.D., F.R.S., F.L.S.

The state of the vegetation in the open ground of the Botanic Garden during the month of December 1863 was so very remarkable that I have been induced to submit a notice of it to the Royal Society. The number of phanerogamous species and varieties in flower during the month amounted to 245; of these 35 were spring-flowering plants which had anticipated their period of florescence, while the rest were summer and autumn flowers which had protracted their flowering beyond their usual limits.

The following are the details as given by Mr M'Nab:—

Plants in flower in the Royal Botanic Garden, Edinburgh, from 1st to 31st December 1863.

Annual plants, chiefly summer and autumn flowering species and varieties, ...	36
Perennial plants, chiefly summer and autumn flowering species and varieties, ...	133
Trees and shrubs, chiefly autumn flowering, . .	41
Spring-flowering trees, shrubs, and perennial herbaceous plants, ...	35
Total flowering plants, . .	245

I have drawn up a list of all the plants in flower during December, arranged according to their natural orders; and I have also requested Mr James Tod, one of my assistants, to dry a complete series of the plants, and to exhibit them in one view on pasteboard.

In looking at the list we shall find that the following spring-flowering plants developed flower-buds and blossoms:—

List of Spring-Flowering Plants picked in flower in Dec. 1863.

Eranthis hyemalis
Helleborus abschasicus
olympicus
purpurascens
Hepatica triloba
Aubrietia grandiflora
Draba verna
Iberis sempervirens

Viola odorata
Orobus cyaneus
 vernus
Cydonia japonica
Potentilla Fragariastrum
Dondia Epipactis
Doronicum caucasicum
Petasites fragrans
 nivea
Erica herbacea
Rhododendron atrovirens
 Nobleanum
Gentiana acaulis
Phlox verna
Anchusa sempervirens
Omphalodes verna
Symphytum caucasicum
 tauricum
Primula denticulata
 elatior and vars. (Polyanthus)
 veris
 vulgaris
Corylus Avellana
Sisyrinchium grandiflorum
Galanthus nivalis
Muscari racemosum
Knappia agrostidea

The following is a complete list of the Plants in flower during December 1863 :—

RANUNCULACEÆ :
 Eranthis hyemalis
 Helleborus abschasicus
 fœtidus
 niger
 odorus
 olympicus
 purpurascens
 Hepatica triloba
 Ranunculus auricomus
 repens
 Trollius asiaticus
BERBERIDACEÆ :
 Berberis Darwinii
 Epimedium violaceum
 Mahonia Aquifolium
FUMARIACEÆ :
 Fumaria officinalis
CRUCIFERÆ :
 Alyssum saxatile
 Arabis albida
 procurrens
 Aubrietia deltoidea
 grandiflora
 Capsella Bursa-pastoris
 Cheiranthus Cheiri
 ochroleucus
 Coronopus didyma
 Koniga maritima
 Draba verna
 Erysimum bipinnatifidum
CRUCIFERÆ :
 Erysimum strictum
 Iberis gibraltarica
 sempervirens
 Lepidium procumbens
 Lunaria biennis
 Matthiola incana
POLYGALACEÆ :
 Polygala Chamæbuxus
RESEDACEÆ :
 Reseda Luteola
 odorata
VIOLACEÆ :
 Viola odorata
 palmensis
 tricolor
 b. arvensis
CARYOPHYLLACEÆ :
 Cerastium tomentosum
 viscosum
 Dianthus Caryophyllus
 chinensis
 Lychnis diurna
 Flos-cuculi
 vespertina
 Silene italica
 muscipula
 Spergula arvensis
 Stellaria media
HYPERICACEÆ :
 Hypericum Androsæmum

GERANIACEÆ:
- Erodium tataricum
- Geranium dissectum
- phæum
- Pelargonium zonale

OXALIDACEÆ:
- Oxalis corniculata

RUTACEÆ:
- Ruta graveolens

RHAMNACEÆ:
- Ceanothus africanus

LEGUMINOSÆ:
- Coronilla Emerus
- Indigofera australis
- Lathyrus odoratus
- Lupinus Murrayanus
- nootkatensis
- Medicago arborea
- Orobus cyaneus
- vernus

ROSACEÆ:
- Acæna adscendens
- novæ-zealandiæ
- pubescens
- Alchemilla alpina
- arvensis
- vulgaris
- Aremonia agrimonioides
- Cydonia japonica
- Geum coccineum
- montanum
- pyrenaicum
- Potentilla alba
- alpestris
- Fragariastrum
- nepalensis
- splendens
- stricta
- Rosa gallica
- indica
- Sibbaldia maxima
- Spiræa Filipendula

MYRTACEÆ:
- Leptospermum salicifolium
- Myrtus communis

ONAGRACEÆ:
- Fuchsia gracilis

PORTULACACEÆ:
- Claytonia perfoliata

HAMAMELIDACEÆ:
- Hamamelis virginica

UMBELLIFERÆ:
- Apium graveolens
- Astrantia major
- Dondia Epipactis
- Myrrhis odorata
- Petroselinum vulgare
- Torilis nodosa

ARALIACEÆ:
- Hedera Helix

CAPRIFOLIACEÆ:
- Viburnum Lantana
- Tinus

LORANTHACEÆ:
- Viscum album

VALERIANACEÆ:
- Centranthus macrosiphon

DIPSACACEÆ:
- Scabiosa atropurpurea
- caucasica
- ciliata
- sylvatica

COMPOSITÆ:
- Achillea Millefolium
- Anthemis Cotula
- nobilis
- Aster foliosus
- novæ-angliæ
- novi-belgii
- rigidulus
- Bellis perennis
- Calendula officinalis
- Calimeris hispida
- Centaurea montana
- Cnicus atropurpureus
- Doronicum caucasicum
- Eurybia Gunniana
- Gazania rigens
- uniflora
- Helichrysum arenarium
- Lapsana communis
- Leontodon Taraxacum
- Matricaria inodora
- Parthenium
- Petasites fragrans
- niveus
- Pyrethrum carneum
- sinense
- Scorzonera hispanica
- Senecio sylvaticus
- viscosus
- vulgaris

Compositæ :
Solidago sempervirens
Sonchus oleraceus
Tanacetum multiflorum
Campanulaceæ :
Campanula grandis
suaveolens
Ericaceæ :
Andromeda floribunda
polifolia
Calluna vulgaris (*rubra* et *alba*
Dabœcia polifolia
Erica ciliaris
cinerea
herbacea
mediterranea hibernica
Mackaiana
stricta
Tetralix
vagans
Phyllodoce cœrulea
empetriformis
Rhododendron atrovirens
Nobleanum
Aquifoliaceæ :
Ilex Aquifolium
Jasminaceæ :
Jasminum nudiflorum
Apocynaceæ :
Vinca major
minor *single* and *double*
Gentianaceæ :
Gentiana acaulis
Polemoniaceæ :
Leptosiphon androsaceus
Phlox Drummondii
verna
Polemonium pulchellum
Boraginaceæ :
Anchusa sempervirens
Omphalodes verna
Symphytum caucasicum
tauricum
Scrophulariaceæ :
Antirrhinum majus
Calceolaria perfoliata
Linaria Cymbalaria
Linariæ :
Linaria tristis
versicolor
Linariæ :
Pentstemon gentianoides
Scrophularia annua
nodosa
vernalis
Verbascum cashmeriense
Veronica agrestis
aggregata
Andersonii
Buxbaumii
decussata
montana
salicifolia
Labiatæ :
Lamium album
lævigatum
maculatum
purpureum
Marrubium vulgare
Nepeta Cataria
incana
Micromeria græca
Prunella origanifolia
Salvia obovata
Sideritis syriaca
Teucrium Arduini
Scorodonia
Primulaceæ :
Primula Auricula
denticulata
elatior and vars. (Polyanthus)
veris
vulgaris
Verbenaceæ :
Verbena Tweediana
Plumbaginaceæ :
Armeria pseudo-armeria
pubescens
Statice latifolia
Polygonaceæ :
Rumex Acetosella
acutus
Thymelæaceæ :
Daphne pontica
Euphorbiaceæ :
Buxus sempervirens
Euphorbia Peplis
Urticaceæ :
Parietaria officinalis
Urtica urens

CORYLACEÆ :
Alnus cordifolia
Corylus Avellana
GARRYACEÆ :
Garrya elliptica
CONIFERÆ :
Cryptomeria japonica
Cupressus Lawsoniana
Thuja plicata
TAXACEÆ :
Cephalotaxus Fortuni
Taxus baccata
IRIDACEÆ :
Iris tenax
Sisyrinchium anceps
grandiflorum
AMARYLLIDACEÆ :
Galanthus nivalis
Alstrœmeria aurantiaca
LILIACEÆ :
Muscari racemosum
Tritoma media
NAIADACEÆ :
Aponogeton distachyum
CYPERACEÆ :
Carex muricata
paniculata
Scirpus Holoschœnus
GRAMINEÆ :
Arrhenatherum avenaceum
Gynerium argenteum
Holcus lanatus
Knappia agrostidea
Lagurus ovatus
Lolium perenne
Panicum capillare
Poa annua
nemoralis = 245

The following Ferns were also in fructification :—

Asplenium Ruta-muraria
Blechnum boreale
Lastrea dilatata
Filix-mas cristata
rigida
Polypodium vulgare
Polystichum acrostichoides
Lonchitis
Scolopendrium vulgare = 9

NOTE.—Up to 4th February the only other plants in flower have been the following :—24th January—*Nordmannia cordifolia.* 2d February—*Galanthus plicatus.* 11th February—*Leucojum vernum.*

The state of vegetation in December was much influenced by the nature of the weather during the preceding months of October and November. No marked check was given to it during these months, and the temperature was such as to stimulate the action of the cells and vessels of the plants. In December the comparatively high temperature continued. I have asked my friend, Mr Alexander Buchan, Secretary of the Scottish Meteorological Society, to draw up for me a tabular view of the temperature of the three months during the last seven years. I have supplied the lowest daily temperatures, as observed in the Botanic Garden; and for want of sufficient data in the garden, he has selected for the other data a station in Fife (Balfour) where the temperatures in general resemble much those noticed at the Botanic Garden. (I hope to be able to make arrangements in future for a full series of thermometrical, barometrical, and hygrometrical observations being made at the Botanic Garden.)

1. *Mean Temperatures at Balfour, in Fife, in the months of October, November, and December, during seven years ending with* 1863. *A comparison of* 1863 *with the Means of the previous six years is also given.*

YEAR.	OCTOBER.			NOVEMBER.			DECEMBER.		
	Mean of Day.	Mean of Night.	Mean Temp.	Mean of Day.	Mean of Night.	Mean Temp.	Mean of Day.	Mean of Night.	Mean Temp.
1857	54·0	41·8	47·9	48·1	36·0	42·0	48·7	39·0	43·8
1858	50·8	38·3	44·5	45·0	33·8	39·4	43·3	33·9	38·6
1859	51·7	39·9	45·8	42·8	32·7	37·8	38·1	30·8	34·4
1860	52·7	42·1	47·4	42·5	37·6	40·0	36·3	29·0	32·6
1861	55·4	43·7	49·6	43·7	34·0	38·8	41·2	32·8	37·0
1862	54·3	41·1	47·7	42·9	30·6	36·8	46·2	38·6	42·4
Mean of 1857–62	53·2	41·1	47·2	44·2	34·1	39·1	42·3	34·0	38·1
1863	53·6	42·5	48·0	49·4	37·3	43·4	46·6	36·5	41·6
Excess of 1863 over the Mean of the previous 6 years . .	0·4	1·4	0·8	5·2	3·2	4·2	4·3	2·5	3·5

II. *The Highest Temperature of the Day observed at Balfour, in Fife, in each week of the three months October, November, and December, during seven years ending with* 1863.

YEAR.	OCTOBER.					NOVEMBER.				DECEMBER.						
	1	8	15	22	29	5	12	19	26	3	10	17	24	Oct.	Nov.	Dec.
1857	63·0	56·0	59·5	56·0	57·0	51·0	51·5	52·5	54·0	56·0	50·5	53·5	51·5	63·0	57·0	56·0
1858	61·0	59·0	51·5	54·0	52·0	47·0	46·0	46·0	56·0	52·0	45·0	50·5	46·5	61·0	56·0	54·0
1859	65·6	61·1	57·6	39·6	45·9	51·6	47·9	46·4	45·6	46·5	45·4	40·1	43·6	65·6	51·6	46·6
1860	60·1	56·6	55·6	59·1	48·6	47·6	46·6	45·1	45·6	45·1	44·6	37·6	36·1	60·1	48·1	45·6
1861	59·6	63·6	56·1	59·6	50·6	49·6	44·6	51·6	54·6	44·6	54·1	47·6	41·6	63·6	54·6	54·6
1862	65·6	65·1	59·6	55·6	54·6	47·6	46·1	43·1	44·1	52·6	49·6	51·6	49·6	65·6	54·6	52·6
1863	61·0	57·0	58·0	58·0	55·0	47·5	56·0	57·0	58·0	52·0	53·0	55·0	50·5	61·0	58·0	55·0

III. *The Lowest Temperature of the Night observed at Balfour, in Fife, in each week of the three months October, November, and December, during seven years ending with* 1863.

YEAR.	OCTOBER.					NOVEMBER.				DECEMBER.						
	1	8	15	22	29	5	12	19	26	3	10	17	24	Oct.	Nov.	Dec.
1857	31·0	44·0	42·0	31·0	31·0	32·5	33·0	26·0	26·0	36·0	36·0	33·0	28·0	31·0	26·0	28·0
1858	35·0	34·5	33·0	30·0	30·0	31·5	28·0	22·0	36·0	26·5	25·0	31·5	31·0	30·0	22·0	25·0
1859	41·3	38·5	29·5	24·5	24·3	24·5	27·5	29·5	28·5	26·5	23·5	15·0	26·5	24·3	24·5	15·0
1860	41·5	30·5	40·0	39·0	37·5	38·5	27·5	26·5	30·0	39·5	30·5	18·0	1·5	30·5	26·5	1·5
1861	36·0	37·5	34·0	35·5	31·5	25·5	23·5	22·5	25·5	29·0	31·5	26·5	22·5	32·5	22·5	22·5
1862	34·5	37·0	36·5	35·0	29·0	27·0	20·5	20·5	22·0	35·5	33·0	34·5	31·5	29·0	20·5	31·5
1863	29·5	45·5	40·0	34·0	28·5	26·5	32·5	35·0	30·0	31·0	38·5	30·0	23·5	29·5	26·5	23·5

IV. *Number of Nights each Week on which the Thermometer, exposed in the Botanic Garden, four feet above the ground, fell to freezing* (32·0). *An asterisk* (*) *is put to indicate the nights on which it fell to at least* 6·0 *below freezing.*

Year.	October.					November.				December.			
	1	8	15	22	29	5	12	19	26	3	10	17	24
1857	1		1				1	*3	2				2
1858				*4		5	*5	*6		2	*5	1	
1859			*2	*5	*3	*2	4	*3	*5	3	*5	*6	6
1860		2			*3	4	*4	*2	*2		3	*7	*7
1861			2		3	*5	*3	*3	*2	1	1	*4	*7
1862					2	5	*6	*7	*5			1	
1863	1			2	*4	*4	1	1	*5	3		3	*5
Lowest each week in 1863, . .	28·0	40·0	35·0	31·0	26·0	23·5	27·0	32·0	26·0	30·0	35·0	25·0	19·0

Report on the Weather of October, November, and December 1863, *as compared with the previous Six Years.* By Mr Alexander Buchan.

The first three tables present a detailed statement of the temperature in October, November, and December, during the seven years ending with 1863, as observed at Balfour, near Markinch, in Fife, one of the stations of the Scottish Meteorological Society. It is the nearest station to Edinburgh at which full and well-authenticated observations on temperature have been made for so long a period, and, besides, its position is such as to represent fairly both sides of the Forth.

Table I. gives the mean monthly temperature of the day and of the night, and the mean temperature of these months for the past seven years, and a comparison of 1863 with the means of the previous six years. From this Table, we learn that the peculiar features of the weather of October, November, and December last, as respects temperature, were as follow :—

In *October*, the mean temperature was nearly a degree (0°·8) above the average of the month ; but whilst the mean temperature of the day was less than half a degree (0°·4), that of the night was about a degree and a-half (1°·4) above the average, thus indicating a cloudy sky and comparative absence of frost. At the Botanic Garden, the thermometer fell only three times to freezing, the lowest being 28°·0 on the night of the 6th. This frost continued but for a short time, and very little damage was done except to Heliotropes; dahlias were only slightly affected.

In *November*, the mean temperature was 4°·2 above the average, which increase was very unequally distributed between day and night,—the mean temperature of the day being 5°·2, and of the night only 3°·2 above the mean of the month. This temperature is not only greatly above the average, but it is also about a degree and a-half higher than any previously recorded November, and 6°·6 higher than the November of 1862.

In *December*, the mean temperature was 3°·5 above the average, and the manner of its distribution between day and night similar to November,—the mean of the day being 4°·2, and of the night 2°·5 above the average.

Hence the characteristic feature of the weather of this period is the unprecedentedly high temperature during the day in November and December,—a point to which special attention is directed.

Table II. gives the highest temperature of the day, and Table III. the lowest temperature of the night, in each week of the period under consideration.

Table IV. gives the number of nights each week on which the temperature at the Botanic Garden fell to freezing or lower, and an asterisk is put to mark those cases when it fell to at least 6°·0 below freezing.

These tables furnish the data from which an explanation may be had of the remarkable vegetation of December last, in so far as that depended on the character of the then current weather. The explanation is twofold—*first*, the high temperature during the day in November and December; and, *secondly*, the comparative absence of frost during the night.

This remarkably high temperature was preceded by a period of cold weather, extending from the 29th of October to the 12th of November, during which frosts were of frequent occurrence. At Balfour the thermometer, four feet above the ground, and protected, fell to 26°·5; and at the Botanic Garden, four feet above the ground, but exposed, it fell to 23°·5, and indicated freezing on ten nights. Though dahlias and other plants were destroyed, yet many survived, owing, it is supposed, to the remarkably dry state of the weather, and to the very brief periods during which the severity of the cold in each instance lasted. This cold period also contributed to the remarkable growth which followed, since by playing the part of winter, though in a modified degree, it arrested the vital functions, and gave plants the benefit of a fresh start with the warmth which succeeded.

The unprecedentedly high temperature began on the 13th of November, and continued with scarcely any interruption till Christmas: see Table II. Of this period the warmest part extended from the 13th of November to the end of the month, during which the mean temperature of the day was 52°·5, or 9°·0 above the average. This day temperature usually prevails about the end of April or beginning of May, when the temperature of the night is much lower than obtained in November last.

In the end of November and beginning of December (see Tables III. and IV.), the temperature of the night declined occasionally to freezing. At Balfour it fell to 30°·0, and at the Botanic Garden (exposed) to 26°·0,—a degree of frost insufficient to damage those autumn flowers which had stood the more severe frost in the beginning of November, or check the growth of the spring flowers rapidly coming into bloom.

This anomalous weather sufficiently accounts for the strange spectacle of *sweet peas* and *Hepaticas* blooming together.

The following Candidates were then balloted for, and elected Fellows of the Society:—

Rev. Daniel F. Sandford.
Robert S. Wyld, Esq., W.S.

The following Donations to the Library were announced:—

A Brief Memoir of the late Mr Thackeray. By James Hannay, Esq., author of "Singleton Fontenoy, R.N.," "Essays from the Quarterly," &c. 8vo.—*From the Author.*

Conspectus criticus Diatomacearum Danicarum. Kritisk oversigt over de Danske Diatomeer af Dr Phil. P. A. C. Heiberg. 8vo.—*From the Author.*

Monthly Notices of the Astronomical Society. Vol. XXIV. No. 2. 8vo.—*From the Society.*

The Journal of the Chemical Society. December 1863, January 1864.—*From the Society.*

Leeds Philosophical and Literary Society. Annual Report for 1862–3. 8vo.—*From the Society.*

Monthly Return of the Births, Marriages, and Deaths registered in the Eight Principal Towns of Scotland. December 1863. 8vo.—*From the Registrar-General.*

The Relations of Science to Modern Civilisation. By Professor H. Hennessy. 8vo.—*From the Author.*

Jahresbericht über die Fortschritte der Chemie, etc. Von H. Kopp u. H. Will, für 1862. Erstes Heft. 8vo.—*From the Authors.*

Proceedings of the Royal Horticultural Society. January 1864. 8vo.—*From the Society.*

Essays on Digestion. By Dr J. Carson. 8vo.—*From the Author.*

Memorie Botaniche. Presentate alla R. Accademia delle Scienze Fisico-Matematiche, anno 1862. 4to.—*From the Society.*

Proceedings of the Royal Society. Vol. XIII. No. 59. 8vo.—*From the Society.*

Edinburgh Astronomical Observations. Vol. XII. 4to.—*From the Royal Observatory; forwarded by the Astronomer-Royal for Scotland.*

Monday, 15*th February* 1864.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1. On the Influence of the Refracting Force of Calcareous Spar on the Polarization, the Intensity, and the Colour of the Light which it Reflects. By Sir David Brewster, K.H., F.R.S.

In the "Philosophical Transactions" for 1819, the author had shown that the doubly refracting force of calcareous spar extended beyond the sphere of the reflecting force, producing a change in the polarising angle varying with the inclination of the incident ray to the axis of the crystal, and producing a deviation of the plane of polarisation from the plane of incidence and reflexion, when the reflecting force of the crystal was reduced by contact with oil of cassia and other oils. These experiments were made on the face of the primitive rhomb.

In the present paper, the author gives an account of the results which he obtained upon other natural and artificial faces of calcareous spar, inclined 0°, $5\frac{1}{2}$°, 12°, $22\frac{1}{2}$°, $67\frac{1}{2}$°, and 90°, to the axis of the crystal. On all these surfaces, when the reflecting force is reduced by contact with oil of cassia or other oils and fluids, the intensity and colour of the reflected pencil, and the deviation of the plane of polarisation from the plane of reflection, experiences remarkable changes, depending on the inclination of the incident ray to the axis of double refraction.

2. On the Most Volatile Constituents of American Petroleum. By Edmund Ronalds, Ph.D.

It was shown by this paper that the gases dissolved in American petroleum, and which gave to it such a high degree of inflammability, were composed of the lower members of the marsh gas series, having the general formula,

$$C_n\ H_{2n+1},\ H,$$

and to which the liquid products have already been referred.

The gases evolved from the Pennsylvanian oil were collected at a temperature of $-1°$ Cent., as they floated, mixed with air, over the surface of the liquid in the casks in which it is imported into this country and the hydrocarbons were shown by eudiometrical analysis to have the composition of a mixture in nearly equal proportions of the hydrides of ethyl and propyl.

The first portions of incondensible gas evolved on warming the most volatile product of the distillation of petroleum on a manufacturing scale were also found to contain a mixture of these hydrides, while portions of gas collected at a later period of the operation approached more closely to the composition of pure hydride of propyl, or were mixtures of the hydrides of propyl and butyl; the last gas collected being nearly pure hydride of butyl.

The liquid condensed by a mixture of ice and salt during the collection of these gases gave, upon redistillation, a considerable portion boiling between 0° and 4° Cent.; this, as well as that which passed over as high as 6° Cent., was shown by analysis to be nearly pure hydride of butyl having the composition C_4H_9, H.

This liquid has a specific gravity of 0·600 at 0° Cent.; it is consequently the lightest liquid known. Its vapour density was by experiment found to be 2·11. It is colourless, possesses a sweet, agreeable smell, is soluble in alcohol and ether, but not in water. Alcohol of 98 per cent. dissolves between 11 and 12 times its volume of the gas at 21° Cent. The liquid and the gas are not preceptibly affected by sulphuric or nitric acid, nor by bromine; mixed with twice its volume of chlorine in diffuse daylight, the gas is converted into liquid chloride of butyl, while the original three volumes become condensed into two volumes of hydrochloric acid.

3.—On the Action of Terchloride of Phosphorus on Aniline. By Magnus M. Tait, F.C.S.

More than a year since my attention was directed to a statement of Hofmann's, that the action of terchloride of phosphorus on aniline yielded a white substance of crystalline character, as the investigation of this compound so produced seemed likely to be of interest, I began its examination, but circumstances prevented me from completing it at that time. The publication of Schiff's papers, however, on the metal-anilides again drew my notice to the subject, and I considered it a duty to myself to publish the results of my experiments, more especially as the reaction which forms the subject of this paper appears to have escaped the attention of that chemist.

Terchloride of phosphorus was added, drop by drop, to the aniline, which required to be kept cool by ice, as the reaction tends to be of a rather violent character, great heat being produced. In a short time the whole solidified into a soft granular mass, which dissolved readily in water, alcohol, and ether. The mass was dissolved in hot water, and, on cooling, the excess of aniline rose to the surface as an oily layer, and was separated by passing it through a moistened filter. The watery solution was evaporated at ordinary temperatures over sulphuric acid, and when it had reached a syrupy consistence it slowly solidified into a mass of fine needle-shaped crystals, which were the hydrochlorate of a new base, to which I give the name of Phosphaniline.

The crystals were well pressed between folds of filter paper, and then being placed on a filter, were washed with a very small quantity of alcohol and ether; again dissolved, and evaporated as before, the crystals were pure. The substance so obtained dissolves easily in water, alcohol and ether, and is neutral to test-papers. Gently heated, it sublimes, and gives fine prismatic crystals. Treated with solution of potash it is decomposed. Strong sulphuric acid expels hydrochloric acid, and gives a colourless solution. Nitric acid oxidises it, and gives a coloured solution.

On analysis, it yielded the following results:—

	I.	II.	Theory.
Carbon, . .	45·12	...	44·63
Hydrogen, . .	4·94	...	4·34
Phosphorus, .	...	...	
Nitrogen, . .	...	...	
Chlorine, . .	24·82	25·89	25·40

This analysis shows that the substance is produced by the direct union of the chloride of phosphorus and aniline. It is, however, a hydrochlorate, and is formed from three equivalents of aniline, in which three equivalents of hydrogen are replaced by phosphorus: thus—

$$\left.\begin{matrix} C_6\,H_6 \\ C_6\,H_6 \\ C_6\,H_6 \end{matrix}\right\} P''' \left\{\begin{matrix} N \\ N \\ N \end{matrix}\right\} + 3HCl.$$

$$C_{18}\,H_{18}\,PN_3 + 3HCl.$$

Platinochloride of Phosphaniline.—A portion of the original salt was dissolved in water, the solution acidified with hydrochloric acid, and bichloride of platinum added, in a short time crystals began to appear; these, after a sufficient quantity had formed, were placed on a filter and washed with a small quantity of alcohol and ether, and dried over strong sulphuric acid, until their weight was constant. They were in the shape of small granular crystals of a light yellow colour, soluble in alcohol and water, but not in ether. On analysis, the following numbers were obtained:—

	I.	II.	III.	Theory.
Carbon,	23·52	...	...	23·33
Hydrogen,	2·40	...	...	2·35
Phosphorus,	...	...	...	
Chlorine,	...	...	...	
Nitrogen,	...	...	...	
Platinum,	...	32·23	32·73	31·98

The platinum in the third column was estimated by direct ignition, the high result obtained was probably owing to the formation of a little phosphide of platinum.

The analysis corresponds with the following formula :—

$$C_{18}\ H_{18}\ P'''\ N_3\ 3HCl + 3PtCl_2$$

Zincochloride of Phosphaniline.—Hydrochloric acid was added to a portion of the solution of the hydrochlorate in water, and then some fragments of pure zinc were thrown in. After the zinc had dissolved the fluid was evaporated at a gentle heat (about 200° Fahr.), and filtered from a few greenish flakes which had formed, as even that low temperature appears to decompose the salt. The clear fluid was then put over sulphuric acid and left for some days, when crystals of a zinc salt were obtained, but under the same conditions as the hydrochlorate, as the solution was very concentrated before the salt appeared, and then it solidified completely. The crystals were pressed between folds of filter paper, and washed with a mixture of alcohol and ether, and dried in vacuo over strong sulphuric acid. They were white needles, slightly deliquescent, and soluble in alcohol. In ether it does not dissolve, but it becomes liquid, having the same appearance as a drop of oil in water.

The chlorine only was estimated, the analysis gave—

	I.	Theory.
Chlorine, ...	34·57	34·23

which agrees with the following formula :—

$$2\ (C_{18}\ H_{18}\ P'''\ N_3\ 3HCl)\ 3Zn''\ Cl_2$$

Bromine water immediately precipitates a brownish-coloured substance from an aqueous solution of the hydrochlorate. This precipitate was washed with water, and a portion of it boiled for some time, and found to be insoluble in water; but a substance appeared to have volatilized along with the vapour of the water, as the neck of the flask and a glass rod which was held over the mouth of it were covered with white feathery crystals. The fluid was filtered, and, after drying the brown residue, it was put into a beaker covered with filter-paper, and left over a water-bath, when it nearly all sublimed in crystals corresponding to those obtained when attempting to dissolve it. A few of these crystals were dissolved in alcohol and bichloride of platinum added, but no precipitate was formed, and on evaporation the original substance crystallized out. These circumstances indicated the body to be Tribromaniline. The filtrate from the brown substance obtained originally was treated with bichloride of platinum also, but no precipitate forming, it was presumed no bromaniline or bibromaniline had been formed.

Cadmium Salt.—Chloride of cadmium gives, with strong solutions of the hydrochlorate, scaly crystals of a double salt, moderately soluble in water.

Copper Salt.—On adding chloride of copper to a solution of the hydrochlorate, and evaporating over sulphuric acid, small granular crystals of a beautiful green colour are obtained.

Mercury Salt.—If a strong solution of chloride of mercury is added to a concentrated solution of the hydrochlorate, beautiful white scaly crystals precipitate out immediately; but if the solutions are dilute no precipitation takes place, if the solution is now warmed, a crystalline substance is thrown down. This appears the more curious, when it is known that the other salts cannot be heated without decomposition.

When the hydrochlorate is heated with potash the phosphaniline, at the moment of separation, appears to undergo decomposition, for the smell of aniline is apparent even in the cold, but no precipitation takes place, so that phosphaniline must be itself soluble in water. An attempt was made to obtain it in the separate state by acting on the hydrochlorate with oxide of silver, a precipitate of chloride of silver was formed immediately. The filtered fluid was alkaline to test paper; it clearly contained phosphaniline, but on evaporating the fluid it became coloured, owing to the decomposition of the base, which is very changeable, and cannot be obtained in the pure state.

4. On Fermat's Theorem. By Professor Tait.

The author stated that in consequence of Legendre's work, the proof of Fermat's Theorem is reducible to showing the impossibility of

$$x^m = y^m + z^m,$$

when m is an *odd prime*, x, y, z being integers.

Talbot has shown that in this case x, y, z are necessarily *composite* numbers.

The author shows, among other results of very elementary processes, that if numbers *can* be found to satisfy the above equation, x and y leave the remainder 1 when divided by m; and that z has m as a factor. Many farther limitations are given on possible values of x, y, z—the process being based on the consideration of their prime factors, and on Fermat's Elementary Theorem $N^m - N = Nm$.

5. Professor Archer called attention to a curious binocular telescope, bearing the following inscription :—

PETRVS PETRONVS
SAC : CÆS$^{\text{Æ}}$: ET CAT$^{\text{Æ}}$:
MAIES$^{\text{IS}}$: OPTICUS
ME$\overline{\text{D}}$LANI 1726

The eye-pieces and object-glasses, each in a separate tube, worked in a case $15\frac{1}{2}$ inches in length by 5 inches in breadth, and 2 in depth, forming, with the bevelled corners, a flat octagon, covered with a species of shagreen, and mounted in silver. An exceedingly simple and ingenious arrangement, consisting of a double screw working four small arms of brass, was placed at each end for the purpose of regulating the distances between each pair of glasses, and silver dial plates enabled the operator to set the instrument according to his ascertained requirements. The instrument belongs to the Royal Institution of Liverpool, and is supposed tc have been part of a collection of rarities, made by Wm. Roscoe, in Italy. As a telescope, it is of great power; the focus is adjusted by one portion of the case acting as a draw-tube within the other part.

The following Gentleman was elected a Fellow of the Society :—

William Wallace, Ph.D., F.C.S.

The following Donations to the Library were announced:—

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1861. Vol. XXI. 8vo.—*From the Radcliffe Trustees.*

Proceedings of the Royal Society of London. Vol. XIII. No. 60. 8vo.—*From the Society.*

The Classification of Animals based on the Principle of Cephalization.—On Fossil Insects from the Carboniferous Formation in Illinois. By James D. Dana. 8vo.—*From the Author.*

Die Fortschritte der Physik in 1861 dargestellt von der physikal. Gesellsch. zu Berlin, XVII Jahrgang. 1te u. 2te Abtheil. 8vo.—*From the Society.*

Sitzungsberichte der königl. bayer. Academie der Wissenschaften zu München. 1863. II. Heft I. and II. 8vo.—*From the Academy.*

Journal of the Royal Dublin Society. No. XXX. 8vo.—*From the Society.*

Journal of the Royal Asiatic Society. Vol. XX. Parts 3 and 4. 8vo.—*From the Society.*

Journal of the Scottish Meteorological Society. Jan. 1864 (New Series). 8vo.—*From the Society.*

Journal of the Chemical Society, February 1864. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIV. No. 3. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. Feb. 1864. 8vo. —*From the Society.*

Abstracts of Proceedings of the Geological Society of London. Nos. 105 and 106.—*From the Society.*

Otago Provincial Government Gazette. Vol. VI. No. 274. Small folio. Containing Report by Dr James Hector, on the Geological Expedition to the West Coast of Otago, New Zealand.—*From the Provincial Government.*

Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Seriei Tertiæ. Vol. IV. Fasc. II. 1863. 4to.—*From the Society.*

Abhandlungen der königl. Academie der Wissenschaften zu Berlin. Aus dem Jahre 1862. 4to.—*From the Academy.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1863–64. No. 64.

Monday, 7th March 1864.

Professor KELLAND, Vice-President, in the Chair.

The following Communications were read :—

1. On the Gods of the Rigveda. By John Muir, D.C.L., LL.D.

After some preliminary remarks on the common origin of the Indians, Greeks, and Romans,—on the expectation thereby raised that we should find in the earliest literatures of these nations some remains of the primeval mythology which their ancestors must originally have possessed in common,—on the partial fulfilment of this expectation by an examination of these literatures,—and on the greater light thrown by the Rigveda than by any other monument of ancient poetry on the genesis of mythology,—the author adverts to the various theories of creation which would naturally be formed by simple men in the earlier ages of the world, to the manner in which the various great phenomena of nature would come to be ascribed to different deities, and to the diverse aspects in which the grander objects of creation, such as heaven and earth, were viewed, sometimes as inanimate, sometimes as animated and divine. The chief deities mentioned in the Rigveda are then passed under review, and their most remarkable characteristics are described ;— viz. *Dyaus* and *Prithivî* (Heaven and Earth), *Aditi* and the *Adityas*, *Varuna* and *Mitra*, *Indra*, *Vâyu*, the *Maruts*, *Rudra*, *Vishnu*, *Tvashtri*, *Agni*, the *Asvins*, *Soma*, *Yama*, and the various goddesses, *Ushas*, *Sarasvatî*, &c. &c. The writer then sums up the instances of well established coincidence between the Indian and the classical deities, which he considers to be few in number; and concludes by noticing how the most prominent gods of the Rigveda lost much of their importance in the later mythology of India, while two of the deities who hold only a subordinate rank in the Veda—viz. *Vishnu* and *Rudra*—were afterwards exalted to the highest position.

2. On the Diffraction Bands produced by Double Striated Surfaces. By Sir David Brewster, K.H., F.R.S.

Having observed a series of serrated fringes in examining the colours produced by the fibres of the crystalline lens of fishes, the author was led to imitate them by the combination of grooves upon glass and steel surfaces, or of grooves taken from these surfaces upon isinglass or gums.

The interference bands thus produced were serrated or rectilineal, sometimes parallel and sometimes at right angles to the direction of the grooves, and varying in their magnitude and character according as they were exhibited on the colourless image, or on the diffracted spectra, or as they were produced at different angles of incidence, or at different distances of the grooved surfaces, or by different numbers of reflexion, or by different numbers and combinations of refracting and reflecting surfaces.

The grooves on glass employed by the author were executed by the late Mr George Dollond, and those on steel, varying from 315 to 10,000 in an inch, by the late Sir John Barton.

3. An Essay on the Theory of Commensurables. By Edward Sang, Esq.

The subject of this essay may be described as an application of the Theory of Number to Geometry, its principal or characteristic problem being to determine under what conditions the sides or surfaces of figures may be represented by integer numbers.

Like all other inquiries into the properties of integers, it is rather speculative than practical, and yet, perhaps on that very account, is more apt to engross the attention of its cultivators than almost any other department of pure mathematics. It seems, indeed, to be of very little moment whether we can demonstrate that the sum of two cubes never can be a cube; and yet one after another of the most eminent mathematicians have tried, and, though foiled, have again and again essayed the proof of Fermat's negation. So it may also appear to be a matter of indifference whether or not we can construct a four-sided figure which may have its four sides, and also its two diagonals, all integer multiples of the linear unit; and yet such inquiries present to the mathematician attractions sufficiently powerful to balance those of more practical investigations.

Nor is the labour bestowed on the cultivation of such subjects altogether or in any degree lost, since the various branches of science are so interwoven, that we cannot improve our acquaintance with one without augmenting our knowledge of those allied to it.

The first part of the paper is occupied with the subject of the orthagonal trigon, and is a collection of previously known propositions, the novelty, if any, being in the arrangement.

The second powers of numbers form the only exception to Fermat's Theorem; the sum of two squares may be a square number; that is to say, the equation

$$a^2 + b^2 = c^2$$

is possible in integer numbers; or, in other words, the altitude, the base, and the hypotenuse of a right-angled trigon may all be expressed in integers.

Among the remarkable properties of these Pythagorean numbers, as they are often called, are that, when in the lowest terms, one or other of the two sides is divisible by 3; that one or other of the two sides is divisible by 4; and that one of the three is divisible by 5. These three propositions are all exemplified in the well-known solution,

$$3^2 + 4^2 = 5^2.$$

It is also a very singular property, that the hypotenusal number can never be a multiple of 7, of 11, of 19, or, in general, of any prime number of the form $4n - 1$, unless the other also be so; and thus that no prime number of that form can ever be a divisor of the hypotenuse when the trigon is in its lowest terms.

And as a companion, we have this other property, that every prime number of the form $4n + 1$, and every product of such prime factors, may be the hypotenuse of a right-angled trigon.

This part of the subject is completed by a table showing every form of right-angled trigon, having its sides expressed in integer numbers, with the hypotenuse under 1000.

In the second part of the paper, the properties of the angles of such right-angled trigons are investigated: to these angles the name *muarif* is given, and their values are entered opposite each of the trigons in the above-mentioned table. Muarif angles are defined to be those which have their sines and cosines rational; and it is shown that the sines and cosines of the sum, or difference of two muarif angles, are also rational, this property being analogous to the arithmetical proposition, that the product of the sum of one pair of squares by the sum of another pair, is also the sum of two squares.

This property of muarif angles is then applied to the demonstration of various theorems, and to the solution of several problems. In the first place, it is shown that if a trigon be constructed with two of its angles muarif, the three sides, the three altitudes, the radius of the circumscribing circle, and the radii of the four circles of contact, are all commensurable, while the area also is commensurable with their squares.

This proposition is then extended thus: that if at the ends of any line assumed as a base, muarif angles (in any number) be made, the sides of these extended indefinitely intercept segments, which are all commensurable with the base, and include areas which are all commensurable with the square of the base.

And, farther, that the same property is extended to the sides of all muarif angles made at any of the intersections of the above-mentioned lines.

Also, it is shown that if a straight line be drawn to touch a circle, and if at the point of contact any number of muarif angles be made, if the extremities of the chords thus formed be joined, and if tangents be applied at those extremities, all the lines being continued indefinitely, then all the intercepted distances are commensurable with the diameter, and all the areas with the square of the diameter.

It is then shown how to construct a muarif angle which may approximate with any required degree of precision to a given angle, and thence how to find a rational trigon approximating to a given shape.

The solution is also extended to this more general problem: having given any polygon inscribed in a circle, to find another approximating to it, and having its sides commensurable with the diameter, and its area with the square of the diameter.

Afterwards, it is shown how to construct a trigon having its sides and the lines bisecting its angles all rational.

In the third part of the paper the construction of polygons having their sides, and also the ordinates of their corners integer, is discussed.

The only regular polygons which can be used to cover surface are the *trigon*, the *tetragon*, and the *hexagon*. Of these the regular tetragon or square is the one in common use for the measurement of surface; but, viewing the matter abstractly, we may as well measure surface by triangular inches as by square inches. Since the regular hexagon contains exactly six regular trigons, it follows that, as far as the doctrine of commensurables is concerned, there are only two possible systems of surface measurement,—viz., That with the square, and that with the equilateral trigon as the superficial unit.

The fourth section of the paper is occupied in discussing the trigonal system of measurement. Just as the right-angled trigon is the guide to the theory of tetragonal commensurables; the trigon having an angle of 120° is the guide to the theory of trigonal commensurables. The leading property of such a trigon is, that the square of the subtense exceeds the squares of the two containing sides by their rectangle; but this is an enunciation in tetragonal language: stated appropriately it is this, that the equilateral trigon constructed on the subtense, is equivalent to those on the two sides together with the original trigon; for in this system, the surface of an equilateral trigon represent the second power of a number, and that of a trigon of 120° (or 60°) the product of two numbers. The arithmetical representative of such a trigon is

$$a^2 + ab + b^2 = c.$$

When the trigon is in its lowest terms, that is, when a, b and c have no common divisor, c cannot be divisible by 2, by 3, by 5, by 11, or in general by any prime number which is not of the form $6n+1$, and conversely, it is shown that every prime number of the form $6n+1$, and every product of such primes, may represent the subtense of 120°, the other sides being rational.

It is worthy of remark, as a notable relation between the properties of numbers and those of surface, that 4 and 6 are the only moduli which separate prime numbers into two classes; all primes, with the exception of 2, being of one or other of forms $4n-1$ and $4n+1$; while, excepting 2 and 3, all belong either to the form $6n=1$ or to $6n+1$. Four squares may lie round a point, and the form $4n+1$, includes all the hypotenuses of right-angled trigons; six equilateral trigons lie round a point, and the form $6n+1$ contains all the subtenses of 120° or of 60°.

A list is given of trigons of 120°, in the lowest terms, of which the subtense does not exceed 1000, accompanied by the value of the smaller angle.

This leads to the recognition of *muarif angles* of the trigonal system, possessing properties analogous to those of the common or tetragonal system.

Thus, if at the extremities of any base trigonal muarif angles be made, all the segments into which the sides of these angles cut each other are commensurable with the base, and all the areas with its equilateral trigon.

And similarly, if at the point of contact of a straight line and circle, trigonal muarif angles be made, if the extremities of the chords be joined, and if tangents be applied at those extremities, all the segments so formed are commensurable with the side, and all the areas with the area of the circumscribed regular trigon; and it may be remarked that in the trigonal system, the inscribed trigon is commensurable with the circumscribed, whereas the inscribed square is incommensurable with the circumscribed.

The existence of these two distinct, yet analogous systems of muarif angles, naturally suggests the inquiry, whether there may not be other systems as well.

The fifth section of the paper treats of muarif systems in general; it shows that if a trigon be constructed with sides, proportional to any three integers whatever, its angles belong to a system of muarif angles possessing properties analogous to those of the two preceding systems, the assumed trigon, or any other one of the system, becoming the unit of surface.

It is also shown that no angle of one can be equal to that of any other muarif system, with the exception of 180° which belongs to all systems.

The general character of a muarif angle is, that its cosine is rational; the value of its sine may or may not involve the square root of an unsquare number; if the sine be rational, the angle belongs to the tetragonal system; but if otherwise, the irreducible surd involved in the expression for the sine becomes the *modulus* or *mastar* of the system, and all angles having the same irreducible surd in the values of their sines, the cosines being rational, belong to the same system.

The modulus of the common or tetragonal system is thus $\sqrt{1}$, that of the trigonal system is $\sqrt{3}$; while the modulus of any other system is the irreducible surd in the common expression for the area of any trigon belonging to it.

The sixth and last section of the paper contains a few miscellaneous propositions. The first group of problems are cases of this general one, "To construct a trigon, of which the three sides and the lines dividing one or more of the angles into equal parts may be all commensurable."

When only one angle is proposed to be divided, or when two angles are to be divided, we can assume these as the proper multiples of muarif angles of any system whatever; but when the three angles are to be divided, we find ourselves restricted in the choice of the system.

Thus, if we wish that the lines bisecting each of the angles be rational, we must use the common or the tetragonal system, because the half of 180° belongs to it. While, if we wish that the lines trisecting the three angles be all rational, we must take the trigonal system, because the third part of 180° is among its angles.

And it is remarkable that we cannot construct a trigon of which the sides and the lines dividing its angles into any other number of equal parts than two and three, may be all rational, because no aliquot part of the half revolution except the half and the third can belong to any muarif system.

P.S.—Since the paper was read, a treatise by Professor Gill of New York, on the "Application of the Angular Analysis to the

Solution of Indeterminate Problems," has been shown to me. In this excellent work the properties of the muarif angles of the tetragonal system are given; and as there is no hint concerning the higher systems of these angles, my impression is confirmed that this part of the subject is entirely new.

4. On Superposition, No. II. By Professor Kelland.

5. On Centrobaric Bodies. By Professor W. Thomson.

(*Abstract by Professor Tait.*)

This is an abstract of an investigation which will be published in full in "Thomson and Tait's Natural Philosophy." It contains the application of Green's wonderful results regarding the potential to the determination of the centre of gravity of a system when there is such a point. Some of the more remarkable propositions, which are thus established are as follows:—

If the action of terrestrial or other gravity on a rigid body is reducible to a single force in a line passing always through one point fixed relatively to the body, whatever be its position relatively to the earth or other attracting mass, that point is called its *centre of gravity*, and the body is called a *centrobaric body.*

If a body is centrobaric relatively to any one attracting mass, it is centrobaric relatively to every other; and it attracts all matter external to itself as if its own mass were collected in its centre of gravity.

The centre of gravity of a centrobaric body necessarily lies in its interior; or, in other words, can only be reached from external space by a path cutting through some of its mass.

No centrobaric body can consist of parts isolated from one another, each in space external to all; in other words, the outer boundary of every centrobaric body is a single closed surface.

A given quantity of matter may be distributed in one way, but in only one way, over any given closed surface, so as to constitute a centrobaric body with its centre of gravity at any given point within it.

Matter may be distributed in an infinite number of ways throughout a given closed space, to constitute a centrobaric body with its centre of gravity at any given point within it.

The moments of inertia of a centrobaric body are equal round all axes through its centre of inertia. In other words, all these axes are principal axes, and the body is kinetically symmetrical round its centre of inertia.

The following Gentleman was elected a Fellow of the Society:—

Professor Robert Dyce, M.D., Aberdeen.

The following Donations to the Library were announced:—

Insanity and Crime: a Medico-Legal Commentary on the Case of George Victor Townley. By the Editors of the Journal of Mental Science. 8vo.—*From the Authors.*

Pinetum Britannicum. Part V. *Picea Apollinis; Pinus Jeffreyii.* Folio.—*From Charles Lawson, Esq.*

Royal Geographical Society's Proceedings. Vol. VIII. No. 1 8vo.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages, registered in the Eight Principal Towns of Scotland. January 1864. (With Supplement for 1863.) 8vo.—*From the Registrar General.*

Journal of the Asiatic Society. Nos. 3 and 4. 1863. 8vo—*From the Society.*

Quarterly Journal of the Geological Society. No. 77. 8vo.—*From the Society.*

Verhandlungen der schweizerischen naturforschenden Gesellschaft bei ihren Versammlung zu Luzern den 23, 24, u. 25. Sept. 1862. 8vo.—*From the Society.*

Quarterly Return of the Births, Deaths, and Marriages, registered in the Divisions, Counties, and Districts of Scotland. No. 36. (With Supplement.) 8vo.—*From the Registrar General.*

Proceedings of the Royal Horticultural Society. Vol. IV. Nos. 2–4. (With Index to Vol. III.) 8vo.—*From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool. No. 17. 8vo.—*From the Society.*

Journal of Agriculture. March 1864. 8vo.—*From the Highland and Agricultural Society.*

American Journal of Arts and Sciences. Jan. 1864. 8vo.—*From the Conductors.*

Proceedings of the Royal Society. No. 61. 8vo.—*From the Society.*

Magnetical and Meteorological Observations made at the Government Observatory, Bombay. 1861. 4to.—*From the Government.*

Abhandlungen herausgegeben von der senckenbergischen naturforschenden Geselschaft. Band V. Heft. 1. 4to.—*From the Society.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München. 1863. II. Heft. III. 8vo.—*From the Akademie.*

Budapesti Szemle, Szerkeszti és Riadja Csengery Antal. XLI—LVII Füzet. 8vo.—*From the Society.*

Magyar Akademiai Értesítō. II. and III. 1–2. 8vo.—*From the Academy.*

Mathematikai s Természettudományi Közlemények Vonatkozólag a Hazai Viszonyokra. II. 8vo.—*From the same.*

De Finibus ultimis Nervorum Muscularium. Autore Th. Margó, Professore Universitatis Pestanæ. 4to.—*From the same.*

Phænomena continentalis elevationis et depressionis partis Europæ inter Orientem et Meridiem sitæ in Epocha Geologis "deluviali" dicta. Autore Josepho Szabó, Professore Universitatis Pestanæ. 4to.—*From the same.*

Monday, 21st March 1864.

The Hon. Lord NEAVES, Vice-President, in the Chair.

The Secretary announced that the Council had awarded the Keith prize for the biennial period 1861-63, to Professor William Thomson, of Glasgow, for his communication entitled "On some Kinematical and Dynamical Theorems."

The following Communications were read :—

1. On the Anatomy and Physiology of the Mitral, Tricuspid, and Semilunar Valves in Mammals, Birds, Reptiles, and Fishes. By James B. Pettigrew, M.D., Edinburgh; Assistant in the Museum of the Royal College of Surgeons of England. Communicated by Wm. Turner, M.B.

The writer begins his communication by giving a brief description of the structures in which valves are found, and takes occasion to comment on the nature and properties of the veins and arteries, and on the arrangement of the muscular fibres in the ventricles, as these necessarily influence, to a greater or less extent, the action of the valves. He also adverts at some length to the shape of the venous, arterial, and auriculo-ventricular orifices, and to the fibro-cartilaginous rings by which the latter are surrounded; as well as to the dilatations or sinuses which are found behind or to the outside of the segments constituting the semilunar valves in the veins and arteries, and to the shape of the ventricular cavities, which, as he points out, bear an important relation to the valves, inasmuch as they determine the direction in which the blood acts upon them; precise information on these points being, according to the author, indispensable to a just appreciation of the subject under investigation.

The object of the Memoir is to prove that in the valves, as in other structures where modifications occur, we rise from the simple to the more complex; in other words, that the valves form a differentiated and gradually ascending series.

In the veins, *e. g.*, the valve consists of a doubling of the delicate membrane lining the vessel, containing some fibro-cellular and elastic tissue, the distribution of which in the horse can be readily made out. The segments of the valve are semi-transparent, and, as a rule, semilunar in shape. They are further placed obliquely, one only being present in the smallest veins, two in the middle-sized ones, and three in the largest. Behind each segment there is a dilatation or bulging of the vessel, which projects nearly as far in an outward direction as the segment extends inwardly, and gives to the latter the requisite degree of curvature. As the dilatation referred to enables the lining membrane which forms the segments to project boldly, and almost transversely, into the vein, it follows that the free margins of the segments run for a certain distance in a nearly parallel direction, the parallelism being maintained by the presence of a fibrous structure,* which projects from the wall of the vessel, and not only supports the free margins, but carries them fairly away from the sides into the interior. This relation of the dilatations to the segments, and of the segments to each other, has not hitherto been recognised, and shows that the union between the latter is not one of the margins simply, as has been supposed, but of the margins and a considerable portion of the sides; the sides of the segments, on account of the angle at which they are set with reference to each other, being more and more involved in proportion to the amount of pressure which is brought to bear upon them. The object of the dilatations is evidently threefold—1*st* (as has been stated), To allow the free margin of the segments to project into the interior, and maintain a position with reference to each other which necessitates their coming rapidly and naturally together; 2*dly*, To increase the space occupied by the blood, and thereby extend the area, and the amount of pressure to which the segments are subjected; and, 3*dly* (which is the most important), To determine the direction in which the blood shall act, that being from above downwards, and from without inwards. The effect of this arrangement on the segments is very obvious; these, when two exist, being forced together in the mesial plane of the vessel, where they mutually support each other; and when three are present, in the axis of the vessel. In the latter case, the segments (from the more or less conical shape assumed by their free margins while in action, and from the fact of their apices being free to move) rotate to a greater or less extent, while in the act of fixing or closing—the closure being effected by a combined wedge and spiral movement.† In the veins the closing of the valves may be regarded as purely mechanical, this being due not to any active power residing in the segments, but to the pressure exerted upon them by the blood, and to the vital contractility residing in the

* The structure adverted to is very well seen in the arterial semilunar valves.

† The spiral wedging movement is especially distinct in the segments of the arterial semilunar valves.

veins, which tends to urge the segments together, while it assists the onward flow of the blood. In the arteries, as, *e. g.*, at the origin of the pulmonary artery and aorta, the segments of the valve are of a semilunar shape, and always three in number. They consist of a doubling of the lining membrane, and contain within their fold certain tendinous bands which run in well-marked directions; the structure closely resembling that met with in the auriculo-ventricular or highest form of valve.* The cusps, moreover, are semi-opaque, stronger, and more ample than in the veins.

In the arteries the dilatations behind the segments, commonly called the Sinuses of Valsalva, are very large, and, as the author has ascertained, curve towards each other in such a manner as ensures that the blood will act upon the segments only in certain directions: in fact, that they will be urged by it towards each other, and fixed by a distinctly spiral wedging movement; the margins of the segments flattening themselves against each other whilst in action, and forming an inverted tripartite dome, the strength of which is limited only by the strength of the materials used in its construction. The action of the arterial semilunar valves may also be considered mechanical, the inconvenience which might be supposed to result from an excess of vital contractility in the arteries and ventricles, between which the valves are situated, being counteracted by the existence at this point of comparatively unyielding fibro-cartilaginous rings. Strongly contrasting with the arterial semilunar valves in mammals whose area of activity is, so to speak, circumscribed, are the semilunar valves situated within the bulbus arteriosus of fishes, which is an actively contracting structure. In these cases the segments, as a rule, are more numerous than in the veins and arteries, and arranged in tiers, so that the blood which is not caught by one tier falls into and is supported by the next. The number of segments, moreover, obviates the evil effects which might accrue from the displacement to which they are subjected by the contraction of the bulb.

In the semilunar valves of fishes we find the first trace of what may be regarded as chordæ tendineæ, in the shape of tendinous

* The arrangement of the tendinous bands in the semilunar and auriculo-ventricular valves, and the structure generally, is described at length.

bands which run between the segments and afford a certain degree of support. The action of the valves in fishes is partly mechanical and partly vital, for we must regard the contraction of the bulb as contributing to the closure. In the auriculo-ventricular valves of mammals, birds, reptiles, and fishes, we have a great variety. These valves are characterised by the presence of tendinous chords (chordæ tendineæ) which connect them with actively contracting muscular structures; as, the interior of the ventricles or the structures arising therefrom—viz., the carneæ columnæ and musculi papillares. They therefore differ from the semilunar valves proper. In the auriculo-ventricular valves there is also gradation. In some instances, *e.g.*, there is only one semilunar flap or segment; in a second there are two flaps or segments, so arranged *that their long diameters correspond to the direction of the muscular fibres with which they are connected directly.* In a third, the two segments are attached to the interior of the ventricle *by rudimentary chordæ tendineæ.* In a fourth, two accessory or smaller segments are added to the two principal ones, *the whole being attached by well-developed chordæ tendineæ to rudimentary musculi papillares.* In a fifth, which is the most perfect form of valve as it exists in man, and in the higher mammalia, the segments are from four to six in number, *most exquisitely and symmetrically formed, and attached by minutely graduated chordæ tendineæ to highly developed carneæ columnæ and musculi papillares;* the latter being distinctly spiral.

The action of the auriculo ventricular valves is varied, and depends on the circulation, on the configuration of the ventricles, and the shape of the ventricular cavities, which adapt and mould the blood, and cause it to act in a definite or given direction. In the Fish, the ventricle and the ventricular cavity are pyramidal in shape, the ventricular fibres being so arranged that the organ contracts and dilates very much as one would shut and open the hand. As, moreover, the circulation is languid, the segments of the valve, when two exist, are forced towards each other, by the contraction of the ventricle and by the blood, in a manner analogous to that by which the segments of the bisemilunar venous valves are approximated, by the retrogressive movements of the slowly advancing venous blood, assisted to a slight extent by the vital contractility of the vessels. In the Reptile, where the circulation is also languid or slow, the shape of the ventricle or ventricles,* and of the ventricular cavity or cavities, is conical; the cone being slightly twisted upon itself. As the muscular fibres forming the ventricle pursue a more or less spiral course, and this arrangement extends to the valves, their action may be aptly compared to that which obtains in the valves of the largest veins, and in those of the arteries. It is, however, in the auriculo-ventricular valves of the Bird and Mammal that the spiral action of the segments becomes most conspicuous; the nature of the action being unavoidably determined by the spiral arrangement of the muscular fibres forming the ventricles, and by the spiral nature of the musculi papillares and ventricular cavities. As the two spiral musculi papillares project into the spiral ventricular cavities, it follows that between them there exist two spiral grooves or depressions, and in these the blood is arranged, on its entrance into the ventricles, in two spiral columns; that fluid, towards the end of the diastole and the beginning of the systole, advancing on the segments of the auriculo ventricular valves in spiral waves, from below upwards, and wedging and screwing them into each other in an upward spiral direction; the musculi papillares, by contracting, dragging the segments towards the end of the systole, by means of the chordæ tendineæ, in an opposite or downward direction, to form a spiral dependent cone, the apex of which points to the apex of the heart. The action of the auriculo ventricular valves is partly mechanical and partly vital, the musculi papillares and analogous structures exercising, through the chordæ tendineæ, at one time a restraining influence to prevent retroversion and regurgitation, at another wielding a direct power for approximating and applying them accurately to each other. The paper, which is based on an extensive series of dissections, is illustrated by upwards of 50 photographs and drawings, showing the structure, relations, and action of the valves.

* In some cases, as is well known, the almost perfect septum divides the ventricle into two.

2. On some points in the Metrology of the Great Pyramid. By Professor C. Piazzi Smyth, Astronomer Royal for Scotland.

This paper was an attempt to submit to a severe and searching examination, the very new and apparently important ideas contained in the work, published four years ago by Mr John Taylor of London, and entitled "The Great Pyramid; why was it Built?" To this end, the original authorities for measures of the Pyramid, had been extensively referred to, from Professor John Greaves in the 17th century, down to Colonel Howard Vyse and Dr Lepsius in the 19th; and their various and sometimes conflicting numerical statements had been computed with all due attention to scientific accuracy, as well as every endeavour to eliminate both personal and other sources of error in the observations.

The result of this proceeding has been most eminently favourable to all the more important and cogent of Mr Taylor's conclusions; not only as to the probability of a common origin in prehistoric times for the *hereditary* weights and measures of all nations, but as to there having been something more than mere human intelligence concerned in their establishment; and also, to the Great Pyramid, besides having been earlier in date, being, in all the spirit of its construction, completely separated from all the other Pyramids, as well as from everything usually thought typical of Egypt, or peculiar to the Pharaonic, or any other, dynasty of the Egyptians; and entirely devoid, in its finished parts, of even the remotest and most distant allusion to any form of idolatrous worship ever practised by any nation of antiquity whatever.

The calculations were prepared in full, and an astonishing series of coincidences upon coincidences given, both as to the relations truly connecting the dimensions of the Great Pyramid, with the latest geodesically-determined numbers for the size and figure of the earth; to the original founding of the standard of that Pyramid's linear measure on the one and only absolutely correct scientific reference which the earth contains—viz., the axis of rotation; to the connecting of its ancient measures of capacity and weight with the weight, or what goes, with the size, to make the weight, of the earth; and to the identification of the very convenient divisor typical to the Pyramid, even in the temperature secured for its standards.

There then followed a comparison of the ancient Pyramid-measures, in length, surface, capacity, and weight, with the English *hereditary* measures still in existence among us; and it showed, first, the extreme closeness of the two systems, especially in the smaller units employed chiefly by the working and poorer classes of our country; and then, the remarkable convenience for scientific purposes and questions of the present day, of the larger Pyramid-units; of which, not the least striking example is, that the large Ordnance map of Great Britain recently commenced, and now being rapidly pushed on by the Government, on a scale of $\frac{1}{2500}$th of nature, the largest, best, and most expensive map of our country which has ever yet been attempted,—but which does not fit into the present British measures at all, requiring long and annoying fractions both for the mile and the acre, to the plague of every British-born working-man who uses it,—fits in *precisely* to the ancient Pyramid measures of 4300 years ago, and represents their mile and their acre *true*, in inches, without the smallest fraction of an inch left over or under.

3. The Decimal Problem Solved. By James Alexander, Esq. Communicated by E. Sang, Esq.

The author having had experience of the simple duodecimal monetary system of Portugal, which is accumulated by multiplication from a decimal minimum unit, proposes to apply the same principle to the British coinage. Having also discovered, while in Canada, that the difference betwixt the British coinage and a decimal position or character, is 20 per cent. over all, he proposes to overcome this by altering the value of the present farthing, by this rate, making it the fifth, instead of the fourth of the penny—the penny of 5 farthings would then become the duodecimal multiplier of all the coins, making the shilling 60 farthings instead of 48, and the pound 1200 instead of 960, and each intermediate coin would be represented by one of the digits and one or two ciphers, while the pound, being represented by 12, the highest single divisor or multiplier, could be kept out as the maximum unit. This would introduce the decimal principle into the coinage, without sacrificing either the pound or the penny, which it has hitherto been declared impossible to do, while it would completely revolutionise our arithmetic, and bring our money into accord with the whole world. By this slight alteration, making no disturbance in the names or values of the coinage—affecting nobody injuriously, but everybody beneficially—a change of notation from the present £ *s.* *d.* is made imperative upon no one who prefers it; but the great mass of traders may at once keep their accounts in pounds and 1200ths, while the larger merchants and bankers may keep them in pounds and 120ths, greatly to the diminution of figuring and arithmetical labour, while the conversion of the decimal into *s.* and *d.* is the simplest mental operation.

4. On the Elevation of the Earth's Surface Temperature produced by Underground Heat. By Professor W. Thomson, F.R.S., F.R.S.E.

Peclet found, by his own experiments, that a body with any common unpolished non-metallic surface, kept by heat from within at 1° higher temperature than that of the air and other objects round it, loses heat from each square metre of surface at the rate of about nine kilogramme-water thermal units per hour, or, which is the same, $\frac{1}{4000}$th of a gramme-water unit from each square centimetre per second. The mean conductivity of the three Edinburgh strata, in which Principal Forbes's underground thermometers were placed, is $2\frac{3}{4}$ grain-water units per second per square foot per 1° per foot rate of variation of temperature, as I have shown previously.*

That of the Greenwich stratum is 2·6, in terms of the same units, according to Professor Everett's recent reductions; and that of certain strata (clay and sand) in Sweden is 1·64, according to Ångström (Poggendorff's *Annalen*, last volume of 1861). The mean of these three numbers is 2·33, which, reduced to the unit

* Trans. R.S.E., April 1860, "On the Reduction of Observations of Underground Temperature," § 42.

of conductivity founded on the gramme-water-second-centimetre units, is ·005. Taking this, therefore, as an average conductivity in the earth's upper crust, we find that if the temperature increased downwards at the rate of 1° per 20 centimetres, the quantity of heat lost by conduction outwards would be $\frac{1}{4000}$th; and therefore, according to Peclet's result, this would keep the surface just 1° warmer than it would be if there were no conduction of heat from within. Hence, to warm the surface to 10° Fahr. above what it would be if there were no conduction from within, the rate of rise of temperature must be 1° Fahr. per 2 centimetres, or ·0656 of a foot (which would probably destroy the roots of any large tree or plant), but at all events could not, as I have shown,* be the real condition of the earth at any time later than about 180 years after even a greater heating (7000° Fahr.) of the whole globe than the greatest we can suppose it at all probable the earth ever experienced. Hence it is certain that the climate can never have been sensibly influenced from the earliest "geological" era by underground heat. This conclusion was stated in § 17 of the paper already referred to "On the Secular Cooling of the Earth," as rendered certain by a rough general knowledge of the circumstances, without any approach to an accurate estimate of the absolute amount of radiation.

We now see, farther, that the present rate of underground rise of temperature, estimated at 1° Fahr. per 50 feet, is only $\frac{1}{75}$th of that which is required to warm the surface by 1°. Hence the surface is only about $\frac{1}{75}$th of 1° Fahr. warmer at present than it would be if there were no supply of heat from within.

The following Donations to the Library were announced:—

The Canadian Journal of Industry, Science and Art. No. 49, 8vo. —*From the Canadian Institute.*

De l'Origine des lacs Suisses, par M. B. Studer. 8vo.—*From the Author.*

Proceedings of the Royal Geographical Society. Vol. VIII. No. 2. 8vo.—*From the Society.*

* Trans. R.S.E., April 1862, "On the Secular Cooling of the Earth," § 18.

Journal of the Chemical Society. March 1864. 8vo.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, &c. February 1864. 8vo.—*From the Registrar-General.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIV. No. 4. 8vo.—*From the Society.*

Bulletin de la Société de Géographie. Cinquième Sériè. Tome VI. 8vo.—*From the Society.*

Sitzungsberichte der könig... bayer. Akademie der Wissenschaften zu München. II. Heft V. 8vo.—*From the Academy.*

Mémoires de l'Académie des Sciences de l'Institut Impérial de France. Tome XXVI. 4to.—*From the Academy.*

Extraits de Géologie pour l'année 1861. 8vo.—*From M. Delesse.*

Proceedings of the Royal Horticultural Society. Vol. IV. March 1864. 8vo.—*From the Society.*

Monday, 4th April 1864.

PROFESSOR INNES, Vice-President, in the Chair.

The following communications were read:—

1. On the Celtic Languages in their Relation to each other, and to the Teutonic Dialects. By W. F. Skene, Esq.

(*This paper was given at the request of the Council.*)

Mr Skene in his paper gave a sketch of the various views which had been entertained regarding the Celtic languages, and advocated the opinion that these languages belonged properly to the Indo-European class. He gave an outline of the distinctive peculiarities of the two branches of the Celtic languages, the Welsh and the Gaelic, and discussed the leading theories regarding the lost Pictish language, only five words of which were now extant. Mr Skene had, as the result of his investigations, arrived at the conclusion that the Pictish language occupied a place between the Welsh and the Gaelic—that it was a Gaelic dialect partaking largely of Welsh forms.

2. On the Protection of Vegetation from Destructive Cold every night. By Professor W. Thomson.

The effect of dew in protecting vegetation every clear still night of summer was long ago pointed out by Dr Wells; the correctness and acuteness of whose views on this subject have been generally recognised. The hypothesis recently put forth by Dr Tyndall, that absorption of radiant heat by aqueous vapour in the atmosphere is an effective defence against destructive degrees of cold, and the ready acceptance yielded to it by some of our highest authorities in the popular promulgation of the truths of science, seem to render it necessary to recall attention to Dr Wells' admirable work. In the first place, when Dr Tyndall announces, as a result of his experiments on radiant heat, that, "It is perfectly certain that more than ten per cent. of the terrestrial radiation from the soil of England is stopped within 10 feet of the surface of the soil," by the absorption it suffers from aqueous vapour; it must be remarked that this absorption cannot go on at the same rate through any great thickness of air. For at the same rate half the radiant heat would be absorbed in 70 feet; $\frac{3}{4}$ in 140 feet; $\frac{7}{8}$ in 210 feet, and so on, which is inconsistent with known facts; as, for instance, the influence of clouds on terrestrial radiation. Hence the quality of rays which passes through the lowest 10 feet of air suffers less than ten per cent. of absorption in the next 10 feet; and it is quite certain that after passing through several times 10 feet of air, the radiant heat must, by having been deprived of the part of it liable to absorption by aqueous vapour, be in a condition in which not one per cent. is absorbed from it in its passage through 10 feet of clear air. Whatever influence true vapour of water really does exercise in checking, by its absorption, the loss of heat by radiation from the earth's surface, it is, even in the most humid conditions of optically clear atmosphere, insufficient to prevent heavy dews; far less than the latent heat of which, taken from the blades of grass, or other finer parts of plants, would leave them destroyed by frost.

In point of fact, therefore, heat *actually is radiated* away into very high terrestrial atmosphere and distant interstellar air or æther, from the upper and finer parts of living plants, in so great amount every clear night of summer, that destruction by frost could not be delayed for many hours after sunset without a compensating supply of heat from some extraneous source. This source, on windy nights, is the thermal capacity of the air whirled about, up and down, and among the stems and leaves of the plants. On still nights it is the latent heat of the vapour condensed into dew. This vapour is taken chiefly from the air engaged among the stems and leaves, which, in the case at least of fine grass, is all *nearly* at the same temperature as the leaves; the temperature of the surface of these being of course rigorously the same as that of the air in contact. Thus the temperature of the leaves can never go *below* the *dew-point* of the air touching them, and any cooling which they experience *after* dew begins to deposit upon them is only equal to the lowering of the *dew-point*, occasioned by the amount of drying experienced by the air in consequence of the condensation of vapour out of it.

Clouds, as remarked first by Prévost, being practically opaque, prevent the surface of the earth from *tending* by radiation to a lower temperature than their own, which, unless they are very high, is generally not much colder than the dew-point of the lower air, but is at all events in general sufficiently warm to prevent the finest blades of grass from acquiring any very sensible dew, or to allow the general temperature of grass and the air engaged among it, even on the stillest night, to sink as low as the dew-point. Thus, either clouds, by their counter-radiation, or wind, by mixing a comparatively thick stratum of air with that next the earth, keep the grass and delicate parts of other plants from sinking to the dew-point; or, when there is not enough of clouds and wind to afford this degree of protection, dew begins to form, and by preventing the temperature of any leaf or flower from sinking below the dew-point, saves them all from destruction, unless, as when hoar-frost appears, the dew-point itself is below the freezing point.

The following Donations to the Library were laid on the Table :—

Catalogue of the Advocates Library. Part I. A—AZZ. 4to.—*From the Librarian.*

Census of Scotland. Population Tables and Report 1861. Vols. I. and II., folio.—*From the Registrar-General.*

Annual Detailed Reports of the Births, Deaths, and Marriages in Scotland. Vols. I.–V. 8vo.—*From the same.*

The Battle of the Standards, the Ancient of four thousand years against the Modern of the last fifty years—the less perfect of the two. By John Taylor, Esq. 8vo.—*From the Author.*

Dana on the Classification of Animals on the Principle of Cephalization, &c. 8vo.—*From the Author.*

Journal of the Statistical Society. March 1864. 8vo.—*From the Society.*

Memoirs of the Geological Survey of India. **2** . 6 . **3** . 1. 4to.—*From Dr Oldham.*

Turgan, Les Grandes Usines de France, Pépinières d'André Leroy à Angers. 8vo.—*From the Author.*

Premium Report on the Progress of the more recently introduced *Coniferæ.* By Robert Hutchison, Esq. 8vo.—*From the Author.*

Reale Instituto Lombardo di Scienze e Lettere. Rendiconti : Classe di Scienze Matematiche e Naturali. Volume I. Fasc. I. e II. Gennaio—Febbraio. 8vo.—*From the Institute.*

Geological Survey of Canada, 1863. 8vo.—*From Lord Monck.*

Proceedings of the British Meteorological Society. Vol. II. No. 10. 8vo.—*From the Society.*

Ricerche Storiche sulla legatura delle Vene e delle Arterie da Celso a Dionis per Giuseppe Longo da Casarano. 8vo.—*From the Author.*

The Shorter Catechism with proofs, in Hebrew and Syriac. By the Rev. H. S. M'Kee, D.D., LL.D. Killimane. 24mo. 1864.—*From the Author.*

Monday, 18th April 1864.

Sir DAVID BREWSTER, Vice-President, in the Chair.

In presenting the Keith Medal to Professor William Thomson of the University of Glasgow, Sir David Brewster made the following remarks:—

It is now nearly half a century since the late Mr Keith, of Dunottar, intimated to me his intention to bequeath L.1000 for the promotion of Science in Scotland, and to appoint me one of the Trustees for the administration of the Fund. I cheerfully accepted the trust, and pointed out to Mr Keith the manner in which the fund might be most advantageously employed.

In conformity with this plan, the sum of L.600 was presented to the Royal Society, "to form a biennial prize for the most important discovery in Science made in any part of the world, but communicated by its author to the Society, and published in its Transactions." The rest of the Fund, which had increased considerably, was subsequently presented to the two Societies in Edinburgh, which had been instituted for the promotion of the Fine and the Useful arts.

Agreeably to the regulations adopted by the Council, the Keith Prize for 1862 and 1863 fell to be allotted to the most important discoveries in Physical Science, made during these two years. In deciding upon its adjudication, the task of the Council was as easy as it was agreeable. Professor William Thomson, who was elected a Fellow of the Society in 1847, had, during the last seventeen years, communicated many valuable papers to the Society, which added greatly to the value of its Transactions. These papers, and others elsewhere published, relate principally to the Theories of Electricity, Magnetism, and Heat, and evince a genius for the mathematical treatment of physical questions, which has not been surpassed, if equalled, by that of any living philosopher.

In studying the mathematical theory of Electricity, he greatly extended the general theorems demonstrated by our distinguished countryman, Mr Green, and was led to the principle of "*Electrical Images*," by which he was enabled to solve many problems respecting the distribution of electricity on conductors, which had been regarded as almost hopeless by the most eminent mathematicians in Europe.

In his researches on Thermo-dynamics, Professor Thomson has been equally successful. In his paper "On the Dynamical Theory of Heat," published in our Transactions for 1851, he has applied the fundamental propositions of the theory to bodies of all kinds, and has deduced many curious and important results regarding the specific heats of bodies, which have been completely verified by the accurate experiments of Mr Joule.

No less important are Professor Thomson's researches on Solar Heat, contained in his remarkable paper "On the Mechanical Energy of the Solar System;" his researches on the Conservation of Energy as applied to organic as well as inorganic processes; and his fine theory of the Dissipation of Energy, as given in his paper "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy." To these we may add his complete Theory of Diamagnetic Action, and his investigations relative to the Secular Cooling of our Globe, and the influence of Internal Heat upon the temperature of its surface.

The value of labours like these could not escape the notice of the Council of this Society, and they would have entitled their author to the Keith Prize, had they not been presented to the Society when the Prize was devoted to other branches of Science. It is not, therefore, for these researches and discoveries that the Keith Medal has been awarded to Professor Thomson, but for the very interesting and important discovery, in Abstract Dynamics, which he has communicated to the Society during the biennial period appropriated to Physical Science.

By the previous researches of Euler, Lagrange, Delaunay, and Bertrand, it had been established that when any system of bodies, connected by any invariable kinematic relations, is struck with impulses of any kind, the kinetic energy thus developed is a maximum. This remarkable principle is of very great use in the investigation of certain complex dynamical problems, but in many important cases it is inapplicable. In the motion, for example, of an incompressible liquid, contained in a vessel whose form is suddenly altered, it is not the impulse on the liquid which is given, but definite kinematic relations are laid down to which the impulsive motion must be subject. In such a case, Professor Thomson has shown that the kinetic energy which has been thus generated is a minimum; and it is for this theorem that the Prize has been awarded,—a theorem which not only affords a direct and simple mode of dealing with questions of more than ordinary difficulty, but which is itself an extremely singular and valuable property of Motion.

The researches of Professor Thomson, to which we have referred, are of too recondite a nature to be generally appreciated. The results of abstract Science have ever failed to excite the notice, or call forth the gratitude, of the State. The question of practical use—the *cui bono* of ignorance—is put every day by educated men in high and responsible positions, to whom are confided the mightiest interests of the nation. History and experience might have taught them, had they been capable of learning, that abstract Science is the life and soul of Industry, and that its successful cultivators are the true benefactors, not of their country only, but of their species. The discoveries of our eminent colleague, and even the very abstract property of motion, to which we have attached so special a value, must, like all similar revelations, find invaluable applications to the material interests of society.

I should be doing injustice, however, to Professor Thomson were I to characterise his researches as wholly abstract and transcendental. The important conclusions which he obtained from the Theory of Induction in submarine Telegraphs, have found a valuable practical application in the Patent Instruments for reading and receiving messages, which he so successfully employed on the submarine cable across the Atlantic; and when that great work is completed, his name will be associated with the noblest gift that Science ever offered to Civilisation. By his delicate Electrometers, his Electric Spark Recorder, and his Marine and Land Reflection Galvanometers, he has provided the world of thought with the finest instruments of observation and research; and the world of action with the means of carrying the messages of commerce and civilisation which have yet to cross the uncabled oceans that separate the families of the earth.

Entertaining these views of the services which my distinguished friend has performed to Science and the Arts, I have much pleasure in expressing the same sentiments on the part of the Society, and in being their organ in delivering to him the Prize which he has so justly merited.

In discharging this duty, I am proud to think, and I am sure that all here will participate in the sentiment, that Scottish Science has such a representative in the University of the West, while, in our own, it has one of kindred genius and power.

Professor Thomson, I now beg to present to you the Keith Medal, and to congratulate you on the honour which you have so justly deserved.

1. On Vital Agency with reference to the Correlation of Forces. By William Seller, M.D., F.R.S.E., Fellow of the Royal College of Physicians of Edinburgh.

In this paper there is presented a series of characteristic examples of vital agency, followed by some considerations bearing on the extent to which, in a physiological point of view, it can be admitted that the physical forces, under exchangeable forms, are concerned in organic phenomena. At the same time, one of the particular objects of inquiry is, whether there be ground for the belief that vital agency, being not a force but a directive principle, may accomplish all the parts assigned to it, solely by means of the physical forces variously modified through organic structure.

It is laid down among the preliminaries, that no facts hitherto discovered bring the origin of organic life within the pale of inductive inquiry; that the transmutation of species by natural selection, though a brilliant conception, holds as yet no foundation of an inductive character; that it remains therefore a fundamental fact in physiology, admitting of no explanation, that all species have their commencement in original parentage; and further, that it is thence correct in principle to maintain that all the multiplied phenomena in the life of a species, of whatever extent, derive their source from the potentiality of the reproductive cells in the primordial parent or parents of that species.

It is also taken for granted that such a directive principle, as that already indicated, must act through the organism and the organic fluids which take their first origin in this manner.

The character of nutrition throughout organic nature is then dwelt on, with the purpose of showing that it is everywhere under the control of more or less perfect organic (physiological) atoms; that even reproduction of species is nutrition of a more special kind, the organic atoms supplied by each sex being thrown off only when the individual or individuals whence they are derived have attained a very perfect maturity.

The maintenance of heat in organic bodies, and particularly in animals of perfect type, is next pointed out as probably indicating the true nature of the connection between vital agency and the physical forces, since in every case the higher temperature has a purely physical source, while it is nevertheless under the control of vital agency.

A rapid view is next taken of acts of relation in the animal world, as more immediately proving the necessity for a directive principle to explain, in any degree, the reference of such acts to physical forces.

Finally, the interference of a directive principle is represented as essential to show why vital agency at last puts a limit to its own operations, even when the material supplied is in abundance, first building up the springs of growth and limiting the size of each individual over which it presides, in accordance with the rule of the species; next building up the springs of reproduction earlier in the one sex than in the other; and, lastly, building up the springs of life itself, and terminating the career of its own individual existence in a manner even less intelligible to finite understandings than any of the most wonderful of its acts of workmanship in the greatest vigour of its power.

A few passages are then devoted to the exhibition of views taken by Carpenter, Leconte, also by Thomson and Tait, in speaking of organic phenomena with reference to the correlation of physical forces or to the conservation of energy.

Affinity and aggregation are next reviewed at some length, with the view of showing that there is no essential difference between affinity in inorganic nature and that affinity which builds up and repairs organic structures when the agency of a directive principle is admitted; that that directive principle operates through organic structure and the protoplasma in vegetable bodies, both of which owe their origin in unvaried succession to the original parents of the species; that all organic structure at present in existence may be traced back to the state of vegetable protoplasma; that the protoplasma in the cells of the green parts of plants becomes augmented by the assimilation of carbon and hydrogen in particular, derived from the carbonic acid and water of the atmosphere, and that this operation is purely chemical, aided by the merely physical agency of light; that the presence of water in so large proportion throughout the living solids, pervading their atoms and interstices like an almost incompressible atmosphere, accounts for many of the peculiarities of organic affinity, and among others for the apparent antagonism between the attraction which holds together the living solids and that which, on the failure of vital action, so quickly reduces them to the state of purely mineral matter—the case being exactly parallel to that of water containing salts in dilute solution, the concentration of which is followed by the precipitation of such insoluble salts as can arise out of the constituents of the salts originally dissolved in the fluid—finally, that the heat which attends the exercise of such affinities as produce water and carbonic acid is due to the rapid movement of the strongly attracted atoms, that being to a far greater degree than in the exercise of the organic affinities.

It is next considered how far electricity is to be regarded as concerned under a directive principle in the phenomena of life, and particularly in the exertion of animal power.

The facts ascertained with respect to electrical fishes are pointed to as sufficient proof, that animals nourished and constituted like vertebrated animals can generate a great amount of electrical force, the peculiarities of the electrical fishes being in fact inconsiderable, when compared with the effects produced. It is further noticed, that the general result of the many experiments made by recent electro-physiologists is to show, that during life, hardly any two parts of the animal body are in electric equilibrium. From all which, and many other facts, there appears to be nothing improbable in the idea that electricity is an active agent in the phenomena of life, more especially in those of the nervous apparatus and the muscular system. Moreover, from what appears to be the fact, that electricity is developed along with heat in the eremacausis or organic decomposition under the influence of oxygen attendant on the occurrence of vital phenomena, while the living body exists in such a non-conducting medium as air; the unsolved question already presents itself—What becomes of that electricity? At the same time, however, it is acknowledged, that as respects physiology, electricity is full of promise rather than of actual results. It is shown that the numerous, and, in some respects, contradictory experiments of Du Bois Reymond and Matteucci, prove that electricity exists in living bodies, but do not conclusively indicate what it does or can perform.

The question of most immediate interest at present in connection with the correlation of physical forces, is whether electricity or heat, or partly the one, partly the other, be the representative of animal power in muscular exertion.

If vital agency be assumed to be not a force—that is, not an immediate source of motion—but only a directive principle analogous to man's intelligence when it compels the properties of bodies and the laws of nature to minister to the fulfilment of ends suggested to him by his appetites, desires, and capacities of enjoyment, then, to avoid the alternative of representing force as springing out of nothing, animal force, as manifested in muscular action, must be considered as metamorphosed from affinity, electricity, or heat. In continuance, a muscle can be conceived to be so built up by affinities, as that it shall, under certain conditions, shorten itself and produce a mechanical effect; but such an effect can take place in this manner only once—to contract again and again in quick succession by the expenditure of affinity, it would require to be rebuilt after each contraction, which seems next to impossible. A muscle, therefore, after one contraction, is in the same predicament as a weight that has fallen from a height to the ground, which, to produce the same effect a second time, must be raised to the same elevation as before. Is it, then, electricity, or heat, or partly the one partly the other, which produces the renovating effect on the muscle? One of the illustrations on this point is the following:—Some physiologists regard a muscle as being in its natural or spontaneous state when in complete contraction, believing, that when the body is at rest, the molecular structure of the muscle is kept by some kind of force in a species of constraint—that on the discharge of this force the muscular fibril contracts, and that the constraining force is immediately renewed. It has been supposed that the force here operative is heat, yet electricity seems better fitted for the purpose. In support of this view is cited the analogy, indicated by some authorities, between the structure of the muscular system and that of the electric organs in the gymnotus and torpedo.

If such a view, under whatever modification, be rejected, heat must be resorted to as the source of animal power.

To prove heat to be the source of animal power, it must be shown that the products of eremacausis, under forcible muscular exertion, both account for the whole temperature manifested in the meantime, and leave a surplus sufficient to be metamorphosed into the calculated equivalent of the mechanical effect produced by the entire amount of that exertion.

Chemists pronounce that the amount of heat in the combustion of hydrogen and carbon, whether slow or rapid, is exactly proportioned to the products in water and carbonic acid; nevertheless, it may be doubted if two circumstances have been taken into account in their estimate as respects the living body, viz., the disturbance of electric equilibrium in such combustion, and the reciprocal convertibility of heat and electricity, so that it may turn out that, with the same amount of material products, there may be room for a reciprocal variation in the proportions of these forces developed.

Whence, though the product in carbonic acid and water be in exact proportion to a given exertion of animal power, the question appears to be still unsolved, Whether heat, or electricity, or both jointly, represent the equivalent of mechanical force put forth in such exertions.

2. On Sun Spots, and their connection with Planetary Configurations. By Balfour Stewart, Esq. Communicated by Professor Tait.

The author was led to examine the sun pictures taken by the Kew Photoheliograph, with the view of ascertaining if any connection exists between the behaviour of sun spots and planetary configurations.

It was found, that when any portion of the sun's disc recedes by virtue of rotation from the neighbourhood of Venus, it acquires a tendency to break out into spots, and, on the other hand, when such approaches Venus, there is a tendency towards the healing up of spots. Carrington's observations were then discussed, which seem to show that, on the whole, the sun's surface is fullest of spots when Jupiter is furthest from our luminary, and freest from spots when he is nearest. This action of Jupiter is not, however, much influenced by the rotation of our luminary, perhaps because the sun's diameter is small compared with the distance of that planet. The mode of action of Venus and Jupiter may both be expressed by the following law:—"When the sun's disc, or part of it, approaches a planet, or when a planet approaches the sun's disc, there is an absence of spots, or a tendency to luminosity produced."

It was then shown that this law was sufficient to explain the phenomena of variable and of temporary stars; and, in conjunction with Professor Tait, the author suggested that it might be analogous to that in virtue of which two atoms rushing together give rise to radiant light and heat.

3. Biographical Sketch of Adam Ferguson, LL.D., F.R.S.E., Professor of Moral Philosophy in the University of Edinburgh. By John Small, Esq., M.A., Librarian to the University of Edinburgh. Communicated by Professor Fraser.

The following Donations to the Library were announced:—

Almanaque Náutico para 1865, Calculado de órden de S.M., en el Observatorio de Marina de la Ciudad de San Fernando, 8vo.—*From the San Fernando Observatory.*

Journal of the Proceedings of the Linnean Society. Vol. VII., No. 28. 8vo.—*From the Society.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight principal Towns of Scotland—March 1864. 8vo.—*From the Registrar-General.*

Journal of the Chemical Society. April 1864. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society. Vol. XXIV. No. 5. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. Vol. IV. No. 6. 8vo.—*From the Society.*

Proceedings of the Royal Society. Vol. XIII. No. 62. 8vo.—*From the Society.*

On the Vertebroid Homologies of the Cranium in Vertebralia or Osteozoa, and the Analogous Homologies of the Annulozoa or Articulata. By William Macdonald, M.D., F.R.S.E., &c. 8vo. —*From the Author.*

Monday, 2d May 1864.

Professor LYON PLAYFAIR in the Chair.

Some of the following Communications were read:—

1. Unpublished Letter of the late Professor Dugald Stewart. Transmitted by John Small, M.A., Librarian to the University. Communicated by the Rev. Dr Stevenson.

The letter which Mr Small has sent to the Royal Society, and which, at the request of the Council, I have the honour of bringing under the notice of the meeting, was acquired by the University in 1861, at the sale of the MSS. of the late Very Rev. Principal Lee. It is by no means destitute of historical importance, though its main value for us may rest on the consideration that it was written directly from the scene of the convulsion which it describes, by Professor Dugald Stewart to the Reverend Archibald Alison. As a zealous student of political philosophy, Mr Stewart took a lively interest in the early stages of the French Revolution. He accordingly visited Paris both in 1788 and in 1789; and while there he maintained an active correspondence on the subject which engrossed him, with his friend Mr Alison. Of this correspondence five letters, unconnected with one another, have been printed in the Appendix to Professor Veitch's Memoir, which forms the first article in the tenth volume of Stewart's collected works. These five are dated, 27th August 1788, 10th May 1789, 30th May and 4th June 1789, 27th June 1789, and 17th September 1789.

The letter now brought to light by Mr Small, the most interesting of the series, so far as it is known to have been preserved, is dated 2d July 1789, and is distinctly connected with that already printed, of date 27th June. In the latter the writer says:—" My Dear Archy—I had begun a very long letter for you, which I find I cannot possibly get ready for you till next post. I must therefore content myself at present with mentioning to you, that the day before yesterday, *i.e.* 25th June, the king sent a letter to the clergy and noblesse, desiring them by every consideration of regard for his person, and of attachment to their country, to unite themselves instantly with the Tiers Etat, which they did that very day." That the document now before us is the " very long letter" thus referred to, becomes obvious from the facts, that it takes up the narrative of events at the 22d of the month, and that, towards the close, it mentions the union of the clergy and noblesse with the Tiers Etat, in nearly the precise words quoted above.

On the 17th of June, the Tiers Etat had declared themselves a " National Assembly," in consequence of which bold step, it was determined by the Court party to close the hall of the said Tiers Etat till June 23. On the 20th, proclamation to this effect was made by the Herald-at-Arms; but the " Assembly," excluded from their own hall, met in the Tennis-Court, and then took the famous Tennis-Court oath—with only one dissentient. On the 22d, no fewer than 148 of the clergy joined the Commons or Tiers Etat, now assuming to itself the unusual name and the boundless powers of " L'Assemblée Nationale." On the next day, the 23d, came the Séance Royale, according to previous proclamation; and here the letter of Mr Stewart takes up the narrative.

" My Dear Archy,—My last letter, if I recollect right, was dated on Sunday, 21st June, at which time everything here was in the utmost confusion. On Monday morning, notice was given in Paris that the *Séance Royale* would not take place till *Tuesday;* and in the meantime copies were distributed of a letter from M. Necker to M. De Crosne (who has the charge of the police in Paris), tending to quiet the apprehensions of the people about the dissolution of the States General, and assuring them that the K. was doing everything in his power to conciliate the different orders. On

Tuesday forenoon I went to Versailles, chiefly from a desire of getting the earliest intelligence of the result (for I had heard before that no strangers were to be admitted into the Assembly), and I arrived just after the time the *Séance Royale* was ended. Everybody seemed to be in the greatest consternation, for the King had gone to the *Salle, without M. Necker*, accompanied by the *Garde des Sceaux* and the other ministers. The noblesse had retired with the King, together with a great part of the clergy; but the Deputies of the people were still sitting, although the K. had given them positive orders to separate immediately, and to assemble again the day following. At that time everybody believed that M. Necker was out of office, and it was generally supposed that the Prince of Conti would be at the head of the new ministry.

"The principal objects of the King's speech were, to annul all the arrêtes of the Tiers Etat, from the time that they had constituted themselves into the National Assembly, and to establish the mode of voting *par ordre*, agreeably to the wishes of the majority of the noblesse and a great party among the clergy. It contains likewise a variety of most important concessions in favour of the people, which I have not time to mention to you at present, and concludes in the following words (for, unfortunately for His Majesty, the speech was immediately printed):—

"'Vous venez, Messieurs, d'entendre le resultat de mes dispositions et de mes vues : elles sont conformes au vif désir qui j'ai d'operer le bien public; et si par une fatalité loin de ma penseé, vous m'abandonniez dans une si belle entreprise seul je ferai le bien de mes peuples, seul je me considerai comme leur veritable representant; et connoissant vos cahiers, connoissant l'accord parfait qui existe entre le voeu le plus general de la nation et mes intentions bien faisantes j'aurai toute la confiance qui doit inspirer une si rare harmonie, et *je marcherai vers le but auquel je veux atteindre avec tout le courage et la fermeté qu'il doit m'inspirer !*

"'Réflechissez, Messieurs, qu'ancien de vos projets, aucune de vos dispositions, ne peut avoir force de loi sans mon approbation speciale. Ainsi je suis le garant naturel de nos droits respectifs, et tous les ordres de l'état peuvent se reposer sur mon equitable impartialité. Toute defiance de votre part seroit une grande injustice. C'est moi jusqú'à present qui fait tout pour le bonheur de mes peuples, et il est rare, peutêtre, que l'unique ambition d'un Souverain soit d'obtenir de ses sujets; qu'ils s'entendent enfin pour accepter ses bienfaits.

"'Je vous ordonne, Messieurs, de vous separer tout de suite, et de vous rendre demain matin, chacun dans les Chambres appretées a votre ordre, pour y reprendre vos séances. J'ordonne en consequence au Grand Maitre des Ceremonies de faire preparer les salles.'

"After the King had retired, he sent two separate messages to the Deputies of the people to separate, and received for answer that nothing but force should determine them to leave the *Salle*, or to interrupt their deliberations. They then proceeded to pass a variety of resolutions, the chief of which were to persist in all their former arrêtes, and to continue their meetings as before, under the title of *Assemblée Nationale.*

"In the afternoon a great crowd assembled before the apartments of M. Necker (among whom were some hundreds of the Deputies of the people, and many people of very high rank), requesting him not to abandon them at so critical a juncture; and about five o'clock, *the very day that the above speech was pronounced*, he received a message from the King *and Queen.* He remained with them a considerable time, and at last came out and told the people he was to continue in office; for, in their anxiety to know the result, an immense crowd had forced their way into the apartments of the palace. He made an attempt to return to his own apartments by a private passage from the King's closet, but he was forced out of doors by the people, and, I am told, was carried home through a crowd who pressed forward to kiss his clothes. The same evening fireworks were thrown before his windows, and, it is said, continued the greater part of the night. I called accidentally next morning on a gentleman, who was in M. Necker's apartment during the whole of the business. It is supposed that this very extraordinary revolution, which took place so suddenly in the plans which the King seemed to have formed in the morning, proceeded from a discovery of the general dispositions of the army, and particularly of the Guards.

"Nothing of much consequence took place at Versailles the three following days. The Deputies of the people continued their *Séances*, under the title of *Assemblée Nationale*, and those of the other two orders in their own chambers. On the Wednesday (24th June), a considerable number of the noblesse, who had been restrained hitherto by the instructions they had received from their constituents, declared their resolution to unite themselves to the National Assembly, and the day following about fifty actually joined the Deputies of the Commons. Among these were the Duke of Orleans, the Comte de Montmorency, the Duc de la Rochefoucault, the Duc d'Aiguillon, the Comte de Clermot Tonerre, and a number besides of the very first names in France.

" *Despremenil*, and some others, particularly of the new noblesse, were still blustering in their own chamber. It is curious that *Despremenil*, who was a *roturier*, and who has not yet held his office the complete term of years necessary to confer *noblesse*, should have been on this occasion the great champion of his order, although he was frequently reminded of the history of his family by some of his brethren, in terms abundantly humiliating. It is said, in particular, that the Duc de Liancourt told him one day, in the Chamber of the Noblesse,—' Il faut avouer, Monsieur, que votre zele pour la noblesse soit bien desinterressé car il vous manque encore six mois d'etre Gentilhomme,' During this time the desertions of the clergy from their own Chamber to that of the Tiers Etat were continuing, insomuch that the President found one morning a bit of paper tied about the tongue of his bell (the Presidents of all the three orders have a small bell before them on the table, which they ring when they wish to establish order in their Assembly), with the following inscription,—*Vox clamans in deserto.*

" At last, on *Saturday*, the King sent a letter to the Chambers of the Clergy and the Noblesse, desiring them to unite themselves without delay to the National Assembly, which they accordingly did that very day.

" Since that time nothing of consequence has been done, as the Assembly has been wholly occupied *in verifying the powers* of the new members, and in some other preliminary business.

" I requested of you in a former letter, to take the trouble of mentioning the principal contents of my letters to D. Bannatyne and Mr Millar. Both of them will naturally expect that I should have written to them from time to time, and you will easily see the absolute impossibility of my doing so. I must therefore at present carry on my correspondence with them in this indirect manner, for which I beg you will make my apology. Remember me also to all my friends in Edinr.,—to whom I consider myself as writing when I address my letters to you. Best compts. to Mrs Alison, &c. &c.—I ever am, dear Archy, yours sincerely,

"D. S.

" *July* 2."

2. The Law of Aëriform Volumes extended to dense bodies. By J. G. Macvicar, A.M., D.D. Communicated by Professor Lyon Playfair.

In this communication the author proceeds to show that when dense bodies, whether liquids or solids, are regarded as consisting of certain molecules, the volumes of these molecules are either equals, halves, or doubles, &c., as in aëriforms.

This he proves by showing that the densities of bodies in general, as determined by the balance, are proportional to the numbers which express the weights of their molecules.

The author's theory of molecules is based on the following reasoning. By the general consent of men of science, nature is a dynamical system—a system of applied mathematics. The molecules of bodies are, when compared with the other properties of bodies, very stable clusters of atoms. In their structure, therefore, they may be expected to display in a high degree the geometrical and the dynamical, that is, the mechanical conditions of stability. These conditions in reference to individualised objects, each having but one centre, that is, in reference to such structures as the molecules of bodies, are most perfectly fulfilled, when the group of their parts or particles, regarded geometrically, is reducible to one or other of the regular polyhedrons. These polyhedrons are five in number; and of these, three (the tetrahedron, octohedron, and icosahedron) are of the same order, all having triangular faces; and all the three may be regarded as culminating in the last named and most perfect of the three, viz., the isocahedron. But the icosahedron, in its turn, is most intimately related to the dodecahedron, each under the application of the law of symmetry developing the other, each inscribing and circumscribing the other, giving both as alternate forms, as the radius lengthens or shortens. The remaining polyhedron, viz., the tube or hexahedron stands out from all the others, and is, in fact, singular, inasmuch as it has no proper poles, and seems unsuited for polarized action.

The author therefore fixes upon the dodecahedron and the icosahedron as the geometrical types of the molecules of bodies. He conceives that their molecules may possibly consist of 12 or of 20 chemical elements or units, either single units, binary units, ternary units, &c., as the case may be. And he proceeds to calculate solely from atomic weights, and without any reference whatever to atomic volumes, the densities of liquids and solids on this hypothesis.

But previously to entering upon details, he finds it necessary to allude to the law of molecular differentiation. Not that there is anything new in this law; for it is merely the further operation, when the stability of a molecule is threatened by heat or otherwise, of the grand principle of all chemical synthesis, viz., the concurrence and apposition of dissimilar particles; but it modifies the number of elements in a molecule according to the risks which that molecule has run; and consequently it modifies also the specific gravity of the mass. Thus taking X to represent any chemical element; instead of simple dodecatoms X_{12} or icosatoms X_{20}, both of which are isometrical as well as homogeneous, we may have a composite molecule, $X_{12}X_{20}=X_{32}$, consisting of both, the one differentiating the other, and thus securing a greater stability for both. Similarly single elements of X may differentiate both X_{12} and X_{20}, giving $X\,X_{12}X=X_{14}$ and $X\,X_{20}X=X_{22}$. And these two, in their turn, may differentiate each other, giving $X\,X_{12}X,\ X\,X_{20}X=36X$. And here one of the limits of the theory as a method of reaching the construction of molecules presents itself. Thus the compound undifferentiated dodecatom $(X_{12})_{12}$, occupying four volumes, must give the same specific gravity as $X\,X_{12}XX\,X_{20}X=36X$, occupying one volume; for $\frac{12\times 12\,X}{4}=36X$.

To obtain densities in the familiar form of specific gravities the molecule or unit volume of water requires to be determined. And this the author finds to be a dodecatom (or rather an isobaric molecule), each constituent element of which is 3HO

$$=36 \text{ aq}=\text{AQ}=36\times 9=324 \text{ when H}=1.$$

He then proceeds to deduce theoretically the specific gravities of between seventy and eighty of the most interesting and abundant of natural and chemical substances, somewhat in the order in which they are treated in chemical works.

A composite molecule, consisting of the two isometrical molecules X_{12} and X_{20}, differentiating each other, and giving $X_{12}X_{20}=X_{32}$, gives the idea of great molecular perfection and stability—as, for instance, repose in the presence of oxygen, &c. He finds, accordingly, that such is the molecule of the precious metals, or metals that remain pure, and the diamond; gold and silver having normal or aqueous volumes, platinum and aluminium half, and bismuth and antimony double volumes; the platinum and antimony molecules being also differentiated, and therefore their molecular structures equivocal. Thus—

$$\text{Gold G}=\frac{Au_{12}Au_{20}}{AQ}=\frac{197\times\overline{12+20}}{324}=19{\cdot}1. \quad \text{Expt. } 19{\cdot}2.$$

$$\text{Aluminium G}=\frac{2(Al_{12}Al_{20})}{AQ}=\frac{2(13{\cdot}75\times\overline{12+20}}{324}=2{\cdot}7. \quad \text{Expt. } 2{\cdot}6\,.\,2{\cdot}7.$$

The diamond, by the greater openness of X_{20} than X_{12} (when both are formed of pentagonal elements), and its more ready combustibility, almost enables us to demonstrate analytically this composite molecule of $X_{12}X_{20}$. In so light an element as carbon, however, when constructed by nature, it is not the single element $C_{12}C_{20}$, but the dodecatom $(C_{12}C_{20})_{12}$ that is in relation with the unit volume of water. Thus—

$$\text{Diamond G}=\frac{(C_{12}C_{20})_{12}}{2AQ}=\frac{12\times 6\times\overline{12+20}}{2\times 324}=3{\cdot}55. \quad \text{Expt. } 3{\cdot}55.$$

$$\left.\begin{array}{l}\text{Unburnt}\\ \text{residuum,}\end{array}\right\}\text{G}=\frac{(C_{12})_{12}}{AQ}=\frac{12\times 6\times 12}{324}=2{\cdot}67. \quad \text{Expt. } 2{\cdot}67 \text{ (Jaquealine).}$$

$$\text{Coke and Graphite? G}=\frac{(C_{20})_{12}}{2AQ}=\frac{12\times 6\times 20}{2\times 324}=2{\cdot}22. \quad \text{Expt. } 1{\cdot}8\,..\,2{\cdot}3.$$

Similarly with phosphorus. White or old $\frac{P_{12}P_{20}}{2AQ} = 1\cdot53$. Least combustible $\frac{2P_{12}}{AQ} = 2\cdot29$. Most combustible $\frac{P_{20}}{AQ} = 1\cdot913$.

The dodecatom generally has half the volume of the icosatom of the same substance. When mercury solidifies, it appears to change from the more open to the more compact. Thus

$$\text{Mercury } G = \begin{cases} \frac{2(Hg)}{AQ} = \frac{2(100 \times 22)}{324} = 13\cdot58. & \text{Expt. } 13\cdot59 \text{ (at Zero.)} \\ \frac{4(Hg)_{12}}{AQ} = \frac{4(100 \times 12)}{324} = 14\cdot8. & \text{Expt. } 14\cdot4. \text{ (Solid.)} \end{cases}$$

Lithium, sodium, potassium, are X $X_{12}X$; sodium occupying a normal volume; lithium, calcium, magnesium, a half; and potassium double volume.

$$\text{Lithium } \frac{2Li_{14}}{AQ} = \frac{2(7 \times 14)}{324} = \cdot60. \quad \text{Expt. } \cdot59.$$

$$\text{Sodium } \frac{Na_{14}}{AQ} = \frac{23 \times 14}{324} = \cdot99. \quad \text{Expt. } \cdot97.$$

$$\text{Potassium } \frac{K_{14}}{2AQ} = \frac{39 \times 14}{2 \times 324} = \cdot84. \quad \text{Expt. } \cdot86.$$

And so on.

$$\text{Bromine } \frac{Br_{12}}{AQ} = \frac{80 \times 12}{324} = 2\cdot99. \quad \text{Expt. } 2\cdot99.$$

$$\text{Table Salt } \frac{(NaCl)_{12}}{AQ} = \frac{12 \times \overline{23 + 35\cdot5}}{324} = 2\cdot16. \quad \text{Expt. } 2\cdot15.$$

$$\text{Quartz } \frac{2(SiO_2)_{14}}{AQ} = \frac{2(30 \times 14)}{324} = 2\cdot59. \quad \text{Expt. } 2\cdot5 \ldots 2\cdot8.$$

$$\text{Sulphur } \frac{S_{20}}{AQ} = \frac{32 \times 20}{324} = 1\cdot975. \quad \text{Expt. } 1\cdot98.$$

$$\left.\begin{array}{c}\text{Glacial}\\ \text{sulphuric}\\ \text{acid}\end{array}\right\} \frac{(SO_3 + 2HO)_{20}}{2AQ} = \frac{20(40 + 18)}{2 \times 324} = 1\cdot79. \quad \text{Expt. } 1\cdot785 \text{ (Playf.)}$$

Most stable hydrate of chlorhydric acid, $G = \frac{2(HCl + 16aq)}{324} = 1{\cdot}111$. Expt. 1·111.

All molecules determined by hydrogen and sulphur are icosatoms, others very generally are dodecatoms.

And so on, with between 70 and 80 familiar substances.

Potass-soda felspar is a dodecatom of Potass felspar, viz.

$$(KOAl_2O_3(SiO_2)_{12}\ O_3Al_2OK)_{12}$$

in which in the two polar elements, KO is substituted by NaO; occupying eight normal volumes as such highly composite molecules usually do.

			Theory.	Abich.	
Felspar	144 SiO_2	4300	65·14	65·72	From Baveno.
	24 Al_2O_3	1248	18·82	18·57	
	20 KO	940	14·17	14·02	
	4 NiO	124	1·25	1·25	

$G = 8 \times 324)\overline{6632}(2{\cdot}55$. The balance gives 2·5552. See *Millar's Miner.*, p. 367.

3. On the Freezing of the Egg of the Common Fowl. By John Davy, M.D., F.R.S. Lond. and Edin.

The author, preparatory to stating the experiments which he has made on the freezing of the egg of the common fowl, referred to the early ones of Mr Hunter on the same subject, and to the later ones of Mr Paget, both these inquirers agreeing as to the results, but differing in their conclusions, Hunter attributing the resistance which the egg offers to freezing to a supposed vital principle, Mr Paget attributing it to the peculiar viscid state of the albumen.

The author, from his results, infers that two causes are mainly operative in protecting the egg; one, the cellular filamentous structure in which the albumen is contained; the other, the peculiar composition of the contents of the egg, and especially their saline elements. He concludes by proposing some queries respecting life, whether it can exist without action, and whether, provided the organic structure is not injured, congelation can take place without the death of the part frozen.

4. On the Variations of the Fertility and Fecundity of Women according to Age. By Dr J. Matthews Duncan.

This paper was divided into four parts. In the first part it was shown :—

1. That the actual, not the relative, fertility of our female population, as a whole, at different ages, increases from the commencement of the child-bearing period of life until the age of 30 is reached, and then declines to its extinction with the child-bearing faculty.

2. That the actual fertility is much greater before the climax, 30 years, is reached, than after it is passed.

3. That at least three-fifths of the population are recruited from women not exceeding 30 years of age.

In the second part it was shown :—

1. That comparative fertility increases gradually from the commencement of the child-bearing period of life until about the age of 30 years is reached, and that then it still more gradually declines.

2. That it is greater in the decade of years following the climax of about 30 years of age than in the decade of years preceding the climax.

In the third part it was shown :—

1. That the fecundity of the mass of wives in our population is greatest at the commencement of the child-bearing period of life, and after that epoch gradually diminishes.

2. That the fecundity of the whole wives in our population included within the child-bearing period of life is, before 30 years of age is reached, more than twice as great as it is after that period.

3. That the fecundity of the wives in our population declines with great rapidity after the age of 40 is reached.

In the fourth part it was shown :—

1. That the initial fecundity of women gradually waxes to a climax and then gradually wanes.

2. That initial fecundity is very high from 20 to 34 years of age.

3. That the climax of initial fecundity is probably about the age of 25.

5. On the Chemical and Physical Principles in Connection with the Specific Gravity of Liquid and Solid Substances. By Otto Richter, Ph. D. Communicated by Professor Maclagan.

The subject of this paper, is of a nature to find favour with all those chemists who are disposed to recognise in the fast accumulating evidence of a new and remarkable order of chemical phenomena rich and valuable materials for the construction of a sounder and more comprehensive chemical theory. This new order of phenomena appears to me, nevertheless, but imperfectly appreciated and understood, even on the part of our most distinguished experimentalists. Thus, for instance, Monsieur Pasteur, the illustrious French philosopher, and with him a host of other eminent thinkers, is of opinion, that matter is indebted for its chemical and physical properties mainly and exclusively to the peculiar manner in which the atoms are grouped together. In alluding to the probable cause of circular polarisation, Monsieur Pasteur considers, that this singular property ought to be referred to the unsymmetrical disposition of the constituents, and that the restoration of the chemical symmetry must at the same time obliterate every trace of circularly polarising power. Again, in order to account for the fact, that certain salts, for instance the chlorate of soda, cease to exhibit circular polarisation so soon as they are made to pass from the solid into the liquid state, he ventures even a step farther. According to him these optical phenomena are really due to two distinct causes, either to the dissymmetrical distribution of the atoms within the limits of each individual molecule, or to the spiral form of aggregation impressed upon entire masses of molecules, although these latter may, as individuals, exist in a state of chemical symmetry and optical neutrality. Monsieur Pasteur adopts the following mode of reasoning :—The chlorate of soda owes its optical activity mainly and exclusively to the spiral form of aggregation; and being destitute of that property, so far as its individual molecules are concerned, it follows, that the destruction of the spiral arrangement during the process of solution, must leave the chlorate of soda optically, because constitutionally, passive.

This argument, which *prima facie* seems so ingenious and plausible, is, nevertheless, in my opinion, void of foundation, because it rests on premises which are *empirically* and *philosophically* inadmissible. In the first place, *empirically*, because the hypothesis postulates, that a ray of light is propagated, both within and beyond the polarising medium, in the form of a spiral; whereas Monsieur Fresnel, another distinguished French philosopher, has clearly proved, both experimentally and mathematically, that the plane of polarisation assumes this twisted form in virtue of the mutual interference of two pencils of light, into which the original beam has resolved itself, and the particles of which, instead of vibrating as formerly in straight lines, are henceforth made to vibrate in the direction of a curve, and across two opposite regions of the influencing molecule. In the second place, *philosophically*, because the hypothesis places us between the horns of the following dilemma: either to make the optical change dependant upon a purely *mechanical* cause, namely, upon the assumption of a pre-existing spiral form of arrangement, in consequence of which a beam of light is *nolens volens* compelled to travel along the solid walls of a winding tunnel, or to make the optical change dependant upon a purely *dynamical* cause, namely, upon the assumption of a pre-existing unsymmetrical disposition of the atoms within the limits of each individual molecule; in consequence of which the molecule is supposed all at once to acquire the power of turning the luminous particles from their rectilinear course.

Now, it is a well known axiom of cosmical economy, that, in trying to interpret facts, we ought not to multiply causes unnecessarily, and that one and the same class of phenomena ought, if possible, to be referred to one cause only; but when, as in the case before us, these causes are so essentially distinct, both in their form and in their mode of action, the arguments employed by Monsieur Pasteur, unsupported as they are by either experiments or calculations, appear to me no longer tenable, and it behoves us, therefore, to search for a more consistent and comprehensive explanation. In reviewing the new order of phenomena above alluded to, and which embraces the following principal physical properties of matter,—viz. specific gravity, specific volume, allotropism and polymorphism, fusing and boiling points, crystalline form, optical, electrical, and magnetic polarity, &c., the general aspect of this order of facts seems to me so marked and peculiar, and at the same time so unchemical, that I consider myself justified in vindicating, for their scientific conception and interpretation, the existence of a principle *sui generis*,—a principle which, in virtue of its characteristic mode of action, I hold to be capable of modifying the chemical and physical energies of every part of a given atomic system, and all this, be it well observed, with the entire preservation of the original arrangement. Let me, in illustration of my meaning, assume, in the first place, that the so-called atoms,—a definite number of which I conceive to be always and inseparably united according to some fixed principle of grouping, and thus to constitute an elementary atomic system or molecule,—are endowed with repulsive energies directly proportional to the range and intensity of their own vibratory movements, which latter may be supposed to consist in a series of periodical expansions and contractions of each spheroidal atom; let me assume, in the second place, that under the influence of a certain physical agent the whole, or a given portion, of the atoms composing a molecule may experience a suspension or restoration of their vibratory movements; and let me assume, in the last place, that the specific volumes of substances in the liquid and solid state depend upon and correspond to the degree of repulsive energy thus developed in contiguous conflicting molecules; then, by means of these three assumptions, we have established a *nexus causalis* between the variations in the specific volume of dense molecules and between the intensity of their repulsive energies. Now it seems to me very clear that, so long as the peculiar force, which causes these variations, and which I will provisionally distinguish by the term *paralytic force*, happens to induce precisely the same changes upon any two opposite sides of a given atomic system, the physical symmetry of that system will not be disturbed, but, on the contrary, that, when these changes differ, physical symmetry can no longer exist, and that the natural result will be the formation of an ethereal current from the stronger towards the weaker side during the act of atomic expansion, and of another current in the contrary direction during the act of atomic contraction. Applying this view to the phenomena of circular polarisation, I have no hesitation in maintaining, that they have their origin in physical dissymmetry only, and that the existence of the vaunted chemical dissymmetry is at least very problematical. The reason, therefore, why chlorate of soda and its congeners lose the property of circular polarisation during the act of solution must be sought in differences of temperature and the altered state of aggregation, both of which conspire in restoring the physical symmetry, while the process of crystallisation tends to produce the opposite effect. I may add, moreover, that the discovery of a substance exhibiting the same optical deportment as chlorate of soda, while these physical processes are reversed, would prove a powerful argument in support of my view, but utterly subversive of Monsieur Pasteur's mode of reasoning.

The theory here advocated naturally leads us to suspect the existence of another set of equivalents, namely, the volume equivalents; their numerical expression would correspond to the highest degree of repulsive energy, and to the greatest amount of vibratory movements, of which the various species of elementary molecules are susceptible. They would, however, differ materially from the weight-equivalents, which are constant, whereas they would, on the contrary, be subject to a peculiar law of variations, which enables them to pass through a series of values from a given maximum down to zero. I am not at present prepared to enter into details, but a careful comparison of facts has convinced me that the variations in the specific volumes of the molecules, or, what comes to the same thing, the variations in the volume-equivalents of their component elements, are genetically connected, and run parallel with the modifications of their various physical properties. If, then, all the chemical and physical properties of matter are due to the simultaneous agency of two essentially distinct principles, it follows that chemistry, both as an art and as a science, rests not on a simple but on a complex foundation. On the one hand, it is the purely chemical principle which determines the various forms of molecular arrangement, and it is the ponderable portion alone of the various kinds of atoms, which, in their constant weight-equivalents, furnishes the basis of calculation. On the other hand, it is the purely physical principle which determines the specific volume of the molecules, and it is the imponderable portion alone of the various kinds of atoms, which, in their variable volume-equivalents, furnishes the basis of calculation. Accordingly, our tree of chemical knowledge splits up into two main branches, to which we might apply the terms Pondo-chemistry and Impondo-chemistry. I beg to remark, in conclusion, that having resolved upon a minute and thorough investigation of this, no doubt very intricate, subject, I was surprised to find, after examining all the principal sources of information, that a complete and trust-worthy catalogue of the leading physical properties of matter was still a desideratum, but more particularly that the determination of the specific gravities of substances in the liquid and solid state had been much neglected. With the most ample resources at my disposal, I have at length succeeded in composing a catalogue of these latter. The number of *bona fide* cases entered therein amounts to about 1800; but this number is after all a mere fraction, in comparison with the hundreds of thousands of non-determined bodies. I may also state, that should a systematic revision of this most needful portion of our science be resolved upon, I shall feel great pleasure in presenting my catalogue, such as it is, to the parties entrusted with its execution.

6. On the Theory of Isomeric Compounds. By Dr A. Crum Brown.

In this paper only those bodies are considered which are "absolutely isomeric," that is, which have not only the same composition per cent. and the same molecular weight, but also the same constitutional formula. As the constitutional formula of comparatively few substances is known, this class is as yet a small one.

The following pairs of substances are probably absolutely isomeric.

1. The alcohol radicals and the hydrides, as methyl gas and the hydride of ethyl.

2. Chloride of ethyl and the product of the action of chlorine on hydride of ethyl.

3. Chloride of vinyl and chloracetene.

4. Fumaric and maleic acids.

5. Bromomaleic and isobromomaleic acids.
6. The two bibromosuccinic acids.
7. The two varieties of malic acid.
8. The two varieties of aspartic acid.
9. Two of the varieties of tartaric acid.
10. Two of the dehydrogenates of pyrotartaric acid.
11. Two of the three bibromopyrotartaric acids.

The following are shown to be probably *metameric*,—

1. The compounds of ethylene and of ethylidene.
2. The alcohols proper and the hydrates of the olefines.
3. Lactic and paralactic acids.

The next point considered is the influence which the existence of such pairs of substances has on the theory of atomicity, and particularly on the question whether all the equivalents of a multequivalent atom are of the same chemical nature.

The consideration of absolutely isomeric bodies leads to the conclusion that there is a difference among the equivalents of the same atom, and that this difference is not entirely due to the structure of the molecule of which the atom forms a part. It is not, however, possible as yet to apply this principle to the explanation of particular cases.

The remarks of Professor Kekulé on the isomerism of the dehydrogenates of succinic and of pyrotartaric acids, and those of Professor Butlerow on the isomerism of methyl gas and hydride of ethyl, are then considered in detail, and Butlerow's hypothesis compared with the views of Kolbe as to the chemical nature of carbon.

7. On the Rhombohedral System in Crystallography. By Alfred R. Catton, B.A., Scholar of St John's College, Cambridge, and Fellow of the Cambridge Philosophical Society. Communicated by Professor Tait.

1. The science of Crystallography has for its object the classification of crystalline forms.

The principles which must guide us in attempting to arrive at a natural classification of crystals are the same as those which have been so successfully applied to the formation of a natural classification of plants by Ray and Jussieu, and of animals by Cuvier.

By the application of these principles it has been found that crystals are formed on six different types or plans of structure, and in consequence crystals have been arranged in six primary classes, termed crystallographic systems. They are named the cubic, pyramidal, rhombohedral, prismatic, oblique, and anorthic systems.

It is the object of this paper to show that the type on which crystals of the rhombohedral system are constructed is the same as that of the prismatic system.

The establishment of this proposition necessitates the abolition of the rhombohedral system, and all crystals hitherto included in it must in future be referred to the prismatic system.

2. In order to establish this proposition it is necessary to show,

(1.) That three axes of symmetry can be found at right angles to each other, such that for them the crystallographic parameters become unequal.

(2.) That the laws of symmetry of crystals of the rhombohedral system are the same as those of the prismatic system.

Now it is easily seen that the three straight lines perpendicular to the planes $10\bar{1}$, $\bar{1}2\bar{1}$, and 111 are at right angles to each other.

For the forms $10\bar{1}$ and $2\bar{1}\bar{1}$ differ only in position, the one being the same as the other turned through an angle of 30^0 about the optic axis.

Also the faces of the form 111 are perpendicular to the faces of each of the above forms. The three straight lines perpendicular respectively to the faces $10\bar{1}$, $\bar{1}2\bar{1}$, and 111, are taken as the new axes of symmetry; the parameters corresponding to them being a, b, c, respectively, it is shown in a later part of the paper that a, b, c, are unequal.

3. The paper then proceeds to show that the laws of symmetry of crystals of the rhombohedral system are the same as those of the prismatic system.

This is done by taking each simple form separately and finding what the indices of its faces become when referred to the new axes; it is then found that the new indices for all the simple forms follow the laws of symmetry of crystals of the prismatic system.

The same process is followed with the hemihedral forms.

4. In order to find the indices of a given face referred to the new axes, it is necessary to solve the following problem :—

"Given the indices and parameters of any face of a crystal when referred to given axes, to find its indices and also the new parameters when referred to any other axes originating in the same point."

This problem is solved in the paper, but the solution is too long to be here given.

For the purposes of this paper only a particular case of the general problem is required.

For in the rhombohedral system the axes make equal angles with each other, and the parameters are equal. Let ω be the angle between the rhombohedral axes, and a the magnitude of each of the equal parameters. Let hkl be the symbol of a face of a crystal belonging to the rhombohedral system, and $h'k'l'$ the indices of this face when referred to axes perpendicular respectively to the faces $10\bar{1}$, $\bar{1}2\bar{1}$, 111, a', b', c', the new parameters.

Then the formulæ obtained in the general case become, in this instance,—

$$\left.\begin{aligned} h' &= \frac{h-l}{2} \\ k' &= \frac{2k-h-l}{6} \\ l' &= \frac{h+k+l}{3} \end{aligned}\right\} \quad . \quad . \quad . \quad . \qquad (1.)$$

These expressions give the new indices.

The new parameters are given by the following formulæ.

$$a'x = \sin \tfrac{1}{2}\,\omega$$

$$b'x = \frac{1}{\sqrt{3}} \sin \tfrac{1}{2}\,\omega$$

$$c'x = \left\{ \frac{1+2\cos\omega}{3} \right\}^{\frac{1}{2}}$$

Where x is a constant.

5. Let α be the "angular element" of a crystal of the rhombohedral system, *i.e.* the angle between normals from the origin to the faces 100 and 111.

Then it is shown in the paper, that the expressions for the new parameters become,—

$$a'x = \left\{ \frac{3}{4+\tan^2\alpha} \right\}^{\frac{1}{2}}$$

$$b'x = \frac{1}{\{4+\tan^2\alpha\}}$$

$$c'x = \frac{\tan\alpha}{\{4+\tan^2\alpha\}^{\frac{1}{2}}}$$

Hence, a', b', c', are respectively proportional to $\sqrt{3}$, 1, $\tan\alpha$;

$$\therefore \quad \left.\frac{a'}{\sqrt{3}} = \frac{b'}{1} = \frac{c'}{\tan\alpha}\right\} \quad . \quad . \quad . \quad . \quad (2.)$$

Hence, given the angular element and the indices of a face, the ratios of the new parameters are determined by the formulæ (2.), and the new indices by the formulæ (1.)

Ex.—Find the new indices of the faces $01\bar{1}$, $13\bar{1}$.

α. The face $01\bar{1}$.

$$h' = \frac{0+1}{2}, \quad k' = \frac{2-0+1}{6}, \quad l' = \frac{0+1-1}{3}$$

$$= \tfrac{1}{2} \qquad\quad = \tfrac{1}{2} \qquad\quad = 0$$

$\therefore$ the new symbol is 110.

β. The face $13\bar{1}$.

$$h' = \frac{2}{2}, \quad k' = \frac{6-1+1}{6}, \quad l' = \frac{1+3-1}{3}$$

$$= 1 \qquad\quad = 1 \qquad\quad = 1.$$

$\therefore$ the new symbol is 111.

6. Also, given the symbol of a simple form belonging to the rhombohedral system, and also the angular element, the indices

of its several faces when referred to the new axes can be determined, and also the ratios of the new parameters.

The simple forms of the rhombohedral system are then taken in succession, and the indices of their faces when referred to the new axes are found. It is then seen that the new indices follow in all cases the laws of symmetry of the prismatic system.

This is done at length in the paper. The general process is exemplified here by its application to one or two simple forms only.

7. The simple form $10\bar{1}$, consists of the following faces.

$$10\bar{1} \qquad 01\bar{1} \qquad \bar{1}10$$

$$\bar{1}01 \qquad 0\bar{1}1 \qquad 1\bar{1}0$$

By the formulæ (1.), it is found that the new indices are, respectively,

$$100 \qquad 110 \qquad \bar{1}10$$

$$\bar{1}00 \qquad \bar{1}\bar{1}0 \qquad 1\bar{1}0$$

These indices are divisible into two groups,

$$\begin{cases} 110 & \bar{1}10 \\ \bar{1}\bar{1}0 & \bar{1}10 \end{cases}$$

$$\text{And} \begin{cases} 100 \\ \bar{1}00 \end{cases}$$

Now, it will be observed that in the first group, the indices always occur in the order 1, 1, 0 ; and that the symbols of the faces consist of every possible arrangement of the symbols ± 1, ± 1, 0, in which unity occupies the first and second places, and zero the last.

The faces of the first group, therefore, follow the law of symmetry of the prismatic system, and belong to the form 110.

Similarly, the faces

$$100$$

$$\bar{1}00$$

belong to the form 100.

Hence, the form $10\bar{1}$ of the rhombohedral system, is a combination of the forms 110 and 100 of the prismatic system.

In a similar manner it can be shown, that the form 211, is a combination of the forms 310 and 010.

8. The form hkl, where one of the indices is an arithmetical mean between the other two, is a double six-faced pyramid, whose base is perpendicular to the optic axis.

First, let $2h=k+l$, or $h-k=l-h$.

The faces may be arranged in the following two groups:—

$$\left.\begin{matrix} hlk & lkh & klh & hkl \\ \bar{h}\bar{l}\bar{k} & \bar{l}\bar{k}\bar{h} & \bar{k}\bar{l}\bar{h} & \bar{h}\bar{k}\bar{l} \end{matrix}\right\} \quad . \quad . \quad (A.)$$

$$\left.\begin{matrix} lhk & khl \\ \bar{l}\bar{h}\bar{k} & \bar{k}\bar{h}\bar{l} \end{matrix}\right\} \quad . \quad . \quad . \quad (B.)$$

Let the new indices of the face hlk be $\alpha\beta\gamma$.

Then $$\alpha=\frac{h-k}{2},\quad \beta=\frac{2l-h-k}{6},\quad \gamma=\frac{h+l+k}{3}.$$

Now, $$\frac{2l-h-k}{6}=\frac{4h-2k-h-k}{6}=\frac{h-k}{2}$$

$$\therefore \beta=\alpha.$$

And $$\frac{h+k+l}{3}=\frac{h+2h}{3}=h.$$

Hence the face hlk becomes $\alpha\alpha h$, where $\alpha=\frac{h-k}{2}$.

Again, let the new indices of the face lkh be $\alpha'\beta'\gamma'$.

Then $$\alpha'=\frac{l-h}{2},\quad \beta'=\frac{2k-l-h}{6},\quad \gamma'=\frac{l+k+h}{3}$$
$$=\frac{h-k}{2}\qquad =\frac{k-h}{2}\qquad =h.$$

Hence the face lkh becomes $\alpha\bar{\alpha}h$.

Similarly, the new indices of the faces klh, hkl are $\bar{\alpha}\alpha h$ and $\bar{\alpha}\bar{\alpha}h$ respectively.

Hence the group of faces, (A), becomes

$$\left.\begin{matrix} \alpha\alpha h, & \alpha\bar{\alpha}h, & \bar{\alpha}\alpha h, & \bar{\alpha}\bar{\alpha}h \\ \bar{\alpha}\bar{\alpha}\bar{h}, & \bar{\alpha}\alpha\bar{h}, & \alpha\bar{\alpha}\bar{h}, & \alpha\alpha\bar{h} \end{matrix}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (A'.)$$

where $\alpha=\frac{h-k}{2}$; if $h-k$ be odd, each of the indices in (A′) must be multiplied by two.

Again, let the new indices of the face lhk be $\alpha'\beta'\gamma'$,

Then $$\alpha'=\frac{l-k}{2},\quad \beta'=\frac{2h-l-k}{6},\quad \gamma'=\frac{l+h+k}{3}$$
$$=h-k\qquad =o\qquad =h.$$

Hence the face lhk becomes $2a\ o\ h$.

Similarly, the face khl becomes $\overline{2a}\ o\ h$.

Hence the group of faces (B) becomes,

$$\left.\begin{matrix} 2a\ o\ h,\ \overline{2}a\ o\ h \\ \overline{2a}\ o\ \overline{h},\ 2a\ o\ \overline{h} \end{matrix}\right\} \quad . \ . \ . \ . \ . \ . \ . \ . \quad (B').$$

Now it will be observed that, in the group (A′), the indices always occur in the order aah; and that the symbols of the faces consist of every possible arrangement of the indices $\pm a$, $\pm a$, $\pm h$, in which a occupies the first and second places and h the last. The faces of the group (A′) are therefore subject to the law of symmetry of the prismatic system, and belong to the form

$$aah.$$

Similarly the faces of the group (B′) belong to the form

$$2a\ o\ h.$$

Hence the form hkl of the rhombohedral system, where $2h = k + l$ is a combination of the forms aah and $2a\ o\ h$ of the prismatic system, where $a = \frac{h-k}{2}$.

If $2k = l + h$, it can be shown in a similar manner that hkl is a combination of the forms $\beta\beta k$ and $2\beta\ o\ k$, where $\beta = \frac{k-l}{2}$.

And if $2l = h + k$, a combination of the forms $\gamma\gamma l$ and $2\gamma\ o\ l$, where $\gamma = \frac{l-h}{2}$.

Ex.—Transfer the forms $13\overline{1}$ and $17\overline{5}$ to the prismatic system.

a. The form $13\overline{1}$.

$$\text{Here } h = 1, k = -1, \therefore a = \frac{2}{2} = 1,$$

$\therefore$ $13\overline{1}$, is a combination of 111 and 201.

β. The form $17\overline{5}$.

$$\text{Here } h = 1, k = -5, \therefore a = \frac{1+5}{2} = 3,$$

$\therefore$ $17\overline{5}$ is a combination of 331 and 601.

9. The results of the examination of the other simple forms of the rhombohedral system will be given without demonstration.

The form *hkl*, where $h+k+l=o$ is a twelve-sided prism, whose axis is parallel to the optic axis.

It is a combination of the following forms of the prismatic system :—

$$\alpha_1\beta_1 o,\ \alpha_2\beta_2 o,\ \alpha_3\beta_3 o,$$

$$\text{where } \alpha_1=\frac{k-l}{2},\ \beta_1=\frac{2h-k-l}{6},$$

$$\alpha_2=\frac{l-h}{2},\ \beta_2=\frac{2k-l-h}{6},$$

$$\alpha_3=\frac{h-k}{2},\ \beta_3=\frac{2l-h-k}{6}.$$

Ex.—The form $3\bar{1}\bar{2}$ is a combination of 210, 130, 510.

10. The form *hkk* is a rhombohedron.

It can be shown that the rhombohedra

$$hkk,$$

$$\text{and } 4k-h,\ 2h+k,\ 2h+k,$$

are inverse with respect to each other.

A combination of these rhombohedra is a combination of the following forms of the prismatic system—

$$3\alpha\ \alpha\ 2\beta;\ o\ \alpha\ \beta,$$

$$\text{where } \alpha=h-k \quad \beta=2k+h.$$

Ex.—A combination of the rhombohedra 100 and $\bar{1}22$ (which are inverse with respect to each other), is a combination of the forms 312 and 011 of the prismatic system.

The rhombohedron *hkk* itself is a combination of two hemihedral forms with parallel faces, viz.,—

$$\pi\ 3\alpha\ \alpha\ 2\beta \text{ and } \pi\ o\alpha\beta,$$

where α and β have the same values as above.

11. The form *hkl*, where *h,k,l* are connected by none of the preceding relations, is sometimes termed a scalenohedron.

It can be shown that the following scalenohedra are inverse with respect to each other, viz.,—

$$hkl$$

$$\text{and } 2k+2l-h,\ 2l+2h-k,\ 2h+2k-l.$$

A combination of these scalenohedra is a combination of the following forms of the prismatic system,—

$$\alpha_1\beta_1\gamma, \ \alpha_2\beta_2\gamma, \ \alpha_3\beta_3\gamma,$$

$$\text{where } \alpha_1 = \frac{k-l}{2}, \ \beta_1 = \frac{2h-k-l}{6},$$

$$\alpha_2 = \frac{l-h}{2}, \ \beta_2 = \frac{2k-l-h}{6},$$

$$\alpha_3 = \frac{h-k}{2}, \ \beta_3 = \frac{2l-h-k}{6},$$

$$\gamma = \frac{h+k+l}{3}.$$

Ex.—The scalenohedra $16\bar{1}$ and $35\bar{2}$, which occur in apatite, are inverse with respect to each other.

A combination of these scalenohedra is a combination of the forms 122, 534, 714 of the prismatic system.

The scalenohedron *hkl* itself is a combination of three hemihedral forms with parallel faces, viz.,—

$$\pi\alpha_1\beta_1\gamma, \ \pi\alpha_2\beta_2\gamma, \ \pi\alpha_3\beta_3\gamma,$$

where $\alpha_1\beta_1$, $\alpha_2\beta_2$, $\alpha_3\beta_3$, and γ have the same values as above.

12. The simple forms of the rhombohedral system, therefore, with the exception of the rhombohedron *hkk*, and the scalenohedron *hkl*, follow the law of symmetry of the holohedral forms of the prismatic system. Hence it follows that the hemihedral forms also, derived from these simple forms, are subject to the laws of symmetry of the hemihedral forms of the prismatic system.

Since the rhombohedron and scalenohedron are themselves combinations of hemihedral forms with parallel faces of the prismatic system, it follows that the hemihedral forms derived from the rhombohedron and scalenohedron are combinations of *tetartohedral* forms, with inclined and parallel faces, derived from the hemihedral forms with parallel faces of the prismatic system.

These tetartohedral forms with inclined and parallel faces, derived from the hemihedral forms with parallel faces, may be denoted respectively by the symbols $\kappa\pi hkl$ and $\pi\pi hkl$.

The tetartohedral form $\pi\kappa hkl$ cannot obviously exist; and it is easily seen that the form $\kappa\kappa hkl$ is included in $\kappa\pi hkl$. Hence the only tetartohedral forms are $\pi\pi hkl$ and $\kappa\pi hkl$,—*i.e.*, they are all derived from the hemihedral forms with parallel faces.

Also $\pi\pi hkl$ can only exist when all the indices h, k, l are finite, and $\kappa\pi hkl$ can only exist when all the indices are finite or one zero.

When hkl are all finite, $\pi\pi hkl$ consists of any pair of parallel faces of the form hkl and $\kappa\pi hkl$ of any pair of inclined faces of the form hkl. When one of the indices is zero, $\kappa\pi hkl$ consists of any single face of the form hkl.

13. Hemihedral forms with inclined faces, derived from the rhombohedron or scalenohedron, have only been observed in the following minerals,—

Cronstedtite.
Phenakite.
Pyrargyrite.
Quartz.
Tourmaline.

In these minerals alone, therefore, do the tetartohedral forms $\kappa\pi hkl$ occur.

Hemihedral forms with parallel faces, derived from the scalenohedron, have only been observed in the following minerals,—

Dolomite.
Dioptase.
Phenakite.

The tetartohedral forms $\pi\pi hkl$ occur, therefore, only in these minerals.

Hemihedral forms with parallel faces, derived from scalenohedra, occur also in apatite. But in this mineral, two scalenohedra, inverse with respect to each other, always occur together on the same specimen, and when one scalenohedron is hemihedral the other is so also. Hence the hemihedral forms in this mineral correspond to hemihedral and not to tetartohedral forms in the prismatic system.

14. Let α_x, α_y, α_z be the new *angular elements* of crystals of the rhombohedral system when transferred to the prismatic system.

$$\text{Let } \alpha_x = 100, 110\,; \ \alpha_y = 010, 011\,; \ \alpha_z = 001, 101.$$

$$\text{Then } \tan \alpha_x = \frac{a'}{b'} \quad \tan \alpha_y = \frac{b'}{c'} \quad \tan \alpha_z = \frac{c'}{a'}\,;$$

And by the formulæ (2), Art 5.

$$\frac{a'}{\sqrt{3}}=\frac{b'}{1}=\frac{c'}{\tan\alpha};$$

$$\therefore\ \tan\alpha_x=\sqrt{3},$$

$$\tan\alpha_y=\frac{1}{\tan\alpha}=\cot\alpha,$$

$$\tan\alpha_z=\frac{1}{\sqrt{3}}\tan\alpha\ .\ \ .\ \ .\ \ .\ \ .\ \ .\ \ .\ \ .\ \ .\quad (a.)$$

$$\therefore\ \alpha_x=60^\circ;\ \alpha_y=\frac{\pi}{2}-\alpha.$$

The other angular element α_z is given by equation (*a.*)

Hence one of the angular elements is always equal to 60°.

15. The results of this investigation may therefore be summed up by the following statement:—All crystals included in the rhombohedral system are merely the particular forms which crystals of the prismatic system assume when one angular element is equal to 60°.

16. Tables are given in the paper containing the symbols of the forms of the prismatic system corresponding to the forms observed in the various minerals belonging to the rhombohedral system.

The following is an example selected from the tables:—

Apatite.

Angular elements—

100, 110 = 60°; 010, 011 = 34° 20′; 001, 101 = 40° 13′.

Simple forms—

100, 010, 001, 011, 101, 110, 111, 012, 021, 102, 201, 310, 112, 114, 311, 312, 314.

The following forms are always hemihedral with parallel faces—

210, 130, 320, 350, 510, 910, 121, 122, 532, 534, 712, 714, 615, 3 7 10, 9 5 10.

Cleavage—

100, 001, 110.

001 not so easily obtained as 100, 110. The angles between the faces are of course the same whatever be the symbols used to represent them. For Apatite they are, therefore, those given on p. 485 of Miller's "Mineralogy."

17. The angular elements of Calcite are—

100, 110 = 60° ; 010, 011 = 45° 23′·4 ; 001, 101 = 29° 40′.

Those of Aragonite are—

100, 110 = 58° 5′ ; 010, 011 = 40° 50′ ; 001, 101 = 35° 47′.

These angular elements differ considerably. Aragonite and Calcite will therefore continue to form distinct mineral species.

18. The author hopes soon to be able to publish the results of investigations which appear to show that the crystals included in the oblique and anorthic systems are formed by the combination of hemihedral and tetartohedral forms of the prismatic system.

8. Preliminary Note on the Connection between the Form and Optical Properties of Crystals. By Alfred R. Catton, B.A., F.C.P.S., Scholar of St John's College, Cambridge.

1. It is the object of this note to give an account of the results of investigations, which have had for their object the discovery of the connection between the form and optical properties of crystals.

It is believed that in the results here given, some of the principal difficulties of this important problem have been overcome.

2. The first step towards the solution of this problem was made by Sir David Brewster in 1818. He discovered that crystals belonging to the prismatic, oblique, and anorthic systems, are biaxal; those belonging to the pyramidal and rhombohedral systems uniaxal, while crystals of the cubic system do not possess double refraction (a fact which had been previously stated by Hauy).

In the prismatic system, the optic axes always lie in a plane containing two of the crystallographic axes, and make equal angles with each of these axes.

Now the theoretical investigations of Fresnel have shown that the optic axes lie in a plane containing the axes of greatest and least elasticity, and make equal angles with each of these axes.

Hence it follows, that, in the prismatic system, the axes of elasticity coincide with the crystallographic axes.

In the oblique system, one axis of elasticity coincides with that crystallographic axis which is at right angles to each of the other two.

In the anorthic system, the position of the axes of elasticity is subject to no known law.

3. These facts show that there is a fundamental connection between crystalline form and optical properties. Of late, nevertheless, many eminent physicists, following the views of De Senarmont, have doubted the existence of such a connection. We shall, therefore, show hereafter that the experiments of De Senarmont as well as those of Des Cloizeaux are not at all opposed to, but important confirmations of, the views here adopted, which are founded on the facts stated above, and in addition on the remarkable relations that have been observed between hemihedral forms and rotatory polarisation in quartz, and dextro- and lævo- tartaric acids.

4. In this note we shall consider in detail the connection between the form and optical properties of crystals belonging to the prismatic system. For crystals belonging to the oblique and anorthic systems, the investigation is still in progress.

5. We proceed to consider the following problem.

"Given the angular elements of a crystal belonging to the prismatic system, to find the angle between the optic axes."

We have before observed, that, in the prismatic system, the optic axes always lie in a plane containing two of the crystallographic axes, and make equal angles with each of these axes.

First, let the optic axes lie in the plane containing the parameters c and a, and each make an angle ω_c with the axis c. Our object is to find an expression for some function of ω_c, say tan ω_c, in terms of the parameters a, b, c.

Now crystals belonging to the pyramidal system have only one optic axis, which coincides with the axis c, if $a = b$. Hence, when $a = b$, the angle which each optic axis makes with the axis c vanishes; or, in other words, both optic axes coincide with the axis c.

Hence, ω_c and $\therefore$ tan ω_c vanishes when $a = b$.

$\therefore$ tan ω_c is divisible by $a - b$.

6. In an abstract of a paper on the "Rhombohedral System," published in the present number of the "Proceedings," it is shown that the crystals hitherto included in the rhombohedral system are merely the particular forms which crystals of the prismatic system assume when one angular element is equal to 60°.

But crystals belonging to the rhombohedral system have only one optic axis, and this, as is shown in the paper referred to, coincides with the axis c if the angular element 100, 110 = 60° ; *i.e.*, if $\frac{a}{b} = \sqrt{3}$.

Hence when $a = b\sqrt{3}$, the angle which each optic axis makes with the axis c vanishes.

Hence, ω_c and $\therefore \tan \omega_c$ vanishes when $a = b\sqrt{3}$.

$\therefore \tan \omega_c$ is divisible by $a - b\sqrt{3}$.

But we have before shown that it is divisible by $a - b$.

$\therefore \tan \omega_c$ is divisible by $(a - b)(a - b\sqrt{3})$.

But all uniaxal crystals belong either to the pyramidal or rhombohedral systems.

Hence these are the only factors containing a and b, by which $\tan \omega_c$ is divisible.

7. Again, if $\omega_c = \frac{\pi}{2}$, the optic axes coincide with the axis a.

But when this is the case, by the same reasoning as before, either $b = c$, or $b = c\sqrt{3}$; $\therefore \omega_c$ must $= \frac{\pi}{2}$, or $\tan \omega_c$ must become infinite when $b - c = o$, or $b - c\sqrt{3} = o$.

Hence the expression for $\tan \omega_c$, in terms of a, b, c, must be a fraction, the denominator of which contains the factors $b - c$ and $b - c\sqrt{3}$; and, for the same reason as before, these are the only factors in the denominator containing b and c.

Hence, since $\tan \omega_c$ is of no dimensions, the expression for $\tan \omega_c$ in terms of a, b, c, must be of the form

$$\tan \omega_c = \frac{C\,(a - b)^m (a - b\sqrt{3})^n}{A\,(b - c)^m (b - c\sqrt{3})^n}$$

where C is independent of a and b, and A of b and c.

8. Crystals belonging to the cubic system do not possess double refraction; in other words, they have an infinite number of optic axes.

Hence, $\tan \omega_c$ ought to become indeterminate, when $a - b = o$ and $b - c = o$, which is the case with the above expression.

9. We have shown from physical considerations, that the factors $a - b$, and $a - b\sqrt{3}$, must enter into the expression, for $\tan \omega_c$ at least, to the first degree; there is, however, no physical reason for

supposing that these factors enter to a degree higher than the first, and we are therefore led to assume that they enter to the first degree only. Hence the expression for tan ω_c becomes

$$\tan \omega_c = \frac{C\ (a-b)\,(a-b\sqrt{3})}{A\ (b-c)\,(b-c\sqrt{3})} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

Similarly, if the optic axes lie in the plane containing the axes a and b, and if ω_a be the angle which each makes with the axis a,

$$\tan \omega_a = \frac{A(b-c)\,(b-c\sqrt{3})}{B(c-a)\,(c-a\sqrt{3})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

Also, if the optic axes lie in the plane containing the axes b and c, and if ω_b be the angle which each makes with the axis b,

$$\tan \omega_b = \frac{B(c-a)\,(c-a\sqrt{3})}{C(a-b)\,(a-b\sqrt{3})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

We shall show, by the comparison of these formulæ with observation, that $\frac{A}{a} = \frac{B}{b} = \frac{C}{c}$.

10. These formulæ can be easily expressed in terms of the angular elements α_1, α_2, α_3.

$$\text{For } \tan \alpha_1 = \frac{a}{b} \qquad \tan \alpha_2 = \frac{b}{c} \qquad \tan \alpha_3 = \frac{c}{a}$$

Hence, putting $\frac{A}{B} = \frac{a}{b}$, the formula (2.) may be written in the form,

$$\tan \omega_a = \frac{(\cot \alpha_2 - \cot 45^\circ)\,(\tan \alpha_2 - \tan 60^\circ)}{(\cot \alpha_3 - \cot 45^\circ)\,(\tan \alpha_3 - \tan 60^\circ)}$$

and so for the others.

11. The angular elements of a crystal are to a certain extent arbitrary; thus the parameters may be changed from a, b, c, to pa, qb, rc—where p, q, r are positive integers none of which are zero—provided the symbols of the simple forms are altered accordingly.

With the new parameters formula (2.) becomes

$$\tan \omega_a = \frac{pa\ (qb-rc)\ (qb-rc\sqrt{3})}{qb\ (rc-pa)\ (rc-pa\sqrt{3})}$$

We conclude, therefore, that finite and integral values of p, q, r may be found such that, with the angular elements given in

Miller's "Mineralogy," or elsewhere, the calculated agrees with the observed angle between the optic axes.

We proceed to the comparison of these formulæ with observation.

12. *Chrysoberyl.*—In this mineral, the optic axes lie in the plane bc, and make angles of 13° 55′, with axis c.

Let ω be this angle.

$$\text{Then } \tan \omega = \cot \omega_b = \frac{C\left(1 - \frac{b}{a}\right)\left(1 - \frac{b}{a}\sqrt{3}\right)}{B\left(\frac{c}{a} - 1\right)\left(\frac{c}{a} - \sqrt{3}\right)} \text{ by formula (3.)}$$

Angular elements,—

100, 110 = 64° 49′; 010, 011 = 39° 1′; 001, 101 = 30° 7′.

$$\therefore \quad \frac{b}{a} = \cot 64° 49' = \cdot 4702.$$

$$\frac{c}{a} = \tan 30° \ \ 7' = \cdot 5801\cdot$$

$$\therefore \ \tan \omega = \frac{\cdot 5298 \times \cdot 1856}{\cdot 4199 \times 1\cdot 152} \times \frac{C}{B} \cdot \qquad \ldots \ldots \ldots \qquad (a.)$$

$$= \cdot 20326 \text{ if } \frac{C}{B} = 1.$$

On this supposition, ω is somewhat less than 11° 30′, which differs by 2° 25′ from the observed value of 13° 55′; this difference is too great to be ascribed either to errors in the determination of the angular elements, or of the angle between the optic axes. Hence $\frac{C}{B}$ is not equal to unity.

The value of $\frac{C}{B}$ must be such that the value of ω given by equation (a) is equal, or nearly so, to 13° 55′.

We find this to be the case on trial, if $\frac{C}{B} = \frac{c}{b}$.

For chrysoberyl $\frac{c}{b} = \cot 39° 1' = 1\cdot 2337$.

Hence, equation (a) becomes

$$\tan \omega = \cdot 20326 \times 1\cdot 2337.$$

$$= \cdot 2507.$$

$$\therefore \ \omega = 14° \ 4'\cdot 5;$$

which only differs from 13° 55′ by 9′·5, a difference quite within the limits of errors of observation.

Hence, from the optical properties of chrysoberyl, we deduce that, if the optic axes lie in the plane bc,

$$\tan \omega_b = \pm \frac{b\,(c-a)\,(c-a\sqrt{3})}{c\,(a-b)\,(a-b\sqrt{3})}.$$

The sign $\pm$ is used, for in the reasoning by which the above formula has been deduced, there is nothing to show whether the factor corresponding to $a=c$ is $a-c$, or $c-a$, or that corresponding to $c=a\sqrt{3}$, $c-a\sqrt{3}$, or $a\sqrt{3}-c$, &c.

13. *Aragonite*—

In this mineral the optic axes lie in the plane ca, and for the fixed line B make angles of 9° 2′ 41″·5 with the axis c, and of 9° 20′ 20″ for the fixed line H.*

Hence by formula (1.),

$$\tan \omega_c = \frac{(pa-qb)\,(pa-qb\sqrt{3})}{(qb-rc)\,(qb-rc\sqrt{3})}\,\frac{rc}{pa}$$

Angular elements—

100, 110 = 58° 5′; 010, 011 = 40° 50′; 001, 101 = 35° 47′.

$$\therefore\ \frac{a}{b} = 1{\cdot}6055 \quad \frac{c}{b} = 1{\cdot}1571 \quad \frac{c}{a} = {\cdot}72078.$$

In the above formula put $p=q=1$ and $r=2$.

The form denoted in Miller's "Mineralogy" by the symbol 201 is thus taken as the form 101.

$$\text{Hence } \tan \omega_c = \frac{{\cdot}6055 \times {\cdot}1266}{2{\cdot}3142 \times 3{\cdot}0084} \times 2 \times {\cdot}72078$$
$$= {\cdot}110106 \times 2 \times {\cdot}72078$$
$$= {\cdot}15872$$
$$\therefore\ \omega_c = 9^\circ\ 2' \text{ nearly,}$$

which differs from Kirchhoff's determination for mean rays, viz., 9° 9′ 35″ by 7′ 35″.

14. *Karstenite* (Anhydrite).—Optic axes in plane ab, and make angles of 20° 18′·5, with axis b. Here,

* Kirchhoff (*Pogg. Annalen.* cviii. (1859), p. 574).

$$\tan \omega = + \frac{(c-a)(c-a\sqrt{3})}{(b-c)(b-c\sqrt{3})} \frac{b}{a}$$

$$\text{putting } \frac{B}{A} = \frac{b}{a}.$$

Angular elements,—

010, 011 = 42° 17′; 001, 101 = 44° 25′.

If these be altered thus,—

010, 011 = 42° 30′ (diff. of 13′); 001, 101 = 44° (diff. of 25′),

we have tan ω = ·37134

$\therefore$ ω = 20° 30′ nearly, which differs by 11′·5 from the observed value.

15. *Nitre.*—Optic axes in plane *ca*, and make angles of about 3° with axis *c*.

Angular elements,—

100, 110 = 59° 25′; 010, 011 = 40° 8′.

If these be altered thus,—

100, 110 = 59° 40′ (diff. of 15′); 010, 011 = 40° (diff. of 8′).

The value of ω given by the formula,

$$\tan \omega = \pm \frac{(a-b)(a-b\sqrt{3})}{(b-c)(b-c\sqrt{3})} \frac{c}{a}$$

is 3° 20′ nearly, differing by about 20′ from the observed angle.

16. *Cerussite.*—In this mineral the optic axes lie in the plane *bc*, and make angles of 4° 8′ with axis *c*.

Angular elements,—

100, 110 = 58° 36′·5; 010, 011 = 40° 9′·5; 001, 101 = 35° 52′.

$$\therefore \quad \frac{b}{a} = \cdot 6102 \qquad \frac{c}{a} = \cdot 723 \qquad \frac{c}{b} = 1\cdot 1851.$$

Hence equation (3.) becomes

$$\tan \omega = \frac{\cdot 3898 \times \cdot 0569}{\cdot 277 \times 1\cdot 0091} \times \frac{C}{B}$$

$$= \cdot 08 \text{ if } \frac{C}{B} = 1.$$

$\therefore$ ω = 4° 36′ nearly, which differs by 28′ from the observed value.

If $\frac{C}{B} = \frac{c}{b} = 1\cdot 1851$, the equation becomes,

$$\tan \omega = \cdot 08 \times 1\cdot 1851 = \cdot 0948.$$

$\therefore$ ω = 5° 24′, which differs from the observed value by 1° 16′.

17. By making small alterations in the angular elements of Glaserite, Brookite, Epsomite, Goslarite, Cordierite, the calculated may be made to agree with the observed angle within the limits of errors of observation.

18. Hence if $\frac{A}{a} = \frac{B}{b} = \frac{C}{c}$, the expressions (1), (2), (3), for the inclination of the optic axes to the crystallographic axes *c*, *a*, *b*, when they lie in the planes *ca*, *ab*, *bc*, respectively, agree with observation, in some cases, without making any, or only slight changes, in the angular elements; but in other cases it is necessary to make considerable changes. It is therefore important to consider whether the changes required are greater than the possible errors in the angular elements.

19. Now, the measurements of the angles between the faces of different specimens of the same mineral, by the same or by different observers, often vary very considerably, sometimes as much as 1° or 2°. In Karstenite, for instance, the angle between the faces of the form 110, which are truncated by the face 010, is variously stated as 96° 36′ or 98° 54′, which differ by 2° 18′. This difference is too great to be ascribed to errors of observation. It only appears possible to account for these differences in the measurements of the same or of equally accurate observers, by supposing that the angular elements of a given mineral are liable to vary slightly in different specimens. The question is, to what causes is this variation due? Now, in isomorphous substances, the angular elements often differ by a degree or more. For instance, the angular elements of the minerals isomorphous with Aragonite are,—

	100, 100	010, 011
Aragonite, ...	58° 5′	40° 50′
Cerussite, ...	58°36′·5	40° 9′·5
Strontianite, . . .	58° 39′	40° 5′
Witherite, ...	59° 15′	38° 45′
Alstonite, ...	59° 25′·5	38° 39′

It will be observed that the angular elements of Alstonite differ respectively by 1° 20′·5 and 2° 11′ from those of Aragonite, those of the other minerals differing by less. Now Alstonite may be considered as Aragonite, in which half the carbonate of lime is replaced by carbonate of baryta. Hence we may say, that when half the lime in Aragonite is replaced by baryta, the angular elements of the latter are altered from 58° 5′ and 40° 50′ to 59° 25′·5, and 38° 39′ respectively.

Reasoning of a similar kind may be applied in a number of other cases.

Hence, we conclude that the angular elements of a mineral vary when the normal constituents are replaced by isomorphous substances.

20. Again, all crystals, except those of the cubic system, expand, in general, differently in different directions under the action of heat. This is always the case in crystals belonging to the prismatic, oblique, and anorthic systems.

Hence a change of temperature alters the angles between the faces, and therefore the angular elements, of crystals belonging to these systems, and the angular elements will in general be permanently altered if the temperature be sufficiently raised.

Hence the angular elements of a mineral depend upon the temperature to which it is or has been exposed.

21. We conclude, therefore, that the angular elements, instead of being constant in all specimens of the same mineral, vary within narrow limits, according to the amount of isomorphous replacement and the temperature to which it is or has been exposed;* and further, that the amount of this variation is quite as great as the differences which must be made in the angular elements, given in Miller's "Mineralogy," in order to make the calculated agree with the observed angle between the optic axes. It is possible that, in a number of cases, the angular elements of the crystal employed

* Many apparent cases of dimorphism may possibly be hence explained. Thus, Aragonite is not pure carbonate of lime, but is always associated with variable quantities of the carbonates of strontia, lead, or manganese. Calcite sometimes contains a considerable quantity of foreign substances,—such as protocarbonate of iron, oxide of zinc, &c. Hence, if isomorphous replacement produces changes in the angular elements, these differences in the composition of Calcite and Aragonite would be sufficient to account for the differences in their angular elements (supposing them both referred to the *prismatic* system). Graphite sometimes contains as much as 10 per cent. of iron; titanic acid is always associated in anatase, rutile, and brookite, with variable quantities of sesquioxide of iron. Differences in the angular elements may also be due to differences in the temperature at which the crystals were formed.

for determining the angle between the optic axes, were, from the causes mentioned, different from those given by Professor Miller.

22. But if the angular elements of a mineral vary within certain limits, the angle between the optic axes, calculated by the formulæ given in this note, must also vary within corresponding limits.*

The causes, therefore, which produce in a given mineral the variations in the angle between the optic axes are the same as those which produce the variations in the angular elements. That the angle between the optic axes of a crystal varies by isomorphous replacement, is established by the experiments of De Senarmont;† that it varies with the temperature to which the crystals are or have been exposed, is established by those of Des Cloizeaux.‡

The existence of this variation, therefore, far from being opposed to the existence of a connection between the form and optical properties of crystals, as argued by De Senarmont,§ is strongly in support of it.

23. Suppose that from either of the causes mentioned, the parameters a, b, c, become $a+x$, $b+y$, $c+z$, where x, y, z, are small quantities. Let the optic axes lie in the plane ca, and make an angle ω with the axis c, and let ω' be the angle corresponding to the new parameters. It is easily seen that

$$\tan\omega' = \tan\omega\left[1+\frac{\dfrac{x-y}{a-b}-\dfrac{y-z}{b-c}+\dfrac{x-y\sqrt{3}}{a-b\sqrt{3}}-\dfrac{y-z\sqrt{3}}{b-c\sqrt{3}}}{1+\dfrac{y-z}{b-c}+\dfrac{y-z\sqrt{3}}{b-c\sqrt{3}}}\right]$$

$$\text{neglecting } \frac{c+z}{a+x}\cdot$$

Hence, if 100, 110 be nearly 45° or 60°, and $x-y$ not very small in the former case, nor $x-y\sqrt{3}$ in the latter, while 010, 011 differs considerably from 45° or 60°, $\tan\omega'-\tan\omega$ will be large. In this case, therefore, the angle between the optic axes will vary considerably.

* Topaz and mica are well known examples of this variation of the angle between the optic axes.

† Annales de Chemie, third series, xxxiii. p. 391.

‡ Annales des Mines, sixth series, ii. p. 327.

§ Ibid., p. 433.

If 010, 011 be nearly 45° or 60°, and $y-z$ not very small in the former case, nor $y-z\sqrt{3}$ in the latter, while 100, 110 differs considerably from 45° or 60°, the value of tan ω' − tan ω, though considerable, will not be so great as before.

If 100, 010 and 010, 011 are both nearly equal to 45° or 60°, tan ω' will differ very little from tan ω, except when $x-y$ and $y-z$, or $x-y\sqrt{3}$ and $y-z\sqrt{3}$ differ considerably.

Hence are explained the variations of the angle between the optic axes produced by an increase of temperature in Brookite and Chrysoberyl, as observed by Des Cloizeaux.

24. We find that the expression for tan ω_c in terms of a, b, c, contains the factor $\frac{c}{a}$. For the existence of this factor no *à priori* physical reason can be assigned. Now $c=o$ represents an infinite plane, containing the crystallographic axes a and b, and tan ω_c vanishes when $c=o$. The physical interpretation of this factor therefore is, that such an infinite plane has only one optic axis which coincides with the axis c. We may compare this result with the fact, that if a ray of light is incident on a crystal of the prismatic system, in the direction of one of the principal planes, one of the refracted rays, which is polarised in that principal plane, follows the ordinary law of refraction.

25. Again, the expression for tan ω_c becomes indeterminate if

$$a-b=o, \text{ and } b-c\sqrt{3}=o;$$
$$\text{or, } b-c=o, \text{ and } a-b\sqrt{3}=o;$$
$$\text{or, } a-b\sqrt{3}=o; \text{ and } b-c\sqrt{3}=o.$$

Hence, if the angular element of a crystal of the pyramidal system were equal to 60°, it would not possess double refraction; the same would be the case if one of the angular elements of a crystal of the rhombohedral system were equal to 60°.

26. If a', b', c' be the optical constants in descending order of magnitude, and ω the angle which each optic axis makes with the axis of least elasticity, we have,

$$\tan^2\omega = \frac{a'^2 - b'^2}{b'^2 - c'^2},$$

assuming Fresnel's expression for the angle between the optic axes in terms of the optical constants;* but if the optic axes lie in the plane ca, we have also,

$$\tan{}^2\omega = \frac{(a-b)^2\,(a-b\sqrt{3})^2c^2}{(b-c)^2\,(b-c\sqrt{3})^2a^2};$$

$$\therefore\ \frac{a'^2-b'^2}{(a-b)^2(a-b\sqrt{3})^2c^2} = \frac{b'^2-c'^2}{(b-c)^2\,(b-c\sqrt{3})^2a^2},$$

which is a relation between the optical and crystallographic constants.

Similarly, if the optic axes lie in the plane ab, and $b'c'a'$ be in descending order of magnitude,

$$\frac{b'^2-c'^2}{(b-c)^2\,(b-c\sqrt{3})^2a^2} = \frac{c'^2-a'^2}{(c-a)^2\,(c-a\sqrt{3})^2b^2},$$

and if the optic axes lie in the plane bc, and $c'a'b'$ be in descending order of magnitude,

$$\frac{c'^2-a'^2}{(c-a)^2\,(c-a\sqrt{3})^2b^2} = \frac{a'^2-b'^2}{(a-b)^2\,(a-b\sqrt{3})^2c^2}.$$

27. A serious objection may be made to formulæ such as the above, expressing relations between a', b', c', and a, b, c.

In the formula

$$\frac{a'^2-b'^2}{b'^2-c'^2} = \frac{(a-b)^2\,(a-b\sqrt{3})^2c^2}{(b-c)^2\,(b-c\sqrt{3})^2a^2}$$

for instance, the left side of the equation is a function of the wavelength.

But since a, b, c depend only on the angles between the faces of crystals, which are of course invariable, the right side of the equation is independent of the wave length.

The only way of overcoming this difficulty appears to be by supposing that the apparent angles between the faces of crystals of the prismatic system, as determined by the reflective goniometer, may vary with the kind of light employed. Some experiments

* The measurements of Kirchhoff (*Ibid.*) have shown that this formula agrees closely with observation in the case of Aragonite.

Also, if $a'=b'$ the crystal becomes uniaxal, and the optic axes coincide with axis c'; hence $\tan{}^2\omega$ ought to vanish when $a'=b'$.

If $b'=c'$ the optic axes coincide with axis a'; hence $\tan{}^2\omega$ ought to become infinite when $b'=c'$. Fresnel's expression fulfils these conditions.

of Sir David Brewster on crystalline reflexion appear to countenance such a supposition; but the problem of crystalline reflexion is involved in obscurity.

28. Since all the properties of crystals, as the values of the principal refractive indices, the wave velocities, the form of the wave surface, &c., depend on the values of a', b', c', it follows that the complete solution of the problem of the connection between the form and optical properties of crystals consists in determining a', b, c' as functions of a, b, c.

$$\text{Let } \frac{a'^2}{f_1abc} = \frac{b'^2}{f_2abc} = \frac{c'^2}{f_3abc}$$

where a' b' c' are in descending order of magnitude,

$$\text{then} \qquad f_1abc - f_2abc = (a-b)^2\,(a-b\sqrt{3})^2\,c^2$$

$$f_2abc - f_3abc = (b-c)^2\,(b-c\sqrt{3})^2\,a^2$$

$$\therefore \frac{a'^2}{(a-b)^2\,(a-b\sqrt{3})^2\,c^2 + (b-c)^2\,(b-c\sqrt{3})^2\,a^2 + f_3abc}$$

$$= \frac{b'^2}{(b-c)^2(b-c\sqrt{3})^2 a^2 + f_3abc}$$

$$= \frac{c'^2}{f_3abc}$$

Hence only one function f_3abc remains to be determined. Symmetry would suggest the value $(c-a)^2\,(c-a\sqrt{3})^2\,b^2$ for f_3abc. We have not as yet, however, attempted to determine the value of f_3abc by the comparison of this formula with observation.

29. The investigation of the optical properties of crystals belonging to the oblique system is still in progress. The following is the method employed in this investigation. Each crystal is referred to three rectangular axes, one axis being perpendicular to the plane of the optic axes, the other two being the internal and external bisectors of the angle between the optic axes. The new parameters are calculated by means of formulæ investigated in a paper on the "Rhombohedral System;" and thence the angle between the optic axes is found, as if the crystal belonged to the prismatic system, by means of the formulæ given in this note. The angle between the optic axes of one mineral belonging to the oblique system has been calculated by this process; and the calculated has been found

to agree approximately with the observed angle. If this should prove to be generally the case, it will not only be a solution of the problem which forms the subject of this note for crystals of the oblique system, but it will prove that these crystals are formed according to the same laws of symmetry as crystals of the prismatic system.

9. A Contribution to the History of the Oxides of Manganese. By W. Dittmar, Esq.

It is known that oxides of manganese, when ignited in air, either absorb or lose oxygen, until they attain the composition expressed by the formula $Mn_3\ O_4$. Schneider found that when they are heated in pure oxygen, they leave the oxide $Mn_2\ O_3$.

This latter result is not what one might have expected, for we know of no positive action exerted on manganese oxides or on pure oxygen by nitrogen. Thus air should act like dilute oxygen, producing the same oxide.

To explain Schneider's result, we must suppose either that artificial oxygen differs from that contained in air, or, what is more likely, that the amount of oxygen which any given quantity of manganese can take up when heated in it, depends not only on the temperature, but also *on the tension of the oxygen* employed.

If, then, it is true, that at a red heat, in presence of oxygen of the tension of one atmosphere, $Mn_2\ O_3$ is a stable compound, while the same oxide, exposed to the same temperature in presence of oxygen of the tension of one-fifth of an atmosphere, is reduced to $Mn_3\ O_4$, the question naturally arises, What oxides will be formed in presence of oxygen of different tensions from those two above mentioned? Is there a continuous series of oxides corresponding to a continuous series of oxygen-tensions under which they have been formed?

These questions seemed to me to merit investigation, especially as their results would form an addition to our very imperfect knowledge of the influence of physical conditions on chemical reactions.

In the first series of experiments, pure peroxide of manganese, in a porcelain or platinum boat, was placed in a porcelain tube, kept at a bright red heat, while a current of nitrogen or oxygen, or of a mixture of these two gases, was passed over it. The resulting oxide was weighed and analysed by determining the quantity of protoxide it yielded when heated in a current of hydrogen. Most of the experiments were carried on under ordinary atmospheric pressure; but in a few cases, the tension of the gas was made less than one atmosphere by connecting the exit end of the porcelain tube with a large bell-jar, within which the pressure was diminished, and kept constant by means of an air-pump.

Eighteen experiments gave the following results.

In all cases, either black Mn_2O_3, or brown Mn_3O_4 was obtained; *no intermediate oxides were formed.*

In all the cases in which Mn_3O_4 was obtained, the partial tension of the oxygen lay between 0 and 0·21 atmospheres (the latter tension being that of the oxygen of the atmosphere). In all the experiments in which Mn_2O_3 was obtained, the partial tension of the oxygen lay between 0·25 and one atmosphere.

Oxygen tensions intermediate between 0·21 and 0·25 did not occur in the series; but in spite of this gap, the results obtained render it highly probable that the function expressing the relation between the composition of an oxide of manganese which is formed at a red heat in an atmosphere of oxygen, and the tension of that oxygen is discontinuous, so that Mn_2O_3 is formed whenever the tension *exceeds*, and Mn_3O_4 whenever it is *below a certain definite limit.*

To determine whether such a point of discontinuity really exists, and if so, its position, a second series of experiments was performed, which were made as uniform, and therefore comparable, as possible. In all cases, the MnO_2 was heated in mixtures of nitrogen and oxygen of exactly known composition, kept at, or very near to, the tension of the surrounding atmosphere. The percentages of oxygen in those mixtures were so chosen as gradually to inclose the value sought for within narrower and narrower limits In each experiment, the height of the barometer was determined, in order to know exactly the partial tension of the oxygen in the mixture.

Eleven experiments were made in all. In eight, the oxides obtained were either pure Mn_2O_3, or Mn_3O_4. In three, the oxides were obtained together, not mixed, but as it were side by side, and occupying different parts of the boat. In those cases, in which

Mn_3O_4 was obtained alone, or at least in which it predominated, the partial tension of the oxygen (when measured by the height of the equivalent column of mercury) did not exceed 7·07 inches.

In those cases in which Mn_2O_3 was obtained, or at least predominated, the partial tension of the oxygen was equal to, or greater than, 6·9 inches. Thus the point of discontinuity lies between the two limits 6·9 and 7·07 inches.

Within these two tensions, sometimes the one and sometimes the other oxide was obtained. This fact does not speak, however, against the existence of some definite point of discontinuity, as the composition of the resulting oxide depends on the temperature at which the experiment is performed, as well as the tension of the oxygen employed. A diminution of temperature is probably of the same effect as an increase in the tension of the oxygen, and *vice versa*. Thus, if the tension of the oxygen in a given mixture of that gas and nitrogen is just equal to that corresponding to the point of discontinuity, for a definite temperature t, a temperature slightly above that will cause the formation of Mn_3O_4, and one slightly below will produce Mn_2O_3.

In one experiment I succeeded in producing the two oxides by means of the same mixture of nitrogen and oxygen, only the tension being slightly varied. Mn_2O_3, heated in this mixture at the atmospheric pressure of 29·9 inches, remained unchanged, while at the tension of 29·5 it was reduced to Mn_3O_4. This is quite within the limit of ordinary barometrical variations.

10. Notice of Glacial Clay, with Arctic Shells, near Errol, on the Tay. By the Rev. Thomas Brown, F.R.S.E.

The author referred to the paper on the Elie Glacial Clay, with Shells, read by him on the 2d of March 1863. During the succeeding summer he learned from Dr M'Bain, that shells had been found in a brickfield near Errol, but so badly preserved, that none of the species had been determined. During the autumn, while staying in the neighbourhood of Perth, he took occasion to visit the Errol brickfield, and found that the shells, which occur in considerable abundance, are precisely the same group with those at Elie. The *Leda truncata*, for example, which is the characteristic shell of the deposit at Elie, is yet more abundant at Errol, along with the *Pecten Grœnlandicus*, and most of the peculiar Arctic shells of the deposit. Some interesting additions to the list of Arctic species were obtained at Errol. The skeleton of a seal was also found; but the description of these fossils, as well as the observations made on the nature of the deposit and its stratigraphical relations, were reserved for a future occasion. The author merely wished to direct attention to the fact, that those glacial clay beds of the Forth are found also in the Tay.

11. Notes on the Boulder-Clay at Greenock and Port-Glasgow. By the Rev. R. Boog Watson, B.A., F.R.S.E., Hon. Mem. Nat. Ver. Lüneburg.

In Greenock, excavations have lately been made for a new gasometer. The works are now completed, but the superintendent, a most intelligent man, took me to the place, and told me what they had found in the course of digging.

The site of the excavation is close to the shore, and very little above the tide-mark.

At the south-east corner of the works, *i.e.*, most remote from the sea, the workmen reached the rock at a depth of 20 feet. It was a soft shale, and I could not ascertain that any striations were observed on it. Probably there were none preserved on such material. Its upper surface was flat. Towards the sea, or north and west, the rock sloped downwards very steeply, and this seaward face was covered by a great bed or bank of sand, that sloped up from the edge of the rock, and as it receded rose higher as a bank.

The flat surface of the rock was covered by from 6 to 12 inches of a fine soft clay without stones. I could not learn whether this clay overlay or dipped under the sand-bank, or whether it simply disappeared altogether at the edge of the rock, where the sand-bank began. The last alternative seems the most probable.

Above the clay lay from 18 to 20 feet of boulder-clay, a little thinner, of course, over the back of the sand-bank. The boulder-clay was dark in colour, sandy, and full of striated stones, some of which were of considerable size—in short, exactly similar to what we have at Leith and Newhaven.

The interest of this section lies in the fact of its proving, that the boulder-clay in this case was deposited in water. This is obvious, not only from the sedimentary character of the underlying clay and sand, with which the boulder-clay is here associated, but also from the soft nature and exposed condition of these underlying beds which could not possibly have resisted the pressure of ice. The boulder-clay seems here, therefore, to have been dropped from under the edge of the ice-cake covering of our land just where it began to float at the shore line, and thus quietly to have buried the true marine deposits now underlying it.

Another locality, where I recently examined the boulder-clay, is in the cutting of the New Wemyss Bay Railway, where it approaches its junction with the present Greenock Railway, just below Port-Glasgow. The new railway cutting here runs at a height of 60 feet above the sea, along the edge of the steep slope, the base of which is the flat known as the 40-foot sea-beach. The old railway runs here along this flat; and it was in this neighbourhood that the shell-bed described by Mr Smith of Jordanhill occurs in a bed of sand overlying the boulder-clay. The boulder-clay is somewhat redder, but otherwise exactly like that in the railway cutting which is now being made between Newhaven and Leith. It is dark, sandy, and full of striated stones. Through it there runs horizontally a well marked stratum of fine sand and clay about two inches thick, which I traced for several yards, till it was lost in the debris of the cutting In the midst of this boulder-clay at a height of about 60 feet above the sea, I found several fragments of shells, one or two of which seemed to belong to an *astarte;* the others were unrecognisable. Under the boulder-clay the rock has been laid bare, and both its seaward face and upper surface are well seen. It is a coarse sandstone; its upper surface is very strongly striated and well rounded.

Here then, as in the former case, we have evidence that the boulder-clay was deposited in the sea. It was land ice which formed the materials of the boulder-clay, and consolidated them by its pressure. This is now generally admitted, but the presence of the shells and the existence of the stratum of sand and clay indicate that these materials were deposited on a surface covered by the sea. But there are indications here of a still more interesting fact. The steep bank or cliff which pretty generally along our coasts rises from a flat elevated about 40 feet above the sea, has always been spoken of as a beach formed by the sea, and not a few calculations have been made to determine from a comparison with our existing sea-beach the length of time during which the sea must have stood at the higher level, in order to its having eroded our land in the very marked way which the upper or 40-foot terrace presents. But plainly, before any such calculations are legitimate, it ought to be proved that the 40-foot terrace is really the work of the sea. Now, this seems to have been somewhat hastily assumed. Undeniably, the sea does act powerfully on the shore, cutting out a step or forming a beach line along its margin; further, it is obvious, that that margin was at one time 40 feet higher along our coasts than now, and the inference has been jumped at, that the terrace which does certainly exist at that level was formed by the sea. In other words, a connection of proximity between the sea and the 40-foot terrace being proved, the connection of cause and effect has been assumed. But is the assumption legitimate? Now this cutting at Port-Glasgow shows that the 40-foot terrace exists not merely on the external surface, but in the rock beneath. The superficial deposits are merely the clothing of a rocky skeleton beneath, and the terrace which we can trace on the surface, we find existing in the rock below. What then gave its form to that rocky skeleton below? Was the sea the agent which cut the terrace there? Plainly not, for when the sea beat on the shore 40 feet above its present level, the rock, in its present form, was buried even deeper than now under that mass of boulder-clay which still covers it, and which the sea, at this particular spot at least, and at many others, was not able to penetrate. But was the boulder-clay already there? Admitting what is obvious, that *if there*, it alone and not the underlying rock could be fashioned by the sea, are we sure that it really was already deposited, or may it not rather have been deposited at the very time we are speaking of, when the land in its upward progress still stood 40 feet lower than now?

Now, of this earlier presence of the boulder-clay we have abundant proof. The rock surface here and elsewhere on our coasts is sharply striated. The striating agent, it is now generally admitted, was land ice in the form of a thick glacier cake, grinding downwards, and pressing outwards towards the sea. This glacier cake must have been slowly floated off by the gradual subsidence of the land. As it floated off the boulder-clay was deposited under the edge of the ice-foot on the freshly striated surface of the rock, protecting it at once from the action of the surf, consolidated under the pressure of the ice-cake, but showing traces in its shells and its stratified layers of the presence of the sea. There on the surface of the rock the boulder-clay has rested throughout the long period during which the land subsided to a depth of 1500 or 1700 feet or more, and again re-emerged till it approached, under an ever softening climate and with a more temperate fauna, to almost its present level.

In short, the 40-foot beach terrace owes its configuration not so much to the external action of the sea, as to the internal contour of the rock. That contour was derived from the grinding agency of the ice-cake covering, and between the period when that contour was given to it, and the presence of the sea at the 40-foot beach-line, there have intervened all the countless ages, with their manifold changes, of the subsidence and re-elevation of our land.

The following gentlemen were elected Fellows of the Society:—

Arthur Abney Walker, Esq.
John Foulerton, M.D.

The following Donations to the Library were announced:—

Memorie della reale Accademia delle scienze di Torino. Serie seconda : tomo XX. 4to.—*From the Academy.*

Proceedings of the Royal Horticultural Society, May 1864. 8vo. —*From the Society.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Germanicæ Naturæ Curiosorum. Tomus Tricesimus. 4to.—*From the Academy.*

Abhandlungen der königl. Gesellschaft der Wissenschaften zu Göttingen. XIter Band. von den Jahren 1862 und 1863. 4to.—*From the Society.*

Nachrichten von der Georg-Augusts-Universität zu Göttingen. Nr. 1–21. Nebst Register. 8vo.—*From the University.*

Mémoires de la Société de Physique et d'Histoire naturelle de

Genève. Tome XVII. Première Partie. 4to.—*From the Society.*

Annalen der königl. Sternwarte bei München IV. Supplement band. 8vo.—*From the Observatory.*

Scheikundige Verhandelingen en onderzoekingen uitgegeven door G. J. Mulder. Derde Deel—derde stuk. 8vo.—*From the Author.*

Journal of the Scottish Meteorological Society, April 1864. 8vo. —*From the Society.*

Proceedings of the Academy of Nat. Sciences of Philadelphia. Nos. 3–7. 1863. 8vo.—*From the Academy.*

Observations on the Genus Unio. By Isaac Lea, LL.D. Vol. X. 4to.—*From the Author.*

Journal of the Academy of Natural Sciences of Philadelphia. Vol. V. Part IV. 4to.—*From the Academy.*

Yorkshire Philosophical Society Annual Report for 1863. 8vo. —*From the Society.*

Astronomical and Meteorological Observations made at the U.S. Naval Observatory during 1862. 4to.—*From the U.S. Naval Observatory.*

Abstracts of Magnetical Observations made at the Magnetical Observatory, Toronto, during 1856–62, and during parts of 1853, 1854, and 1855. 4to.—*From the Observatory.*

Observations of the Spots on the Sun from November 9, 1853 to March 24, 1861, made at Redhill by Richard Christopher Carrington, F.R.S. 4to.—*From the Author.*

Jahresbericht über die Fortschritte der Chemie herausgegeben von H. Kopp u. H. Will, für 1862. Zweites Heft. 8vo.—*From the Authors.*

Comptes Rendus for 1863. 4to.—*From the Academy of Sciences.*

Journal of the Society of Arts for 1863. 8vo.—*From the Society.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1864–65. No. 65.

Eighty-Second Session.

Monday, 28th November 1864.

His Grace THE DUKE OF ARGYLL, in the Chair.

The following Council were elected:—

President.

Principal Sir DAVID BREWSTER, K.H., LL.D., D.C.L.

Vice-Presidents.

Dr Christison.
Professor Kelland.
Hon. Lord Neaves.
Principal Forbes.
Professor Innes.
Prof. Lyon Playfair, C.B.

General Secretary,—Dr John Hutton Balfour.

Secretaries to the Ordinary Meetings.

Dr George James Allman.
Professor P. Guthrie Tait.

Treasurer,—David Smith, Esq.

Curator of Library and Museum,—Dr Douglas Maclagan.

Councillors.

Dr William Robertson.
Dr E. Ronalds.
T. C. Archer, Esq.
W. F. Skene, Esq.
A. Keith Johnston, Esq.
Rev. Dr Stevenson.
Dr Stevenson Macadam.
Hon. Lord Jerviswoode.
James T. Gibson-Craig, Esq.
Edward Sang, Esq.
Sir James Coxe, M.D.
Rev. Dr Blaikie.

Monday, 5th December 1864.

His Grace the Duke of Argyll, at the request of the Council, delivered the following Opening Address:—

In opening this Session of the Royal Society of Edinburgh, at the close of my tenure of the Presidency, I must express my sincere regret on account of the small amount of attendance which it has been in my power to give. I can only assure you that, if I had had the opportunity, my attendance would have been far more regular; and that nothing but the impossibility of reconciling this with other duties has prevented my occupying this chair as often as the honour you have done me, and not less my own inclination, would have led me to do.

During the years which have elapsed since I first had the honour of addressing you from this chair, science has been enriched by an accumulated store of facts in many branches of inquiry, and by not a few of those discussions which so often promote, quite as much as actual discovery, the advance of knowledge. Our own Society has not been idle. Valuable papers have been communicated on a great variety of subjects; and when we look, not merely at the number and variety of these, but at the detailed character of many of them, and remember the number of Societies which are specially devoted to special subjects, it is impossible not to be impressed with the immense scope, as well as with the laborious minuteness, of modern investigation. But, divided and subdivided as the natural sciences have come to be, they all touch each other at innumerable points; and there are some questions touching the shadowy line that connects rather than separates the physical and the metaphysical, on which almost all the sciences are found to have a common, and often an unexpected bearing. Such, for example, is the subject with which Geology, and Palæontology, and Comparative Anatomy, and Archæology, and the mental sciences, have all been of late years so busy, and on which different schools of thought are now disputing every inch of ground. That subject is the history of Organic Life; and the question, whether in that history we can trace anything beyond a series of disconnected facts, —anything in the nature of a Law.

I propose in this paper to make some observations upon this subject, in two of its most general aspects—

1. Upon the idea of "Creation by Law," how we should define it, and in what light we should regard it.

2. On the bearing which existing theories on the "Origin of Species" have upon our knowledge and conception of Creation by Law.

The word "Law" is very often so loosely used that it is absolutely necessary to begin any discussion on this subject by defining the sense in which it is to be understood. Much dispute, in science as well as in other matters, may often be avoided by a simple definition. If Law be understood to mean nothing more than an "observed order of facts," there need be no discussion at all on "Creation by Law." There can be no doubt whatever that there is an "observed order" in the forms of organic life. They are all allied to each other after an order and gradation which is as certain as it is mysterious. But, assuredly, this is not the sense in which creation by law is so eagerly affirmed by some, and as jealously contested by others. "Law," however, generally means not merely the "observed order of facts," but some Force which is its compelling cause. Force is the root idea of Law in its scientific sense. The law of gravitation, which is the purest example, is not merely the "observed order" in which the heavenly bodies move, but it is the force which compels those movements, and (in a sense) explains them. The difference between "law" in the narrower, and "law" in the larger sense, may be roughly illustrated by the "Three special Laws" discovered by Kepler, as compared with the one universal Law discovered by Newton. The Three Laws of Kepler were simply and purely "an observed order of facts," in respect to the planetary orbits. They stood by themselves—disconnected —their cause unknown. But the higher law discovered by Newton revealed their connection and their cause. The "observed order" which Kepler had discovered was simply a necessary consequence of the law of gravitation. In its light, the three laws of Kepler have been merged and lost.

It is true, indeed, that Law, in the narrower sense, suggests and implies the existence of Law in the wider sense. An observed order of facts—assuming, of course, that the order is constant under the same conditions—implies the action of some force of which that order is the index and the result. But the mere general idea that *some* force is at the bottom of all phenomena which are invariably consecutive, is a very different thing from knowing what that force is, in respect to the rule or measure of its operation. It is, indeed, the great object of pure science, to ascertain the measures of force. Mr Lewes, in the very curious and interesting work which he has lately published on the philosophy of Aristotle, has maintained that the knowledge of measure—or what he calls the "verifiable element" in our knowledge—is the element which determines whether any theory belongs to science, or to metaphysics; and that any theory may be transferred from metaphysics to science, or from science to metaphysics, simply by the addition or withdrawal of its "verifiable element." In illustration of this he says, that if we withdraw the formula "inversely as the square of the distance, and directly as the mass," from the law of universal attraction, "it becomes pure metaphysics."* If this means that, apart from ascertained numerical relations, our conception of law loses all reality and distinctness, I do not agree in the position. I think the idea of natural forces is quite separate from any ascertained measurement of their energy; that, for example, the knowledge that all the particles of matter exert an attractive force upon each other, is, so far as it goes, true physical knowledge, even though we did not know the farther truth that this force acts according to the numerical rule ascertained by Newton. That matter attracts matter is a definite idea,—although it is less definite, or less complete than the idea that the measure of that attraction is "directly as the mass, and inversely as the square of the distance." This is undoubtedly the highest, or perhaps I ought to say, the ultimate, conception of a scientific "law,"—force ascertained according to some method and measure of its operation.

But now we must go a step farther. What is force? What is our conception of it? What idea can we form, for example, of the real nature of that force, the measure of whose operation has been

* Aristotle. By G. H. Lewes. P. 84.

so exactly ascertained—the force of gravitation? It is invisible, —imponderable. All our words for it are but circumlocutions to express its phenomena or its effects. There are many kinds of force in nature—which we distinguish after the same fashion—according to their effects, or according to the forms of matter in which they become cognisable to us. But if we trace up our conceptions on the nature of force to their fountain-head, we shall probably find that they are connected, more or less directly, with our own consciousness of living effort,—of that force which has its seat in our own vitality, and especially with that kind of it which can be called forth at the bidding of the will. If we can ever know anything of the nature of any force, it ought to be of this one. And yet the fact is that we know nothing. The vital forces which work in our organisation, work, for the most part, entirely independent of our will, and even of our consciousness. Those of them which are at the bidding of will are subject to it only through an elaborate machinery; and if that machinery be damaged, we know too often, by sad experience, that their connection with the will is broken. If, then, we know nothing of that kind of force which is so near us, and with which our own intelligence is, so to speak, in such close alliance, much less can we know the ultimate nature of force in its other forms. I dwell on this because I think that both the aversion with which some men regard the idea of creation by Law, and the eagerness with which some others hail it, are founded on a notion, that when we have traced any given phenomena to what are called natural forces, we have traced them farther than we really have. We know nothing of the ultimate seat of force. Science, in the modern doctrine of the Conservation of Energy and Convertibility of Forces, is already getting something like a firm hold of the idea, that all kinds of force are but forms and manifestations of some one central force, issuing from some one fountain-head of power. Sir John Herschel has not hesitated to say, that "it is but reasonable to regard the force of gravitation as the direct or indirect result of a consciousness, and a Will existing somewhere."* And even if we cannot assume that force, in all its forms, is due to the direct working of the Creator, at least let us not

* Outlines of Astronomy. 3d ed. p. 265.

assume the contrary,—let us not speak or think as if the forces of nature were either independent of, or even separate from, His power. The idea of Creation by Law leaves these questions exactly where it found them. It has no adverse bearing on theology; and those who prize it under the notion that it has this bearing, as well as those who dread it on the same account, are equally forgetful of what "Law," in a scientific sense, must be defined to be.

But there is still another sense in which the word "Law" is habitually used in science; and this is perhaps the most common and the most important of all. It is used to designate not merely an observed order of facts—not the bare abstract idea of force—not mere individual forces, according to ascertained measures of operation—but forces as combined with each other, and fitted to each other for the attainment of special ends. The whole science of mechanics, for example, deals with Law in this sense—with natural forces as related to purpose and subservient to intention. And here we come upon "Law" in a sense which is more perfectly intelligible to us than in any other; because, although we know nothing of the nature of force, even of that force which is resident in ourselves, we do know for what ends we exert it, and what is the "law" governing our devices for its use. That law is—combination for the accomplishment of purpose. The universal prevalence of this idea in nature is indicated by the irresistible tendency which we observe in the language of science to personify the forces, and the combinations of force, to which all natural phenomena are in the first instance due. It is a great injustice, too often committed, to suspect scientific men of unwillingness to accept the idea of a personal Creator, merely because they try to keep separate the language of science from the language of theology. The separation may sometimes be due to such unwillingness, but quite as often—I hope much oftener—it is a separation which is maintained for other and better reasons. But it is curious to observe how the attempt breaks down,—that is, how impossible it is, in describing physical phenomena, to avoid the phraseology which identifies them with the phenomena of mind, and is moulded on our own conscious personality and will. It is impossible to avoid this language, simply because no other language conveys the impression which innumerable structures leave upon the mind. Take, for example, the word "Contrivance." How could science do without it? How could the great subject of animal mechanics be dealt with scientifically without continual reference to Law as that by which, and through which, special organs are formed for the doing of special work. What is the very definition of a machine? Machines do not increase force, they only adjust it. The very idea and essence of a machine is that it is a contrivance for the distribution of force with a view to its bearing on special purposes. A man's arm is a machine in which the law of leverage is supplied by the vital force for the purposes of prehension. A bird's wing is a machine in which the same law is supplied, under most complicated conditions, for the purposes of flight. It is impossible to describe the facts we meet with in this or in any other branch of science, without investing the laws of nature with something of that personality which they do actually reflect, or without conceiving of them as partaking of those attributes of mind which we everywhere recognise in their working and results. If any one imagines that the idea of Creation by Law casts out the idea of creation under the supreme control of purpose, let him read one of the later works of Mr Darwin,—I refer to his most curious work on "The Fertilisation of the Orchids." In investigating the laws which determine the form and the propagation of this strange order of plants, Mr Darwin finds it impossible to describe them without exhausting all the forms of language in which we can express the workings of intention and of mind in the determination of physical results.

I am afraid that to some this discussion may, at first sight, appear irrelevant. But I am sure this impression will be removed in those who recollect how powerfully ambiguity of language reacts upon the progress of knowledge. Words which should be the servants of thought are too often its masters; and I know of no word which has been used more ambiguously, and therefore more injuriously, than the word "Law." I do not mean that it may not be legitimately used in several different senses. It is in all cases, as applied in science, a metaphor, and one which has relation to many different kinds and degrees of likeness in the ideas which are compared. It matters little in which of these senses it is used, provided the distinctions between them are kept clearly in view, and provided we watch against the fallacies which must arise when we pass, in its use, from one meaning to another. There are at least four different senses which must be carefully distinguished—

1. We have Law as applied simply to "an observed order of facts."
2. To that order as involving the action of some force or forces, of which nothing more may be known.
3. As applied to individual forces, the measure of whose operation has been more or less defined and ascertained.
4. As applied to those combinations of force which have reference to the fulfilment of purpose or to the discharge of function.

Now, in which of these senses does science justify us in entertaining the idea of "Creation by Law?"

First, it is certain that there is an "observed order of facts" both in the organic and in the inorganic world. I mean to speak in this paper of the organic world alone, and chiefly of those higher forms which are the seat of animal life. In these there is an observed order in the most rigid scientific sense, that is,—phenomena in uniform connection, and mutual relations which can be made, and are made, the basis of systematic classification. These classifications are imperfect, not because they are founded on ideal connections where none exist, but only because they fail in representing adequately the subtle and pervading order which binds together all living things. But the order which prevails in the existing world is not the only order which has been recognised by science. A like order has prevailed through all the past history of creation. Nay, more; it has, I think, been clearly ascertained, not only that relations similar to those which now exist have existed always among all the animals of each contemporary creation, but that order of a like kind has connected with each other all the different creations which were successively introduced. In almost all the leading types of life which have existed in the different geological ages, there is an orderly gradation connecting the forms which were becoming extinct with the forms which were for the first time appearing in the world. It is still disputed by some geologists, whether we have certain evidence that this gradation has been the gradation of a rising scale—of progressive creations from lower to higher types. But this dispute is maintained only on the ground, that we cannot safely trust to negative evidence. It is an unquestionable fact, that so far as this kind of evidence can go, it does testify to the successive introduction of higher and higher forms of Life. Very recently, a discovery has been made, to which Mr Darwin only a few years ago referred, as "a discovery of which the chance is very small," viz., of fossil organisms in beds far beneath the lowest Silurian strata. This discovery has been made in Canada—in beds far down, near the bottom even, of the rocks hitherto termed "Azoic." But what are the forms of life which have been found here? They belong to the very lowest of living types,—to the "Rhizopods." So far as this discovery goes, therefore, it is in strict accordance with all the facts previously known,—that as we go back in time, we lose, one after another, the higher and more complex organisms,—first, the Mammalia; then, the Vertebrata; and now lastly, even the Mollusca. It is in accordance, too, with another fact which has been observed before, viz., that particular forms of life have attained, at particular epochs, a maximum development both in respect to size and distribution,—the favourites as it were, of Creation for a time. These earliest Rhizopods seem to have been of enormous size and developed on an enormous scale, since there is good reason to believe that beds of immense thickness are composed of their remains. All that is new in this discovery is the vast extension which it gives in time to the same rules which had been already traced through ages which we cannot number. The facts of creation, therefore, do range themselves in an observed order, and in this sense, at least, it may be said with truth that creation has been "by Law."

And now we advance one step farther. Every observed order in physical phenomena does suggest irresistibly to the mind the operation of some physical cause—the working of some force or forces, of which nothing more may be known than these their visible effects. This is the second of the four senses in which I have said that "Law" is frequently used. We say of an observed order of facts that it must be due to some "Law," meaning simply that all order involves the idea of some arranging cause, the working of some force, whether it be one which we can trace and define or not. In these two senses, then, both somewhat vague, it cannot be doubted that Creation has been by Law.

The next question, however, is the main one—Is the observed order which prevails in nature, and especially in the organic world, an order of which we can even guess the physical cause? Is it an order which contains within itself any indications of the force or forces which have been concerned in producing it?

In considering this question, there is one thing to be observed at the outset. It is certain that nothing is known or has been even guessed at, in respect to the history and origin of Life, which corresponds with Law in its strictest and most definite sense. We have no knowledge of any one or more forces—such as the force of gravitation, or of magnetic attraction and repulsion—to which any one of the phenomena of Life can be traced. Far less have we any knowledge of any such laws which can be connected with the successive creation or development of new organisms. Professor Huxley, in a recent work,* has indeed spoken of "that combination of natural forces which we term Life." But this language is purely rhetorical. I do not mean to say that Life may not be defined to be a kind of force, or a combination of forces. All I mean is, that we know nothing of any of these forces in the same sense in which we do know something of the force of gravity, or of magnetism, or of electricity, or of chemical affinity. These are all more or less known, not, indeed, in respect to their ultimate nature, but in respect to certain methods and measures of their operation. No such knowledge exists in respect to any of the forces which have been concerned in the development of Life. No man has ever pretended to get such a view of any of these as to enable him to apply to them the instruments of his analysis, or to trace in their working any of those definite relations to space, or time, or number, which are always the ultimate quest of science, and the discovery of which is her great reward.

Since, then, laws, in this most definite sense of the word, have not been discovered in the existing phenomena, or in the past history of organic life, let us look a little closer at the ideas which

* Elements of Comparative Anatomy, p. 2.

these phenomena have suggested to the mind of those who have speculated on the origin and development of species.

There is one idea which has been common to all theories of development, and that is the idea that ordinary generation has somehow been producing, from time to time, extraordinary effects, and that a new species is, in fact, simply an unusual birth. It is worthy of observation, that the earlier forms in which the theory of development appeared, did suggest something more nearly approaching to a law of creation than is contained in the later form which that theory has assumed in the hands of Mr Darwin. The essential idea of the theory of development, in its earlier forms, was, that modifications of structure arose somehow by way of natural consequence from the outward circumstances or physical conditions, which required them, and from the living effort of organisms sensible in some degree of that requirement. Now, inadequate and even grotesque though this idea may be as explaining the origin of new species, it cannot be denied, that it makes its appeal to a process which, at least to a limited extent, does operate in producing modifications of organic structure. For example, the same species of mollusc has often a shell comparatively weak and thin, or a shell comparatively robust and strong, according as it lies in tranquil or in stormy water. The shell which is much exposed needs to be stronger than the shell which is less exposed. But the mere fact of the need cannot supply the thing needed, unless by the adjustment of some machinery for the purpose. How the vital forces of the mollusc can thus be made to work to order, under a change of external conditions, we do not know. But we do know, as a matter of fact, that the shell is thickened and strengthened, according as it needs resisting power. This result does not appear to arise from any difference in the amount of lime held in solution in the water, but upon some power in the secreting organs of the animal to appropriate more or less of it, according to its own need. The effects of this power are seen where there is no difference of condition except difference of exposure. I have seen it stated, that they are observable in the shells which lie on the different sides of Plymouth breakwater,—the sheltered side and the exposed side. The same power of adaptation is seen in many other forms. Trees which are most exposed to the blast are the most strongly anchored in the soil. Limbs which are most used are the most developed. All these results arise by way of natural consequence. How shall we describe them? Shall we say that they are the result of Law? We may safely do so, remembering only that by Law, in this sense, we mean nothing but the co-operation of different natural forces, which, under certain conditions, work together for the fulfilment of an obvious intention. Of the nature of those forces we know nothing; nor is it easy to conceive how they have been so co-ordinated as to produce effects fitting with such exactness into the conditions requisite for the preservation of organic life. If there were any evidence that by the same means new forms of life could be developed from the old, I cannot see why there should be any reluctance to admit the fact. It would be different from anything that we see; but I do not know that it would be at all more wonderful, or that it would bring us much nearer than we now stand to the great mystery of creation. I look upon the adaptation and arrangement of natural forces, which can compass these modifications of animal structure, in exact proportion to the need of them, as an adaptation and arrangement which is in the nature of creation. It can only be due to the working of a power which is in the nature of creative power. We are so accustomed to these and other similar phenomena, and to hide our own ignorance of their cause, by describing them as the result of "Law," that we forget what a multitude of natural forces must be concerned in their production, and what complicated adjustments of these amongst each other for the accomplishment of purpose. It is purely, therefore, in my view, a question of evidence, whether this particular law of adaptation has or has not been the means of introducing new forms of life. There is no evidence that it has. So far as we know, this power of self-adaptation, wonderful as it is, has a comparatively limited application; when that limit is outrun by changes in outward conditions, which are too great or too rapid, whole species die and disappear. Nevertheless, the introduction of new species to take the place of those which have passed away, is a work which has been not only so often, but so continuously repeated, that it suggests the idea of having been brought about through the instrumentality of some natural process. But we may say with confidence, that it must have been a process different from any that we yet know—a process not the same as that, obscure as this is, which produces the lesser modifications of organic forms.

It has not, I think, been sufficiently observed, that the theory of Mr Darwin does not address itself to the same question, and does not even profess to trace the origin of new forms to any definite law. His theory gives an explanation, not of the processes by which new forms first appear, but only of the processes by which, when they have appeared, they acquire a preference over others, and thus become established in the world. A new species is, indeed, according to his theory, as well as with the older theories of development, simply an unusual birth. The bond of connection between allied specific and generic forms, is in his view simply the bond of inheritance. But Mr Darwin does not pretend to have discovered any law or rule according to which new forms have been born from old forms. He does not hold that outward conditions, however changed, are sufficient to account for them. Still less does he connect them with the effort or aspirations of any organism after new faculties and powers. He frankly confesses that "our ignorance of the laws of variation is profound;" and says, that in speaking of them as due to chance, he means only "to acknowledge plainly our ignorance of the cause of each particular variation."* Again he says—"I believe in no law of necessary development."† This distinction between Mr Darwin's theory and other theories of development, has not, I think, been sufficiently observed. His theory seems to be far better than a mere theory—to be an established scientific truth—in so far as it accounts, in part at least, for the success and establishment and spread of new forms *when they have arisen.* But it does not even suggest the law under which, or by which, or according to which, such new forms are introduced. Natural selection can do nothing except with the materials presented to its hands. It cannot select except among the things open to selection. Natural selection can originate nothing; it can only pick out and choose among the things which are originated by some other law. Strictly speaking, therefore, Mr Darwin's theory is not a theory on the origin of species at all, but only a theory on the causes which lead to the

* Origin of Species, p. 131 (1st edition). † Ibid. p. 351.

relative success or failure of such new forms as may be born into the world. It is the more important to remember this distinction, because it seems to me that Mr Darwin himself frequently forgets it. Not only does he speak of natural selection "producing" this and that modification of structure, but he undertakes to affirm of one class of changes that they can be produced, and of another class of changes that they cannot be produced, by this process.* Now, what are the changes for the preservation of which his theory does, in some sense, account? They are such changes, and these only, as are of some direct use to the organism in the "struggle for existence." Any change which has not this direct value, is not provided for in the theory. All structures, therefore, are unaccounted for—not only as respects their origin, but even as respects their preservation—in which the variations have no other value than mere beauty or variety. Accordingly, Mr Darwin is tempted to deny that any such structures exist in nature. Now, I hold that any theory of which this denial is really a necessary part, is self-condemned. Yet a theory may be good as accounting for the preservation of some structures, although it fails to account in this respect for others. And so the fact that natural selection cannot have operated on structures of mere beauty and variety is no proof that the theory of natural selection is false, but only that it is incomplete. It does not account for the origin of any structure; and it accounts for the preservation of only a certain number. Surely, then, Mr Darwin assigns to his "law" of natural selection a range far wider than really belongs to it, when, on the strength of it, he denies that beauty for its own sake can be an end or object in organic forms. He says—"This doctrine, if true, would be absolutely fatal to my theory." Why should this be fatal to his theory, except on the supposition that Natural Selection gives a complete account both of the origin of new forms, of which, in reality, it gives no account at all, and of their preservation, of which it does give some account, but one which is only partial? I dwell on this, because it lies at the very root of the question how far Mr Darwin's theory can be said to suggest anything in the nature of a creative law of a kind to explain the

* Origin of Species, p. 200 (1st edition).

method which has been followed in the introduction of new forms. Let us test this question by bringing to bear upon it some particular example of specific variation. I select for this purpose one example to which my attention has been lately directed, which will illustrate what I mean better than any abstract discussion. It is the case of the Humming-birds.

This group of birds seems to me to exhibit, in the most striking form, not a few of those mysteries of creation which at once tempt us to speculate on the origin of species, and at the same time confound every endeavour to bring it into relation with any process which we know or can conceive. In the first place, they are sharply defined from all other forms in that class of the animal kingdom to which they belong. It is most difficult to say what is their nearest affinity, and the nearest, when it is found, is very distant. Secondly, they are absolutely confined to one continent of the globe. In the third place, the various species as amongst themselves are very closely united, ranging indeed over a great variety of forms, but for the most part connected with each other by very nice gradations. In the fourth place, there are, so to speak, some gaps in the scale, which suggest that some species have either been lost, or have not yet been discovered. In the fifth place, each of these species, however nearly allied to some other, appears to be absolutely fixed and constant, there being not the slightest indication of any mixture—of any hybrid forms. In the sixth place, there is the most wonderful adaptation of special organs for the performance of special functions, and for the relation of these organs to particular structures in the vegetable kingdom. In the seventh place, there is a development, for which in extent and variety there is no parallel in the world, of structures designed for mere ornament, and entirely separate from any other known or conceivable use.

A few words on some of these characters will show their separate and joint bearing on the idea of Creation by Law.

In the first place, then, the absolute distinctiveness from all others of this family of birds, coupled with its immense extent, gives the idea of some common bond, some physical cause, to which such an identity in physical characters must be due. This identity prevails not only in such essential matters as the structure of the bill and tongue, in the form of the feet and of the wings, in the habits of flight, in the nature of the food, but runs also into some very curious details, as for example, in the number of feathers in the tail and in the wings, which are constant numbers—adhered to even when some of the feathers, not being used even for ornament, are reduced almost to rudiments. But under degrees of development which are very variable, the number is invariable. This identity of structure is the more remarkable from the immense extent of the group which it characterises. There are now known to science no less than 416 different species of humming-bird ; and it cannot be doubted that many more remain to be discovered among the immense forests and mountain ranges of Central America.

Now, what is the bond which unites so closely, in a common structure, all the forms of this great family of birds ? We think it a sufficient explanation sometimes of the likeness of things, that they are made for a common purpose. And so it is an explanation in one sense, but not in another. It gives the reason why likeness should be aimed at, but not the cause through which it has been brought about. Sameness in the purpose for which things are intended, is a reason why those things should be made alike; but it is no explanation of the process to which the common aspect is due. It is an explanation of the "why ;" but it is no explanation of the "how." Purpose is attained in nature through the instrumentality of means; and community of aspect in created things suggests the idea of some common process in the creative work. The likeness which is due to common parentage serves the most important purposes ; but it is not the less the result of a physical cause, out of which it arises by way of natural consequence. The likeness of the Humming-birds to each other suggests this kind of cause. It is true that the organs which it principally affects are specially adapted for a special habit of life. They are fitted to enable the bird to feed on the nectar, and the insects which frequent the nectar of flowers. But there are flowers in abundance in other quarters of the globe where there are no Humming-birds. And here we come on the curious facts of geographical distribution,—a class of facts which, as much as any other, suggest some specific methods as having been followed in the work of creation. Humming-birds are absolutely confined to the great continent of America with its adjacent islands. Within those limits there is every range of climate, and there are particular species of Humming-bird adapted to every region where a flowering vegetation can subsist. It is therefore neither climate nor food which confines the Humming-birds to the New World. What is it, then? The idea of "centres of creation" is at once suggested to the mind. It seems as if the Humming-birds were introduced at one spot, and as if they had spread over the whole continent which was accessible to them from that spot. They are absent elsewhere, simply because from that spot the other continents of the world were inaccessible to them. But if these ideas are suggested to the mind by the general aspect of this family as a whole, they are strengthened by some of the facts which we discover when we examine and compare with each other the genera and species of which it is composed. There is a beautiful gradation between the different genera and the different species, so much so, that it has been found impossible to divide the Humming-birds into more than two sub-families, from the absence of sufficiently well-marked divisions. And yet, on the other hand, they cannot be arranged in anything like a continuous series, because some links appear to be missing in the chain.

But these general facts terminate in nothing more definite than a vague surmise. When we enter farther into details, we feel at once how little they agree with any physical law which is known or even conceivable by us. If the likeness which prevails in the whole group reminds us of the likeness which is due to community of blood, it is equally true that the differences between the species are totally distinct both in kind and degree from the variation which we ever see arising among the offspring of the same parents. Let us look at what these differences are. The generic and specific distinctions between the humming-birds are mainly of two kinds,—1*st*, Differences in the form of essential organs, such as the bill and the wings; 2*d*, Differences in those parts of the plumage which are purely ornamental. Now, of these two kinds of variation, the only one on which the law of natural selection has any bearing at all, is the first. And on that kind of variation, the only bearing which natural selection has is this—that if any Humming-bird were born with a new form of bill, or a new form of wing, which enabled it to feed better and to range farther, that improved bill and wing would naturally tend to be perpetuated by ordinary generation. This is unquestionably true ; but it really does not touch the facts of the case. The bills and wings of the different genera do not differ from each other in respect of any comparative advantage of this kind, but simply in respect to variety corresponding with the variety of certain vegetable forms. One form of bill is as good as another, but some forms are adapted to some special class of flower. Some bills, for example, are formed of enormous length, specially adapted to obtain access to the nectar chambers of long tubular flowers, such as the Brugmansia. Some, on the other hand, as if to show that the same end may be attained by different means, obtain access to the same flowers by a shorter process, and pierce the bases of the corolla instead of seeking access by the mouth. Some have bills bent downwards like a sickle, adapted to searching the bark of palm-trees for the insects hid under the scaly covering; others have bills curved in the opposite direction, fitted, apparently, to the curious construction of some of the great family of Orchids so immensely developed in the forests of Central America. Some have bills equally well adapted for searching a vast variety of flowers and blossoms, and these, accordingly, migrate with the flowering season, and issuing from the great stronghold of the family in tropical America, spread like our own summer birds of passage, northwards to Canada, and southwards to Cape Horn, in the corresponding seasons of the year. In contrast with these species of extended range, there are many species whose habitat is confined, perhaps, to a single mountain, and there are some which never have been seen beyond the edges of some extinct volcano, whose crater is now filled with a special flora. Many of the great mountains of the Andes have each of them species peculiar to themselves. On Chimborazo and Cotopaxi, and other summits, special forms of Humming-birds are found in special zones of vegetation even close up to the limits of perpetual snow. Again, many of the islands have species peculiar to themselves. The little island of Juan Fernandez, 300 miles from the mainland, has three species peculiar to itself, of which two are so distinct from all others known, that they cannot for a moment be confounded with any of them. It is impossible not to see, in such complicated facts as these, that the creation of new species has followed some plan in which mere variety has been in itself an object and an aim. The divergence of form is not a divergence which can have arisen by way of natural consequence, merely from comparative advantage and disadvantage in the struggle for existence. Bills highly specialised in form are certainly not those which would give the greatest advantage to birds which have equal access to the abundant flora of an immense continent. Some form of bill adapted to the probing or piercing of all flowers with almost equal ease, would be the form most favourable to the multiplication and spread of Humming-birds. Continued approximation to some common type would seem to be quite as natural, and a much more advantageous kind of change as regards advantage in the struggle for existence, than endless divergence and special adaptation to limited spheres of enjoyment. At all events, we may safely say that mere advantage, in Mr Darwin's sense, is not the rule which has chiefly guided creative power in the origin of these new species. It seems rather to have been a rule having for its object the mere multiplying of life, and the fitting of new forms for new spheres of enjoyment, according as these might arise out of corresponding changes in other departments of the organic world.

If, now, we turn to the other kind of specific distinction between Humming-birds, viz., that which consists in differences in the mere colouring and disposition of the plumage, we shall find the same phenomena still more remarkable. In the first place, it is to be observed of the whole group that there is no connection which can be traced or conceived between the splendour of the Humming-birds and any function essential to their life. If there were any such connection, that splendour could not be confined, as it almost exclusively is, to one sex. The female birds are of course not placed at any disadvantage in the struggle for existence by their more sombre colouring. Mere utility in this sense, therefore, can have had no share in determining one of the most remarkable of all the characteristics of this family of birds. Those who by special study have laid their mind alongside of the mind of Nature in any one of its departments, have generally imparted to them a true sense, so far as it goes, in the interpretation of her mysteries. Let us then hear what Mr Gould says on this point :—" The members of most of the genera have certain parts of their plumage fantastically decorated; and in many instances most resplendent in colour. My own opinion is, that this gorgeous colouring of the humming-birds has been given for the mere purpose of ornament, and for no other purpose of special adaptation in their mode of life; in other words, that ornament and beauty, merely as such, was the end proposed."* Different parts of the plumage have been selected in different genera as the principal subject of ornament. In some, it is the feathers of the crown worked into different forms of crest; in some, it is the feathers of the throat, forming gorgets and beards of many shapes and hues; in some, it is a special development of neck plumes, elongated into frills and tippets of extraordinary form and beauty. In a great number of genera the feathers of the tail are the special subjects of decoration, and this on every variety of plan and principle of ornament. In some, the two central feathers are most elongated, the others decreasing in length on either side, so as to give the whole the wedge form. In others, the converse plan is pursued, the two lateral feathers being most developed, so that the whole is forked after the manner of the common swallow. In others, again, they are radiated, or pointed and sharpened like thorns. In some genera there is an extraordinary development of one or two feathers into plumes of enormous length, with flat or spatulose terminations. Mere ornament and variety of form, and these for their own sake, is the only principle or rule with reference to which Creative Power seems to have worked in these wonderful and beautiful birds. And if we cannot account for the differences in the general style and plan of ornament followed in the whole group, by referring them to any sort of use in the struggle for existence, still less is it possible to account, on this principle, for the kind of difference which separates from each other the different species in each of the genera. These differences are often little more than a mere difference of colour. The radiance of the ruby or topaz in one species, is replaced perhaps by the radiance of the emerald or the sapphire in another. In all other respects the different species are sometimes almost exact counterparts of each other. As an example, let me refer to the two species figured by Mr Gould as the Blue-tailed and the Green-tailed Sylphs; and also to two species

* Gould's "Trochilidæ," Introduction.

of the "Comets," in which two different kinds of luminous reds or crimsons are nearly all that serve to distinguish the species.

A similar principle of variation applies in other genera, where the amount of difference is greater. For example, one of the most singular and beautiful of all the tribe is comprised within the genus "Lophornis," or the "Coquettes." The principle of ornament in this genus is, that the different species are all provided both with brilliant crests, and with frills or tippets on the neck. The feathers of these parts are generally of one colour, ending in spots or spangles of another; the spangles being generally of metallic lustre. There seems to be a rule of inverse proportion between the two kinds of ornament. The species which have the neck plumes longest have the shortest crests, and *vice versâ.* In the shape and structure of all essential organs there is hardly any difference between the species. I need not multiply instances farther, since many others of the same kind will be observed in Mr Gould's splendid work. Now, what explanation does the law of natural selection give—I will not say of the origin, but even of the continuance and preservation—of such specific varieties as these? None whatever. A crest of topaz is no better in the struggle for existence than a crest of sapphire. A frill ending in spangles of the emerald is no better in the battle of life than a frill ending in spangles of the ruby. It is impossible to bring such varieties into relation with any physical law known to us. It has relation, however, to a purpose, which stands in close analogy with our own knowledge of purpose in the works of man. Mere beauty and mere variety, for their own sake, are objects which we ourselves seek when we can make the forces of nature subordinate to the attainment of them. There seems to be no conceivable reason why we should doubt or question, that these are ends and aims also in the forms given to living organisms, when the facts correspond with this view, and with no other. In this sense, we can trace a creative law,—that is, we can see that these forms of life do fulfil a purpose and intention, which we can appreciate and understand.

But then it may be asked, has this purpose and intention been attained without the use of means? Have no physical laws been used, whereby these new forms of beauty have been evolved, the one from the other, in a series so wonderful for its variety in unity, and its unity in variety? I am not now seeking to answer this question in the negative. All I say is, that the physical laws which are made subservient to this purpose are entirely unknown to us. That particular combination of a great many natural laws, which Mr Darwin groups under the name of Natural Selection, does not in the least answer the conditions which we seek in a law to account for either the origin or the spread of such creatures as the various kinds of Humming-birds. On the other hand, if I am asked whether I believe that every separate species has been a separate creation —not born, but separately made—I must answer, that I do not believe it. I think the facts do suggest to the mind the idea of the working of some creative law, almost as certainly as they convince us that we know nothing of its nature, or of the conditions under which it does its glorious work. Our experience of the existing order of nature is, that the young of each species repeat the form and the colours of their parent, and that even where variations occur, they are inconstant, and tend to disappear. We have no knowledge, for example, that from the eggs of the Blue-tailed Sylph a pair of Green-tailed Sylphs can ever be produced. We have no reason to believe that a species of "Lophornis," with a tippet of emerald spangles, can ever hatch out a pair of young adorned with spangles of some other gem. And yet we cannot assert that such phenomena are impossible, nor can it be denied that, as a matter of speculation, this process is natural and easy of conception, as compared with the idea of each species being separately called into existence, out of the inorganic elements of which its body is composed. Such new births—if they do take place—would perfectly fulfil, I think, the only idea we can ever form of new creations. For example, it would appear that every variety which is to take its place as a new species must be born male and female; because it is one of the facts of specific variation in the Humming-birds, that although the male and female plumage is generally entirely different, yet the female of each species is as distinct from the female of every other, as the male is from the male of every other. If therefore, each new variety were not born in couples, and if the divergence of form were not thus secured in the organisation of both the sexes, it would fail to be established, or would exhibit for a time the phenomena of mixture, and terminate in reversion to the original type. Now here again we have the emphatic declaration of Mr Gould, that among the thousands of specimens which have passed through his hands, from all the genera of this great family, he has never seen one case of mixture or hybridism between any two species, however nearly allied. But this passage is so important, that I quote it entire. "It might be thought by some persons that four hundred species of birds so diminutive in size, and of one family, could scarcely be distinguished from each other; but any one who studies the subject, will soon perceive that such is not the case. Even the females, which assimilate more closely to each other than the males, can be separated with perfect certainty; nay, even a tail-feather will be sufficient for a person well versed in the subject to say to what genus and species the bird from which it has been taken belongs. I mention this fact to show that what we designate a species has really distinctive and constant characters; and in the whole of my experience, with many thousands of humming-birds passing through my hands, I have never observed an instance of any variation which would lead me to suppose that it was the result of a union of two species. I write this without bias, one way or the other, as to the question of the origin of species. I am desirous of representing Nature in her wonderful ways as she presents herself to my attention at the close of my work, after a period of twelve years of incessant labour, and not less than twenty years of interesting study."*

If, therefore, new species are born from the old, it is not by accidental mixture; it is not by the mere nursing of changes advantageous in the battle of life; it must be from the birth of some one couple, male and female, whose organisation is subjected to new conditions corresponding with each other, and having such force of self-continuance, as to secure it against reversion. It matters not how small the difference may be from the parent form; if that difference be constant, and if it be associated with some difference equally constant in the female form, it becomes at once a new species. There are some cases mentioned by Mr Gould which may possibly be examples of the first founding of a new species. In the beautiful genus "Cynanthus," he tells us that there are some

* Gould's "Trochilidæ," Introduction.

local varieties near Bogota, in which the ornament is partially changing from blue to green; and it is a curious fact, that this variation appears to be taking effect under the direction of some definite rule or "law,"—inasmuch as it is only the eight central feathers of the tail which are tipped with the new colour. Mr Gould expressly says of one such variety from Ecuador, that it possesses characters so distinctive as to entitle it, in his opinion, to the rank of a separate species. The very discussion of such a question shows the possibility of new births being the means of introducing new species. But my object here is simply to point out that Mr Darwin's theory offers no explanation of such births, either as respects their origin or their preservation, neither does it even approach to tracing these births to any physical law whatever. It fails also to recognise, even if it does not exclude, the relation which the birth of new species has to the mental purpose of producing mere beauty and mere variety. Nevertheless it may be true that ordinary generation has been the instrument employed; but if so, it must be employed under extraordinary conditions, and directed to extraordinary results.

The only senses, therefore, in which we get any glimpse of creation by law are these—1*st*, That the close physical connection between different specific forms is probably due to the operation of some force or forces common to them all; 2*d*, That these forces have been employed and worked with others equally unknown, for the attainment of such ends as the multiplication of life, in forms fitted for new spheres of employment, and for the display of new kinds of beauty.

Is there anything in this conclusion to conflict with such knowledge as we have from other sources of the nature and working of creative power? I do not know on what authority it is that we so often speak as if creation were not creation, unless it works from nothing as its material, and by nothing as its means. We know that out of the "dust of the ground," that is, out of the ordinary elements of nature, are our own bodies formed, and the bodies of all living things. Nor is there anything which should shock us in the idea that the creation of new forms, any more than their propagation, has been brought about by the use and instrumentality of means. In a theological point of view it matters nothing what those means have been. I agree with Mons. Guizot when he says that "Those only would be serious adversaries of the doctrine of Creation who could affirm that the universe—the earth and man upon it—have been from all eternity, and in all respects just what they are now."* But this cannot be affirmed except in the teeth of facts which Science has clearly ascertained. There has been a continual coming-to-be of new forms of life.† This is Creation, no matter what have been the laws or forces employed by Creative Power. The truth is, that the theory which fixes upon inheritance as the cause of organic likeness, startles us only when it is applied to forms in which unlikeness is more prominent than resemblance. The idea, for example, that the different kinds of Pigeon, or of Humming-birds, have all descended through successive variation from some one ancestral pair, whether it be true or not, would not startle any one. Yet, if this be true, we must be prepared for the same surmise extending farther. The advocates of development urge that time is a powerful factor. They say that if small changes, but constant enough, and definite enough to constitute new species, can and do arise out of born varieties, it is impossible to fix the limits of divergence which may be reached in the course of ages. Yet it surely does not follow that there is no such limit because we cannot fix it. It does not necessarily follow that because we admit the idea of the Rock-dove, and the Turtle-dove, and the Ring-dove being all descended from one ancestral Pigeon, we are bound to accept the idea of the Whale, and the Antelope, and the Monkey being all descended from some one primeval mammal. Mr Darwin says, truly enough, that inheritance "is that cause which alone, as far as we positively know, produces organisms quite like, or nearly like, each other." But this is no reason why we should conclude that inheritance is the only cause which can produce organisms quite unlike, or only very partially like, each other. We are surely not entitled to assume that all degrees and kinds of likeness can only arise from this single cause. Yet until this extreme proposition be proved,

* Méditations sur l'Essence de la Religion Chrétienne, p. 49.

† "We discern no evidence of a pause or intermission in the creation or coming-to-be of new plants and animals."—*Instances of the Power of God as manifested in His Animal Creation*, by Professor Owen.

or rendered probable, we have a sound scientific basis for doubting the application of the theory precisely in proportion to the unlikeness of the animals to which it is applied. And this is the ground of reasoning, besides the ground of feeling, on which we revolt from the doctrine as applied to Man. We do so because we are conscious of an amount and of a kind of difference between ourselves and the lower animals, which is, in sober truth, immeasurable, in spite of the close affinities of bodily structure. But the closeness of these affinities is a fact. Man, as Archbishop Whately has said, besides being man, is also an animal. Science will ask, even if she never gets an answer, What is the common cause of this common structure? The fact which it has always appeared to me most difficult to disengage from the theory of development, is the existence of rudimentary or aborted organs; the existence of teeth, for example, in the jaws of the Whale—teeth which never cut the gum—and which are entirely useless to the animal. We have an inherent conviction that this must have some use in the future, or it must have had it in the past. Whether we look at it in the light of history, or prefer to regard it in the light of prophecy, it points to the existence of some derivative form in which these teeth have been, or are to be, turned to use. There is one suggestion on this subject which I cannot accept. When men were yet unwilling to admit the existence of life and death upon the globe so long before the creation of man, it used to be said that fossils were only "sports of nature." So in our own day, I have heard it said that rudimentary organs are merely intended to satisfy that condition of our finite minds, in virtue of which we are unable to conceive creation, except in connection with some history and method of growth. And so, as a condescension to this weakness, aborted members are given to suggest a history which was never true, and a method which was never followed! Now, of one thing I feel as sure as I can be of any truth, viz., that there are no fictions in nature, and no jokes. Whatever natural things really point to, they point to faithfully; and the conclusions really indicated are never false. Abortive organs mean something, and they mean it truly. Still, there is no proof that inheritance is the only cause from which such structures can arise. In the inorganic world we know that not mere similarity, but absolute identity of form, as in crystals, is the result of laws which have nothing to do with inheritance, but of forces whose nature it is to aggregate the particles of matter in identic shapes. It is impossible to say how far a similar unity of effect may have been impressed on the forces through which vital organisms are first started on their way. There are some essential resemblances between all forms of life which it is impossible even in imagination to connect with community of blood by descent. For example, the bilateral arrangement is common to all organisms, down at least to the Radiata. Again, the general mechanism of the digestive organs by which food is in part assimilated and part rejected, is also common through a range of equal extent. These are fundamental similarities of plan, depending probably on the very nature of forces of which we know nothing, but which we have not the slightest reason to suppose are due to inheritance. Other similarities of plan may depend on the same laws, equally unconnected with inheritance by descent. Indeed, inheritance has been suggested as the cause, mainly because there is a difficulty in conceiving any other. But there is at least an equal difficulty in conceiving the applicability of this cause to Man. Mons. Guizot, in the work already quoted,* lays it down as a physical impossibility that Man—the human pair—can have been introduced into the world except in complete stature—in the full possession of all his faculties and powers. He holds it as certain that on no other condition could Man, on his first appearance, have been able to survive and to found the human family. Even those who distrust this argument as entitled to the rank of a self-evident physical truth, must admit that it is at least quite as good as the opposite assertion, that any origin except the origin of natural birth is inconceivable. Where our ignorance is so profound no reasoning of this kind is of much value; but there is much to be said in support of Mons. Guizot's position. Certainly, Man as a mere animal is the most helpless of all animals. His whole frame has relation to his mind, and apart from that relation, it is feebler than the frame of any of the brutes. Yet in its plan and structure it is homologically, that is ideally, the same as theirs—organ answering

* Méditations sur l'Essence de la Religion Chrétienne, p. 22.

to organ, and bone to bone. "Adherence to Type" are words expressive of an idea, of a purpose, which we see fulfilled in organic forms. But this purpose must have sought its own accomplishment by the use of means, and the question of science always is, what were these? Love of beauty is equally a purpose which we see fulfilled in nature, but in the case of the Humming-birds this has been accomplished by giving to their plumes the structure of "thin plates," which decomposes light and flings back its prismatic colours to the eye. Fitness and special adaptation is another of the purposes of creation, but this also is attained through the careful arrangement, and pliability to use, of physical laws. In like manner, "Adherence to Type" is the expression of a fact, or the statement of a purpose, which, like all the other purposes fulfilled in nature, invites to an investigation of the instrumentality employed. We see the purpose but we do not see the method. We see the purpose, for example, in the wonderful adaptability of the vertebrate type to the infinite varieties of life to which it serves as an organ and a home. There is at least one conclusion which I hold to be certain, namely, this—that no theory in respect to the means and method employed in the work of creation, can have the slightest effect in removing that work from the relation in which it stands to the attributes of creative Will.

We cannot too completely shake off the notion that things which happen by way of "natural consequence" are thereby removed from being the effect of purpose and the work of Will. We forget that all our own works are works done through the use and instrumentality of natural forces, and it is knowledge and intelligence alone which enable us to combine these forces for the accomplishment of our designs. All that we do, or can effect, is brought about by way of natural consequence. The steam-engine works by way of natural consequence; so does Mr Babbage's calculating machine,—so does the electric telegraph,—so does the solar system. Everything that is done in nature, as well as everything that is done in art, seems to be done—as it were—by knowing how to do it. Whatever may be the ultimate seat of the elementary forces of nature, they can only produce the effects which we desire to attain by being combined under the control of mind. They appear to be used in the works of nature precisely on the same principle on which they are used by man. The fewer those elementary forces, the greater must be the mental power, and skill, and knowledge, under which they are yoked to such various use. And it is apparently out of a small number of elementary forces, having fixed rules too, limiting their combination, that all the infinite varieties of organic and inorganic matter are built up by means of nice adjustment. As all the faculties of a powerful mind can utter their voice in language whose elements are reducible to twenty-four letters, so all the forms of nature, with all the ideas they express, are worked out from a few simple forces, having a few simple properties.

And here I cannot help saying that I do not share in the impression which is felt by many, that the progress of modern investigation is in a direction tending to materialism. Of course I am not speaking of what may be the tone of individual minds. But I do speak, and with strong conviction, of the general bearing of scientific truth. I not only do not share in that impression, but I entertain an exactly opposite belief. Nothing is more remarkable in the present state of physical research than what may be called the transcendental character of its results. And what is transcendentalism but the tendency to trace up all things to the relation in which they stand to abstract ideas? And what is this but to bring all physical phenomena nearer and nearer into relation with the phenomena of mind? Is this materialism? Some of the ablest writers who have incurred reasonable suspicion as to the drift of their teaching, nevertheless give witness most emphatically to what I would call the purely mental quality of the ultimate results of physical inquiry. Mr Lewes, whose work on Aristotle I have already quoted, says, "The fundamental ideas of modern science are as transcendental as any of the axioms in ancient philosophy."* And this is true. Let us look for a moment on the light, small as it may be, which physiology has cast on the great mystery of Life. We never see Life separate from some material organisation. Yet what is the doctrine proclaimed, I believe, first, by the great John Hunter, and now emphatically repeated by men like Professor Huxley and Dr Carpenter? It is that organisation is not the cause of Life, but Life is the cause of organisation.

* Lewes' Aristotle, p. 66.

Material organs are merely the special forms built up and fashioned by the vital forces, whatever these may be, for the discharge of special functions. And it is well worthy of remark, that some of the most clear and striking illustrations of this truth are to be found in some of the lowest forms of life, revealed to us only by the microscope. Professor Huxley and Dr Carpenter both refer to the Foraminifera, in which the most beautiful and complicated forms of shell are evolved by the vital force working in creatures composed of simple jelly, without parts, without structure, without organs of any kind. Thus the deeper we go in science, the more certain it becomes that all the realities of nature are in the region of the Invisible; so that the saying is literally true, that the things which are seen are temporal, and that it is only the things which are not seen that are eternal. Surely if this is materialism, it is materialism spiritualised. These doctrines seem to me rather to bring into the strict domain of science, ideas which, in the earlier stages of human knowledge, lay wholly within the region of faith or of belief. For example, the writer of the Epistle to the Hebrews specially declares that it is by faith that we understand "that the things which are seen were not made of things which do appear."* Yet this is now one of the most assured doctrines of science, that invisible forces are behind and above all visible phenomena, moulding them in forms of infinite variety, of all which forms the only real knowledge we possess lies in our perception of their beauty and their fitness—in short of their being all the work of "Toil co-operant to an end." Creation by Law means nothing but Creative Force directed by Creative Knowledge, worked under the control of Creative Power, and in fulfilment of Creative Purpose.

During the past year there have been more deaths than usual among the members of the Society. Of Foreign Honorary Fellows we have lost one, Baron Plana of Turin. On our home list we have to lament the loss of 10 of our Ordinary Fellows, some of whom had attained the full term of human life, while others have been cut off in their prime. Their names are—Leonard Horner, Professor Miller, Robert Morrieson, Dr Newbigging, Professor

* Fide intelligimus aptata esse sæcula verbo Dei; ut ex invisibilibus visibilia fierent.— *Vulgate.*

Pillans, Dr Archibald Robertson, Dr Smyttan, Lieut.-General Swinburne, Dr R. D. Thomson, and Lord Wood.

To replace these we reckon 16 new Fellows,—viz., Dr A. Crum Brown, Prof. Robert Dyce, Dr John Foulerton, Rev. John Hannah, Robert Hutchison, Wm. Lindsay, Peter M'Lagan, J. D. Marwick, Rev. D. F. Sandford, Prof. Sellar, R. W. Thomson, Arthur Abney Walker, Dr William Wallace, Dr Alex. Wood, Robert S. Wyld.

Our roll, therefore, stands thus:—The number of Fellows in 1863 was 274 (omitting Dr William Somerville, born at Minto in Roxburghshire, 22d April 1771, and died at Florence, 24th June 1860, whose name by mistake had been continued in the last list). Of these 274 we have lost by death 10, and by resignation 1, making in all 11, thus leaving 263. To which add the new Fellows, 16, making the whole number of Fellows of the Society at the commencement of this session 279, a larger number than has been on our list for many years.

Baron Giovanni Plana was born about 1790. After studying at the Polytechnic School, he was made Professor of Mathematics in the Military School of Alexandria, and then Professor of Mathematics in the University of Turin. In 1820 the King of Sardinia directed him to erect the observatory at Turin, of which he was made Director in 1822. He became Director of the Military School, Member of the Academy of Sciences at Turin, of which he was afterwards president, Chevalier of the Iron Crown, and of the Civil Order of Savoy, and member of various foreign academies. He was elected a Corresponding Member of the French Institute, and in 1860 one of the eight foreign Associates of that body. In 1820 he received from the Academy of Sciences in Paris the great mathematical prize for his "Theory of the Lunar Motions." He was elected an Honorary Fellow of this Society on 19th January 1835.

He married the niece of the celebrated Lagrange. He died at Turin on 20th January 1864.

He is the author of many celebrated memoirs in the Transactions of the Turin Academy. The most important of them relate to the Constitution of the Atmosphere and Astronomical Refraction, the Theory of Distribution of Electricity, the Theory of the Moon's Motion, and the Perturbations of the Satellites of Jupiter and Saturn.

Leonard Horner was born in Edinburgh on the 17th January 1785. He was the third and youngest son of John Horner, a merchant and linen-manufacturer, who long resided in George Square, Edinburgh, and was a citizen of marked ability, possessing much information, and full of anecdotes of old times. Leonard's mother was Joanna Baillie of the family of Baillies of Dochfour, Inverness-shire. He was sent to school at the age of seven, and when he was nine years old he entered the High School. His brother Francis was also a pupil of the same school, which at that time was presided over by its celebrated rector Dr Adam. He was a lively, but rather careless boy, and did not display the diligence or perseverance of his brother. His amiable manners, however, made him a great favourite with all. He displayed at first a fancy for a sea-faring life, but the idea was afterwards abandoned. On leaving the High School he entered the University of Edinburgh. He attended the lectures on mathematics by Playfair, and those on moral philosophy by Dugald Stewart, and in 1802 he became a pupil in the chemistry class taught by Dr Hope. At this time mineralogy occupied a share of his attention, and he began to form a collection of minerals. This early taste was developed in his after life.

About the age of nineteen he went to London with his father, and there the family resided for many years. At the age of twenty-one he married Miss Lloyd, daughter of a landed proprietor in Yorkshire. He now entered with devotion into the study of science, and was received into eminent literary and scientific society in London. The intercourse which existed between his grandfather's family and Dr Hutton seems to have operated on the mind of young Horner in inspiring him with a taste for geology. He entered the Geological Society in 1808, the year after its formation. He was one of its earliest secretaries, and he continued to the last to take a warm and active interest in its proceedings. Circumstances connected with the linen-trade obliged him to return to Edinburgh in 1815 in order to attend to business. In 1816 he became a Fellow of the Royal Society of Edinburgh. He contributed a paper on the occurrence of *Megalichthys Hibberti* in a bed of cannel coal in Fifeshire. Soon after this the premature death of his brother Francis, who was rising into eminence as a statesman, cast a gloom over his spirit. His brother died in the year 1817, at Pisa, where he had gone for the sake of his health. Leonard Horner left his family, and accompanied his brother to Pisa, and was with him at his death. A monument was erected to Francis Horner in Westminster Abbey.

Edinburgh at this time possessed many eminent Whig lawyers, who distinguished themselves in politics and literature. Horner warmly joined them from congeniality of opinions and sentiments, and by his active and methodical habits he became the chief organiser of their political meetings. In 1825 he acted as chairman at the dinner given to Joseph Hume. He had a deep sympathy for those who had been exiled from their country on account of liberal opinions. Several of the Italian emigrants, Ugoni, Demarchi, Arrivabene, Castiglione, and others, shared his hospitality. To this is perhaps due that love for Italy which the family of Leonard Horner have always maintained. One of his daughters has translated the history of Colletta, has written a short history of Naples, and a few days before her father's death published a book on the poet Giusti, all which are works of much value.

He also espoused with earnestness the cause of the working men, whose education he considered as having been neglected on all hands. In 1821 he founded the School of Arts in Edinburgh, for the instruction of mechanics, and he never ceased to contribute to its welfare. This school has gone on prosperously. The average attendance for the last four years has been 700 annually. No similar institution in the empire has been so successful. This success is owing to the soundness of its constitution, which was entirely the work of Mr Horner. The students have no connection with its management. The Directors have the sole superintendence, and they are elected by the subscribers out of their own body, and are always men of good position and of education. Females are not allowed to attend. There are a given number of subjects, each taught by able and permanent lecturers. No casual or itinerant lecturers are employed. Mr Horner acted as honorary secretary till he went to London in 1828. He founded a permanent prize of three guineas, to be awarded by competitive examination in the classes of mathematics, natural philosophy, and chemistry, in succession.

Desiring to promote classical education among the middle classes in Edinburgh, he, along with Lord Cockburn, set about the establishment of the Edinburgh Academy, which has continued to flourish since its foundation. Mr Horner visited the Academy on many occasions even after he left Edinburgh, and the last time he did so was in July 1863. On the same occasion he visited the High School, in which he had been a pupil, and he was present at the distribution of prizes, and gave an excellent address.

In 1827 he became Warden of the London University. This office he resigned after four years, and retired to Bonn, where he remained for six years with his family. In 1833 he accepted the office of Inspector of Factories, and did his duty most faithfully and philanthropically. By his labours great improvements took place in the mills and mines, more especially in regard to the employment of women and children. He earned the respect and the goodwill of the operatives, and this is evinced by the memorial presented to the Misses Horner after his death by the operative cotton-spinners of Lancashire, in which they express their feelings of heartfelt sorrow and regret, as well as of profound sympathy, on the death of Mr Horner, their father. They speak with grateful recollections of his unremitting labours in the cause of justice and humanity, his impartiality in the administration of the laws made for the protection of their wives and children, and his firmness in their vindication.

He was assiduous in his attendance at the Royal and Geological Societies of London. He entered the former on 11th November 1813, and he was subsequently one of the Vice-Presidents of the Society; of the latter he was twice chosen President. His efforts were directed to the better organising of these Societies, and he was successful in adding materially to the efficiency of the Royal Society as regards the election of members and the conduct of business. In 1861 he delivered his last address as President of the Geological Society. He had likewise published a memoir of his brother Francis, in two large volumes, and had translated a work by Cousin on education in Germany.

In 1851 Mr Horner suggested a series of investigations as to the deposits of the Nile. These were conducted by an Armenian officer of engineers, Hekekyan Bey. These researches seemed to support the view then propounded as to the great antiquity of man and his works. The results were given to the Royal Society in 1855. The experiments thus instituted in the hope of obtaining an accurate chronometric scale for testing the age of a given thickness of Nile sediment, are not considered by experienced Egyptologists to be satisfactory.

After acting for thirty years as Inspector of Factories, he resigned his office, and devoted his attention principally to geology, classifying and arranging with great patience, perseverance, and skill, the foreign collection of the Geological Society in Somerset House. In 1861 he visited Italy, and resided for eight months at Florence. There he met with a sad bereavement in the death of Mrs Horner, his companion for fifty-six years. She was a most attractive lady, with a highly cultivated mind. From the shock of this event Horner never recovered completely, and it threw a shade over his declining years. When at Florence he translated with happy fidelity Villari's "Life of Savonarola," which he afterwards published with notes. He continued to work to the end, and he died on 5th March 1864, at 60 Montagu Square, London, at the age of seventy-nine.

A correspondent in America says of Horner—"Among us in the United States not a few knew and valued him as the biographer of his brother, Francis Horner, a statesman whose early death is still to be counted among the misfortunes of his country, and whose life, republished here in 1853, has served to join and strengthen the principle of many an aspiring young jurist in the United States, as it has in England, from its first appearance there. Others on our side of the Atlantic have known Mr Horner as a naturalist, who was at one time President of the Geological Society, and who contributed many valuable papers to its 'Transactions.' Others again have known him personally as the father of Lady Lyell, to whom and her eminent husband so many Americans became attached during their visit to the United States, and who were always proud to present to their distinguished father the friends from abroad who visited them in London." It has been well remarked, that Mr Horner was one of the living links which bound the present race of geologists to the fathers and founders of British geology. His recollections went back to the latter part of last century, and he used to tell anecdotes of the days of Hutton, and Playfair, and Hall—names to which we now-a-days look through such a long vista of years, crowded with discovery, that they seem to stand far away amid the halo of an early heroic life.

James Miller was born at the Manse of Eassie in Forfarshire, on the 22d of April 1812. He was the third son of the Rev. James Miller, minister of the parish, and his wife Elizabeth Martin, daughter of the Rev. Dr Martin, minister of Kirkcaldy, in Fife.

At Eassie Mr Miller received his early training, and till he went to College at St Andrews he was constantly under the parental eye; for his father, aided by teachers and tutors, conducted the education of his own family, along with the sons of several neighbouring proprietors. Surrounded by home influences, Mr Miller received the early training which fitted him, when a lad of only twelve, for the Literary and Arts classes of the University of St Andrews. Here it was he first began to show his great intellectual facility, taking bursaries, and distinguishing himself, more particularly as a scholar in classics and metaphysics, in competition with lads considerably older than himself.

After three years spent at St Andrews, he repaired to Edinburgh in 1827, and commenced his medical studies, not only under the distinguished professors of medicine who then adorned our University, but also under the late Mr Liston, who, as a private lecturer unconnected with the University, had at that time taken the whole country by surprise as a teacher and practitioner of surgery.

In 1828 Mr Miller became a pupil of Liston's, and under that tutelage there grew up between the master and student an affection and mutual regard, which, though interrupted, so far as daily personal intercourse was concerned, by Liston's removal to London, and finally eclipsed by the premature death of that illustrious man, remained throughout life as one of the tenderest and warmest emotions of Mr Miller's inmost feelings. It was about this time that Mr Miller's anatomical skill led to his selection by Professor Munro *tertius* as his demonstrator of anatomy; and in the discharge of the duties of that responsible office, he acquired both that familiarity with normal texture and diseased structure, as well as that facility of description and easy diction, which were eminently characteristic of him throughout his after life.

It was during this period that his first essays in writing for the press commenced, Dr Munro having largely made use of his ready pen in preparing for publication his famous work upon the Gullet.

In 1832, having taken his diploma as surgeon, he commenced practice as Liston's resident assistant; and during the two succeeding years immediately preceding Liston's removal to London, Mr Miller not only acted in his absence, but largely relieved him in the daily press of business, while his evenings were occupied in re-writing and preparing Mr Liston's Practical Surgery for publication.

When Liston went to London, Mr Miller commenced practice on his own account, and during the succeeding eight years continued to make a growing reputation, and to acquire a large circle of attached friends—a reputation not only as a practitioner and teacher of surgery in the extra-academical school, but as a graceful public speaker, and as an attractive lecturer to art students upon pictorial anatomy.

In 1840 he became a Fellow of the Royal College of Surgeons, and was shortly afterwards elected surgeon to the Royal Infirmary. In 1842, when the Chair of Surgery in the University of Edinburgh became vacant, by the death of Sir Charles Bell, Mr Miller was unanimously elected to the Professorship by the Town Council, who then exercised the patronage over all, except the Crown appointments. At this period he was only thirty years of age. From that time to this, for twenty-two sessions, Mr Miller uninterruptedly lectured to overflowing classes of attentive and admiring students.

It was during the first year of his University course that a duodecimo edition of his Principles and Practice of Surgery was published by the Messrs Black—a work which, passing through four editions in octavo, acquired a world-wide reputation, and of which the fifth edition, under the title of "A System of Surgery," had only been completed a few months before his last fatal illness manifested itself.

It was in 1842, shortly after becoming Professor of Systematic Surgery, that Mr Miller was elected a Fellow of the Royal Society of Edinburgh.

His printed works and papers amount to upwards of thirty, and are by no means confined to purely professional matters, his warm interest and zeal in social and religious questions leading him to spend much time in giving his support to whatever views his convictions espoused. The same conscientious love for the success of truth stole away many an hour from the but limited leisure which his professional avocations afforded him, and induced him to appear in public and advocate from the platform, to eagerly attentive audiences, the same views to which his pen lent so ready and powerful a support.

On the 17th of June, after an illness of only three weeks' duration, which at first created no serious anxiety in the minds of his medical attendants, James Miller passed away from amongst us, in the fifty-second year of his age, and the twenty-second of his Professorship.

Robert Morrieson was born in Edinburgh on the 18th January 1787, and was educated at the High School and University there. He studied medicine, and obtained a surgeon's diploma at the early age of nineteen. His intentions were to proceed to India at once in a medical capacity, but he was prevented from doing so by a regulation of the Court of Directors requiring medical officers to be of the age of twenty-two. Mr Morrieson, however, received from his uncle, Sir Hugh Inglis, a direct civil appointment, and he proceeded to India in 1806 as a civil servant, although very reluctant to give up the profession he had early chosen, with the benevolent purpose of doing good to his fellow-creatures. He found, however, afterwards many opportunities of gratifying this desire, and employed his medical skill among the poor natives of India. He remained a considerable time at Beerbhoom under his own brother, and rose to be Judge and Magistrate there. Afterwards he became one of the Judges of the Circuit Court at Moorshedabad, in which office he continued till, owing to the state of his health, he returned to Scotland in 1829; and till his death on the 10th November 1864, he has chiefly resided at his house No. 6 Heriot Row, Edinburgh, and at Harvieston in Mid-Lothian. He became a Fellow of the Royal Society in 1822.

Mr Morrieson was certainly one of those who, while they exercise no small influence among the men and movements of their day, are, by reason of their retiring modesty, comparatively unknown to almost all beyond the circle of admiring and attached friends whom they invariably attract to themselves. That he had not merely a large heart, inclining him to consider, sympathise with, and assist whatever justly claimed his sympathy, but also a ready and liberal, though discriminating hand, is attested not only by his cordial support of the institutions and schemes of the Church with which he was connected, but by the spirit and manner in which he aided other enterprises of benevolence and usefulness. From his extensive connection with the management of trusts, which as a friend he had undertaken, he was brought largely into contact with young people. To their instruction and enjoyment few could give themselves with greater geniality and success. He took a lively and active interest in the great questions and movements of his times, especially those involving or in any way affecting the principles of Divine Revelation or the cause of Protestantism. It might well have been supposed that when nearly sixty years of age, Mr Morrieson's days of active study were over; yet twenty years ago he was among the most regular attenders upon the prelections of Drs Chalmers and Cunningham in the New College. His power and habits of regular study, early formed and matured by long practice, continued with him to the last. He devoted a fair portion of time to the consideration of scientific subjects, on which he possessed a large and varied fund of information, and to historical and general literature. His latter end was peace. He rests from his labours, and his works do follow him.

Patrick Small Keir Newbigging was born at Edinburgh on 2d November 1813. He was the fifth son of Sir William Newbigging, who for many years practised medicine in Edinburgh with great success. Three of his brothers, William, Robert, and George, studied medicine; but all of them, as well as John, who was a writer to the Signet, died at comparatively early ages. Dr Patrick Newbigging prosecuted his studies at Edinburgh, and graduated there in 1834; his thesis being on the Causes of the Impulse and Sounds of the Heart. He became a Fellow of the Royal College of Surgeons in the same year. During his student life he was elected a President of the Royal Medical Society. Before settling in practice he spent some time abroad in acquiring additional professional knowledge at foreign schools. On his return he became associated with his father in practice, and he joined the New Town Dispensary as one of its medical officers. The subject of Auscultation occupied a considerable share of his attention, and in 1842 he published a translation of Barth and Roger's Practical Treatise on that subject. He communicated a paper to the Royal Society of Edinburgh on certain circumstances affecting the colour of blood during coagulation.

Dr Newbigging filled many important situations in Edinburgh, such as Surgeon to John Watson's Institution, and to Cauvin's Hospital; Medical Referee of the Life Association Insurance Company of Scotland; Physician to the Sick Children's Hospital, an institution in the foundation of which he took a lively interest; Examiner in the College of Surgeons, and President of that body, 1861–63, as well as President of the Royal Scottish Society of Arts. He became a Fellow of the Royal Society in 1848. For several years he suffered from valvular disease of the heart and aneurism of the aorta. The symptoms were long very obscure, and the existence of the disease was only known to a very few intimate friends. In spite of it he continued to perform efficiently his responsible duties to the last. Long before his death he found that any exertion, especially in walking up a rising ground, caused breathlessness and exhaustion. He did not make this known, and rather endeavoured to conceal it; so that few who saw his cheerful and active demeanour could have suspected that he was labouring under a fatal disease which was gradually undermining his constitution. The autumn before his death he resided for some time at Callander, where, by quiet and relaxation, he hoped to recruit his strength. On his return to Edinburgh, however, in October, the symptoms became aggravated, although he was able to visit his patients till within three days of his death, which took place on the morning of Saturday 10th January 1864. Those who knew him intimately perceived a softening influence coming over him, and an occasional solemnity of expression which betokened Christian preparation for a life beyond the present. He was a sound, judicious, and successful practitioner, and was much beloved by his patients. He exhibited on all occasions a courteous, cheerful, and gentlemanly demeanour, and his amiability gained him many friends.

James Pillans, M.A, LL.D., Professor of Humanity in the University of Edinburgh, was born at Edinburgh in 1779, and died on 27th March 1864, at the advanced age of eighty-five. His father was a printer in Edinburgh, and he was educated there. He attended the High School when Dr Adam was Rector, and at the annual examination in 1792 he ranked next to Francis Horner, who then carried off the highest honours. After a distinguished career in Edinburgh University, he became tutor in the family of Mr Kennedy of Dunure, and afterwards in a family in Northumberland, finally settling in Eton as a private tutor. On the death of Dr Adam, in 1809, Pillans became a candidate for the office of Rector in the High School, and he was ably supported by Francis Horner and other influential friends who knew his merits as a scholar and a teacher. On the 24th January 1810, he was unanimously elected to the office by the Town Council. His long residence in England, and his intimate acquaintance with the course of study pursued in the great schools in that country, rendered his appointment of no small importance to his native city. He continued to discharge the duties of the office for upwards of ten years in so able a manner as to attract the attention of educationists both at home and abroad. During his tenure of office, the numbers in the class were doubled. The death of Professor Christison, in June 1820, having occasioned a vacancy in the Humanity Chair of the University, Mr Pillans was unanimously elected by the patrons as his successor. For a period of more than forty years he discharged the duties of this office. His advancing years called for relaxation, and he resigned his professorship in 1863.

During the whole of his long life, Mr Pillans devoted himself with all the energy and fervour of his nature—and these were great—to the elevation of the elementary and higher education of this country. By speech, writing, and example he endeavoured unceasingly to promote the views which he had adopted or originated; and to no man in Scotland is the progress which has been made in rational methods of teaching and in exalted views of school discipline more indebted than to Professor Pillans. During his long career, first as Rector of the High School of Edinburgh, from 1810 to 1820, and afterwards as Professor of Humanity, from 1820 to 1863, he is universally and gratefully acknowledged to have been signally successful in his efforts to awaken the intelligence of boyhood and youth—infusing into his pupils much of his own ardour and classical refinement, and investing with interest and charm studies too often presented to the minds of youth in forms which perhaps justify their aversion. In noticing, therefore, the death of the most venerable of our members—one who connected this Society with three generations—it is due to him to record the eminent educational services which he rendered to Scotland at large, and in an especial manner to this city. Professor Pillans received the degree of LL.D. from the University of Edinburgh in 1863. He entered the Royal Society in 1811. Like his friend Horner he took a lively interest in the School of Arts, and continued to the last to attend the examinations of the school of which he had been for some time President. He was for many years senior member of the Senatus of the University of Edinburgh, and many of his former pupils were his colleagues. Some years ago a dinner was given to him by his pupils, and a very large number of all ranks and professions assembled to do honour to their former instructor, under the presidency of Lord Neaves, one of his former duxes. Among his writings are the following:—

1. Principles of Elementary Teaching, chiefly in reference to the Parochial Schools of Scotland; in two letters to (his first pupil) T. F. Kennedy, Esq., M.P. 12mo. Edinburgh, 1828. 2d edit. 1829.

2. Three Lectures on the proper Objects and Methods of Education, in reference to the different orders of Society; and on the relative utility of Classical Instruction. 8vo. Edinburgh, 1836.

3. Eclogæ Ciceronianæ: A Selection from the Orations, Epistles, and Philosophical Dialogues of Cicero; to which are added selected Letters of Pliny the younger, with a copious Preface. 18mo. Edinburgh, 1845.

4. Outlines of Geography, principally Ancient, with Introductory Observations on the system of the World, and on the Best Manner of teaching Geography. 12mo. Edinburgh, 1847. These "Outlines" had been repeatedly printed, but were not *published* till 1847.

5. Eclogæ Curtianæ; containing the Third, Fourth, and Fifth Books, with Extracts from the remaining Five, of Quintus Curtius Rufus de Gestis Alexandri Magni; to which are added, an English

Supplement to the lost Books, and a Map of Alexander's march; with a Discourse on the Latin Authors read, and the order of reading them, in the earlier stages of Classical Discipline. 18mo. Edinburgh, 1847.

6. Excerpta ex Taciti Annalibus, with a Prefatory Notice. 12mo. London, 1848.

7. A Word for the Universities of Scotland, and a Plea for the Humanity Classes in the College of Edinburgh. 8vo. Edinburgh, 1848.

8. Contributions to the Cause of Education, collected and amended. 1 vol. 8vo.

In addition to the above, Mr Pillans has contributed several articles to the "Edinburgh Review," chiefly on education; to the "Encyclopædia Britannica;" a speech on Irish education, in 1832; evidence printed in the Report of the Committee of the House of Commons on Education, in 1834; and a Paper to the Royal Society of Edinburgh on the Origin of the Adjective.

Dr Archibald Robertson, an English physician, died at his residence at Clifton, on 19th October 1864, at the age of seventy-four. He was born at Cockburnspath, near Dunbar, on 3d December 1789. He was educated at Dunse school, and afterwards by Mr Strachan, in Berwickshire. He prosecuted his medical studies at Edinburgh. He passed assistant-surgeon in 1808, and was appointed to Mill Prison Hospital at Plymouth, for French prisoners. In 1809 he was appointed to the "Caledonia," Lord Gambier's flag-ship, Basque Roads, when Lord Dundonald tried to burn the French fleet. He served in the Baltic, and afterwards in the West Indies, in the "Persian" and in the "Cydnus." He saw a good deal of boat service in the attempt on New Orleans. At the peace with North America he went on half-pay, having received a medal with two clasps. He graduated at Edinburgh in 1817—his thesis being on the Dysentery of hot climates. He settled in Northampton in 1818, where he acquired a large practice. In 1853 he retired from active practice, and went to Clifton to reside. He was a learned and accomplished physician, and, at the same time, a most genial and kind-hearted gentleman. He was highly respected in Northampton, and he enjoyed extensive reputation as a medical man.

He was for many years Physician to the Northampton Infirmary, to which he was elected in 1820. He wrote some papers for Forbes's Cyclopædia of Medicine, and he contributed an article on Fever to the "Edinburgh Review." He also wrote on the Contagion of the Plague and on the Quarantine Laws. He reviewed "Modern Scepticism," "Peter's Letters to his Kinsfolk," Mrs Brunton's "Emmeline." He wrote Lectures on Civilisation, on the Wisdom of God, and on the Living Principle in Plants, Animals, and Man. He was an F.R.S., and joined the Royal Society of Edinburgh in 1836. He was Vice-president of the British Medical Association at the time of his death, and at the meeting of the Association at Northampton in 1844, he was chosen President. He made a large fortune by practice. He leaves one son, who is a clergyman of the Church of England.

Dr George Smyttan was born at Dunkeld on 17th June 1789. He received his early education at the grammar-school of that place, and studied at the universities of St Andrews and Edinburgh. He took his diploma as surgeon at Edinburgh in 1808, and his degree of M.D. at Aberdeen, when home from India on furlough. In 1808 he went out to Bombay as surgeon in the service of the H.E.I.C., and, including a year or so of furlough, remained in India thirty years, by which time he had risen to the head of the Medical Board. He came home in 1839, bearing with him the affection and esteem of a large circle of friends and associates, and the gratitude of missionaries and native converts, affecting testimonies of which have been received since his death. He was spared to see twenty-five years in his own country after his return, sixteen of which were spent in zealous activity, promoting many a Christian enterprise, the remaining nine in the more difficult service of patient submission under bodily weakness and inaction, the effects of a paralytic seizure in September 1854. At the disruption of the Church of Scotland, he warmly espoused the cause of the Free Church, and to it was thenceforth devoted a large share of his energies and his substance. In all its schemes he took a lively interest, especially in its Indian Missions. But his philanthropy was far from being confined to denominational objects. Most of the benevolent efforts of the day shared his liberality. He was a warm supporter of the Medical-Missionary Society, the importance of which he was one of the first to recognise. While not entering deeply into science, he was fond of the study, and attended assiduously the lectures of Dr Fleming. He entered the Royal Society in 1841, and when in health was a regular attender of its meetings. His attachment to Dunkeld was warm, and showed itself in substantial kindness. Every summer was spent at Birnam, till compelled to quit it in 1854. In 1860 he bought the small property of Canaan Park, where his latter years were tranquilly passed, till Christmas day 1863, when he died.

Lieutenant-General Thomas Robert Swinburne was descended from the ancient family of the Swinburnes of Swinburne Castle, in Northumberland. His grandfather married Mary, co-heiress of Anthony Meaburne of Pontop Hall; his father married Charlotte, coheiress of Robert Spearman of Old Acres, in the county of Durham, and he succeeded to these properties. The estate of Marcus, in Forfarshire, he himself acquired by purchase. General Swinburne was born in 1784. He entered the 1st Foot-Guards in 1813, served with them in Holland under Lord Lynedoch, subsequently in the Peninsula and South of France; was in the campaign of 1815, including the battles of Quatre Bras and Waterloo, the storming of Peronne, where he commanded a storming party, and the occupation of Paris. He retired from active service on an unattached Majority, and came to reside in Edinburgh, where he had received part of his education. He became a Fellow of the Society in 1839. He rose through the various grades to the rank of Major-General, which he attained on 4th June 1857, and was gazetted as Lieutenant-General only a few weeks before his death, which took place on 29th February 1864. General Swinburne, though in no respect a cultivator of science, was, as a well-educated gentleman, deeply interested in all that concerned the progress of human knowledge, and will long be cordially remembered by those who knew him for his personal and social qualities, which made him a typical specimen of the fine old English gentleman.

Robert Dundas Thomson, M.D., F.R.S.L. & E., was second son of the Rev. James Thomson, D.D., minister of Eccles, Berwickshire, in the manse of which parish he was born on the 21st September 1810. From the Grammar-school of Dunse he proceeded to the University of Edinburgh, where, after going through the usual arts course, he began the study of medicine. From Edinburgh he went to Glasgow, where his uncle, Dr Thomas Thomson, was then professor of chemistry. He not only made every use of the advantages which he there enjoyed of studying that science, but became so much attached to it, that it became the pursuit of his life.

Dr Thomson graduated at Glasgow in 1831, and, after a voyage to India and China in one of the Company's ships, he settled in London as a physician. At the beginning of his career there, he was associated with several active and zealous men, of his own standing, in establishing the Blenheim Street School of Medicine, in which he lectured on Chemistry. For a short time he assisted Dr Farr in editing the "British Annals of Medicine," and about the same time he undertook the publication of the "Records of Science." Active, enthusiastic, and persevering, he had already got over the first difficulties of a London practice, and was becoming known as a scientific physician, when he left London to take the place of assistant to his uncle at Glasgow, whom advancing age compelled to relinquish first a part, and soon after the whole of the duties of the Chemical Chair. At Glasgow he was a most successful teacher, and acquired the confidence and esteem of the manufacturing body. In 1852 he was an unsuccessful candidate for the Chair of Chemistry, which then became vacant. He therefore returned to London, where he was appointed Lecturer on Chemistry at St Thomas' Hospital. In 1855 he was elected Medical Officer of Health for the parish of St Marylebone. This was a new office just established under Lord Llanover's Act. It was an office for which his chemical, medical, and local knowledge rendered him admirably fitted. Firm when needful, and at all times patient and conciliatory, he was able to carry the vestry and householders with him. The water supply, the drainage, the food, and the hygiene, not only of the private houses, but of the large public establishments of the parish, were all in their turn attended to; and he was able by degrees to make great improvements in the sanitary state of the parish. The labour, however, was enormous, and began at last to tell on his once vigorous constitution. About two years ago his friends began to notice his failing health, but it was only within the last six months that they became seriously alarmed. Early in the summer of 1864 he removed to the house of his brother near Richmond, in the hope that change of air might restore him. Unfortunately his illness made rapid progress, and he rested from his labours on the 17th August last, to the inexpressible regret of a wide circle of friends.

Dr Thomson was an accomplished chemist. His elementary works on that science (" School Chemistry" and the " Cyclopædia of Chemistry") are of standard value, and he has enriched it by numerous detached papers. His labours in physiological chemistry, and on sanitary questions, were of the highest value. The adulteration of drugs, the chemistry of digestion and of cholera, were in turn skilfully treated by him. He investigated most ably, under the orders of Government, the nutritive value of the different kinds of food for cattle. The question of water supply he made especially his own ; and his monthly analyses of the waters of the different London companies, published by the Registrar-General, were the best safeguard of the public. He was also an enthusiastic meteorologist, and at the time of his death President of the Meteorological Society of London. He became a Fellow of the Royal Society of Edinburgh in 1850, and he was elected a Fellow of the Royal Society of London on 1st June 1854. He was also a Fellow of the Chemical and Medico-Chirurgical Societies of London, of the Botanical Society of Edinburgh, and of the Berwickshire Naturalists' Club, which he entered on 22d September 1831. He contributed a paper on Tea-oil to the Royal Society of Edinburgh.

Alexander Wood, Esq., late one of the Senators of the College of Justice, Fellow of the Royal Society of Edinburgh, was born in Edinburgh on the 12th November 1788. He was the son of George Wood, M.D., and grandson of the well-known Alexander Wood, surgeon in Edinburgh. His mother was Miss Campbell of Glensaddle, through whom he was descended from the Earls of Crawford.

He was a pupil of the High School of Edinburgh, and afterwards under a clergyman in the city of Durham. His later education was completed at the University of Edinburgh.

He passed at the Bar in 1811, and was appointed Stewart of Kirkcudbright in 1830. This office he resigned upon his election as Dean of the Faculty of Advocates on 12th November 1841, which honourable position he held but a short time, having, on 21st November 1842, been appointed one of the judges of the Supreme Court. He became a Fellow of the Royal Society of Edinburgh in 1825.

His learning and skill as a counsel were universally acknowledged, and his practice while at the bar was large. On the bench he was looked to by the profession and the public as eminently combining the wisdom of the judge with the polished courtesy of the gentleman.

For several of the later years of his life his health was delicate, and it was only the solicitation of those who knew and estimated his high judicial qualifications which induced him to struggle with indisposition and continue his services to the public. He retired from the bench in January 1862, thus terminating a long and honourable professional career.

But while his duties in his profession and on the bench of course occupied him for many years almost exclusively, the short leisure he could command was most cheerfully, though unostentatiously, given to the public, especially in the cause of education and in the encouragement of art.

His refined and cultivated taste pointed him out as peculiarly qualified to promote the advancement of art in Scotland; and, as might be expected, he was many years ago selected as a member of the Board of Trustees and Manufactures in Scotland, to whose proceedings he gave able co-operation, taking a leading part in the remodelling of the School of Design, and acting as the convener of their committee for the erection and arrangements of the National Gallery and the promotion of its collections. In early life, he showed his zeal in the cause of general education, by taking an active part in the institution of the Edinburgh Academy.

Many years ago, the late Sir William Fettes nominated him, along with others, including Mr Rutherfurd, afterwards Lord Rutherfurd, and Mr Corrie, Manager of the British Linen Company —all three fellow-students and intimate friends of his deceased son—to be trustees for carrying out the Fettes Endowment for the

" maintenance, education, and outfit of young people, whose parents have either died without leaving sufficient funds for that purpose, or who, from innocent misfortune during their own lives, are unable to give suitable education to their children."

Mr Wood had for many years been the sole survivor of the original trustees; and, with the aid of those who were from time to time assumed to fill up the trust, he devoted much time towards the execution of the very ample powers conferred by the deed. In this object he took the most lively interest, both from his respect for the venerable friend who had selected him, and from his warm interest in the cause of education. In the careful management of the large funds, and in the preparation of the scheme for the establishment, and of the rules for its management, Lord Wood's prudence and experience qualified him to take the leading charge which he did.

The guidance of his mature taste, also, was given in the selection of a commanding site for the intended building, and in superintending the beautiful plans prepared by Mr Bryce, the architect. The adjustment of this, which will ere long be a most important institution, was a favourite occupation of Lord Wood during what leisure he could spare in his professional and judicial life, and to it he gave even more of his time and thoughts after his retirement. He lived to know that the foundation of the *Fettes College* was laid, although the state of his health prevented his presence on the occasion.

Those who knew him best are well aware that he would have looked upon it as one of the most honourable memorials of his name, that it should be remembered in connection with what he did for the furtherance and intentions of his old and highly respected friend as to this endowment, which promises to be one of the greatest ornaments to the city, and benefits to many of its sons.

The following gentlemen were elected Honorary Fellows, having been proposed, *vivâ voce*, at the Meeting of the Society on 28th November :—

I. FOREIGN.

ROBERT WILHELM BUNSEN, *Heidelberg*.
JEAN BERNARD LEON FOUCAULT, *Paris*.
ELIAS FRIES, *Upsala*.
HERMANN HELMHOLTZ, *Heidelberg*.
ALBERT KÖLLIKER, *Wurzburg*.
RICHARD LEPSIUS, *Berlin*.
RUDOLF LEUCKART, *Giessen*.
THEODOR MOMMSEN, *Berlin*.
ADOLPHE PICTET, *Geneva*.
CHRISTIAN FRIEDRICH SCHÖNBEIN, *Basle*.
KARL THEODOR VON SIEBOLD, *Munich*.

II. BRITISH.

JOHN STUART MILL, *London*.
GEORGE GABRIEL STOKES, *Cambridge*.
ALFRED TENNYSON, *Freshwater*, *Isle of Wight*.

The Council reported on the remit made to them by the General Meeting of 28th November, in reference to Honorary Vice-Presidents, and recommended that those Fellows who had filled the office of President should, on retiring from office, become Honorary Vice-Presidents—the designation being, "Honorary Vice-President having filled the office of President." They also recommended that His Grace the Duke of Argyll should be elected an Honorary Vice-President.

On the motion of Lord Neaves, these recommendations were unanimously adopted.

The following Donations to the Library were announced:—

Transactions of the Royal Society of London. Vol. CLIII. Part II. 4to.—*From the Society*.

Proceedings of the Royal Society of London. Nos. 63–68. 8vo.—*From the Society*.

Transactions of the Zoological Society of London. Vol. V. Part III. 4to.—*From the Society*.

Proceedings of the Zoological Society of London. Parts I.–III. 1863. 8vo.—*From the Society*.

Transactions of the Royal Irish Academy. Vol. XXIV. Antiquities, Parts I. and II.; Literature, Part I.; Science, Part III. 4to.—*From the Academy*.

Proceedings of the Royal Irish Academy. Vol. VIII. Parts I.–VI. 8vo.—*From the Academy*.

Proceedings of the Royal Geographical Society of London. Vol. VIII. Parts III.–VI. 8vo.—*From the Society.*

Address at the Anniversary Meeting of the Royal Geographical Society, May 1864. By Sir Roderick I. Murchison, K.C.B. 8vo.—*From the Author.*

Proceedings of the British Meteorological Society. Vol. II. Nos. 11–14. 8vo.—*From the Society.*

Proceedings of the Linnean Society. Vol. VIII. Zoology, No. 29; Botany, Nos. 29, 30. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Nos. 1, 2. 1864. 8vo.—*From the Society.*

Journal of the Geological Society of London. Vol. XX. Parts II.–IV. 8vo.—*From the Society.*

Address delivered at the Anniversary Meeting of the Geological Society of London, 19th February 1864. By Professor A. C. Ramsay. 8vo.—*From the Author.*

Journal of the Royal Dublin Society. No. 31. 8vo.—*From the Society.*

Journal of the Chemical Society of London. May to October 1864. 8vo.—*From the Society.*

Proceedings of the Society of Antiquaries of London. Vol. I. No. 8; Vol. II. Nos. 1–5. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. IV. Nos. 5 and 6. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XXVII. Parts II. and III. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society, London. Vol. IV. Nos. 8 and 9. 8vo.—*From the Society.*

American Journal of Science and Arts. Nos. 110–113. 1864. 8vo.—*From the Editors.*

Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. July and October 1864. 8vo.—*From the Society.*

Transactions of the Entomological Society of New South Wales. Vol. I. Part II.—*From the Society.*

Canadian Journal of Science and Art. Nos. 50, 51, and 53. 8vo. —*From the Canadian Institute.*

Magnetical and Meteorological Observations made at the Government Observatory, Bombay, in 1862, under the Superintendence of Commander E. F. T. Fergusson, I.N., F.R.A.S. 4to.—*From the Indian Government.*

Sixth Annual Report of the Registrar-General of Births, Deaths, and Marriages, in Scotland. 1864. 8vo.—*From the Registrar-General.*

Quarterly Return of the Births, Deaths, and Marriages. Nos. 37 and 38. 8vo.—*From the Registrar-General.*

Monthly Return of the Births, Deaths, and Marriages, April—August 1864. 8vo.—*From the Registrar-General.*

Libros del Saber de Astronomia del Rey D. Alfonso X. de Castilla, copilados, anotados y comentados por Don Manuel Rico y Sinobas. Tom. I., II. Fol.—*From the Academy of Sciences, Madrid.*

Societa reale di Napoli; Atti dell' Accademia delle Scienze Fisiche e Matematiche. Vol. I. 4to.—*From the Academy.*

Societa reale di Napoli; Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche. Anno II. Fasc. 4–12. Anno III. Fasc. 1, 2; e Rendiconto delle Scienze Morali e Politiche. April to December 1863. 4to.—*From the Academy.*

Societa reale di Napoli; Rendiconto della reale Accademia Archeologia, Lettere, e Belle Arti, Anno 1863. 4to.—*From the Academy.*

Atti del reale Istituto Lombardo di Scienze, Lettere, ed Arti. Vol. III. Fasc. 5–8 and 15–20. 4to.—*From the Institute.*

Memorie del reale Istituto Lombardo di Scienze, Lettere, ed Arti. Vol. IX. Fasc. 2, 4, and 5. 4to.—*From the Institute.*

Natuurkundige Verhandlingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem, XVIII^{e}. Deel. 4to.—*From the Academy.*

Verhandelingen der Koninklijke Akademie van Wetenschappen. Tweede Deel. Amsterdam. 4to.—*From the Academy.*

Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Band V. Heft 2. Frankfurt. 4to. —*From the Society.*

Abhandlungen der Philosophisch-philologischen Classe der Koniglich Bayerischen Akademie der Wissenschaften. Band VIII. Abth. 1. 4to.—*From the Academy.*

Neue Denkschriften der Allegemeinen Schwiezerischen Gesellschaft für die Gesammten Naturwissenschaften. Nouveaux Mémoires de la Société Helvêtique des Sciences Naturelles. Band XX. 4to.—*From the Society.*

Schriften der Königlichen Physikalisch-Okonomischen Gesellschaft zu Königsberg. Abth. 1–2. 1863. 4to.—*From the Society.*

Memorias da Academia Real das Sciencias de Lisboa. Classe des Sciencias Mathematicas, Physicas e Naturaes. Tomo III. Part I. 4to.—*From the Academy.*

Historia e Memorias da Academia Real das Sciencias de Lisboa. Classe de Sciencias Moraes, Politicas e Bellas-lettras. Tomo III. Part. I. 4to.—*From the Academy.*

Memorias de la Reale Academia de Ciencias Exactas, Fisicas y Naturales de Madrid. Tomo II. Part 2; Tomo III. Part 3; Tomo IV. Part 1. 4to.—*From the Academy.*

Ueber die Stellung und Bedendung der Pathologischen Anatomie, von Dr Buhl. 4to.—*From the Author.*

Atti dell' imp. Reg. Istituto Veneto di Scienze, Lettere, ed Arti. Tomo ottavo, serie terza, dispensa decima. 1862–63. Tomo nono, serie terza, dispensa primia-quinta. 1863–64. 8vo.—*From the Institute.*

Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin. Jan.–Dec. 1863. 8vo.—*From the Academy.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe. Band XXII. 4to.—*From the Academy.*

Sitzungsberichte der Kaiserl. Akademie der Wissenschaften zu Wien, Mathematisch-Naturwissenshaftliche Classe. Band XLVII. Hefte 5; Band XLVIII. Hefte 1–4; Band XLIX. Heft 1. Mineralogie, etc. Band XLVII. Hefte 4–5; Band XLVIII. Hefte 1–5; Band XLIX. Heft 1. Philosophisch-Historische Classe. Band XLII. Hefte 1–3; Band XLIII. Hefte 1–2; Band XLIV. Hefte 1–3; Band XLV. Heft 1. 8vo.—*From the Academy.*

Almanach der Kaiserl. Akademie der Wissenschaften. 1863. 8vo. —*From the Academy.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen, Afdeeling Letterkunde. Deel VII. Afdeeling Natuurkunde. Deel XV., XVI. 8vo.—*From the Academy.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Band XIII. N°. 4; Band XIV. Nro. 1. 8vo.—*From the Archivar of the Reichsanstalt.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1863, Nos. 1, 2. 8vo.—*From the Society.*

Annales des Mines. Tome V. Livraisons 1, 2. 8vo.—*From the Ecole des Mines.*

Sitzungsberichte der Königl. bayer. Akademie der Wissenschaften zu Munchen. Heft 1, 2. 1864. 8vo.—*From the Academy.*

Jaarboek van der Koninklijke Akademie van Wetenschappen gevestigd te Amsterdam, 1862. 8vo.—*From the Academy.*

Observations Météorologiques faites à Nijne-Taquilsk. Année 1863. 8vo.—*From the Russian Government.*

Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome VI. Nos. 2, 3. 8vo.—*From the Society.*

The following Publications have been presented by the Dêpôt de la Marine, Paris.

Cartes de la Pilote Française, Météorologie Nautique—Vents et courants routes Générales, extrait des Sailing Directions de Maury, et des Travaux les plus recents, par M. Charles Ploix. 4to.

Annales Hydrographiques; Recueil d'Avis, Instructions, Documents, et Mémoires, relatifs à l'Hydrographie et à la Navigation, publiés par le Dépôt des Cartes et Plans de la Marine. Paris, 1863–64. 8vo.

Instructions Nautiques, sur la Mer Baltique et le Golfe de Finlande, par M. A. Le Gras. Paris, 1864. 8vo.

Instructions Nautiques, sur les Côtes Est de la Chine, la Mer Jaune, les Golfes de Pe-chili et de Sian-Tung, et la Côte Ouest de la Corée, par M. de Ventre. Paris, 1863. 8vo.

Instructions Nautiques, sur les Côtes Occidentales d'Amérique du Golfe de Penas à la Rivière Tumbeza, par Robert Fitzroy; traduit de l'Anglais par M. Mac-Dermott. Paris, 1863. 8vo.

Instructions Nautiques, sur les Côtes Occidentales d'Amérique de la Rivière Tumbeza à Panama, par Robert Fitzroy; traduit de l'Anglais par M. Mac-Dermott. Paris, 1863. 8vo.

Instructions Nautiques, sur les Côtes de la Patagonie depuis la Terre des Etats, à l'est, jusqu'au Cap Tres Montes, à l'ouest. Compris le Détroit de Magellan, et la Côte de la Terre de Feu. Traduites de l'Ouvrage Anglais des Capitaines Parker, King, et Robert Fitzroy, par M. Paul Martin. Paris, 1863. 8vo.

Instructions Nautiques, sur les Côtes Orientales de l'Amérique du sûd comprises entre la Plata et le Détroit de Magellan, par les Capitaines Philip, Parker, King, et Robert Fitzroy. Traduites de l'Anglais par M. E. Hamelin. Paris, 1863. 8vo.

Instructions pour aller chercher la Barre de Bayonne et entrer dans la Rivière. Paris, 1863. 8vo.

Les Côtes du Bresil, Description et Instructions Nautiques, par M. Ernest Monchez. Paris, 1864. 8vo.

Pilote de l'Ile Vancouver; routes à suivre sur les Côtes de l'Ile Vancouver et de la Colombie Anglaise, depuis l'entrée du Détroit de Fuca, jusqu'au Golfe Burrard, et au Haure Nanaimo, par le Capitaine George Henry Richards. Traduit par H. Perigot. Paris, 1863. 8vo.

Pilote de l'Ile Guernesey, publié par Ordre de l'Amirauté Anglaise et traduit par M. Massias. Paris, 1864.

Rapport sur une Nouvelle Route pour doubler le Cap de Bonne-Esperance de l'est à l'ouest pendant la saison d'Hiver de Mai à Septembre, proposée par M. Bridet. Paris, 1863. 8vo.

Sur l'emploi du Compas Etalon et la Courbe des Deviations à Bord des Navires en Fer et autres. Par M. B. Darondeau. Paris, 1863. 8vo.

Mer de Chine—Route de Sincapour à Saigon. Paris, 1863. 8vo.

Rensiegnements sur la Mer Rouge. Par M. Lapierre. Paris, 1863. 8vo.

Formule Générale pour trouver la Latitude et la Longitude, par les Hauteurs hors du Méridien. Par Louis Pagel. Paris, 1863. 8vo.

1er Supplement au Catalogue Chronologique des Cartes, Plans, Mémoires, et Instructions Nautiques. Paris, 1863. 8vo.

Annuaire des Marées des Côtes de France pour l'an 1865. Par M. Gaussin. Paris, 1863. 16mo.

Report of the Commissioner of Patents, Arts, and Manufactures, 1861. Washington, U. S. 8vo.—*From the U. S. Patent Office.*

Annual Report of the Board of Regents of the Smithsonian Institution for 1862. 8vo.—*From the Institution.*

Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo XII. Serie 2. Tomo I., II. 4to.—*From the Academy.*

Rendiconto delle Sessioni dell' Accademia delle Scienze dell' Istituto di Bologna, 1861–62, 1862–63. 8vo.—*From the Academy.*

Berichte über die Verhandlungen der Königlich Sachsischen Gesellschaft der Wissenschaften zu Leipzig. Mathematisch-Physische Classe, 1863. Philologisch-Historische Classe, 1863–1864. 8vo.—*From the Society.*

Elektrodynamische Maassbestimmungen insbesondere über Elektrische Schwingungen. Von Wilhelm Weber. Band VI. 8vo.—*From the Author.*

Darlegung der Theoretischen Berechnung der in den Mondtafeln Angewandten Störungen. Von P. A. Hausen. Band VII. 8vo.—*From the Author.*

Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger ag dets Medlemmers Arbeider, 1862–63. 8vo.—*From the Academy.*

Report of the Superintendent of the U.S. Coast Survey for 1861. 4to.—*From the Survey.*

Smithsonian Contributions to Knowledge. Vol. XIII. 4to.—*From the Smithsonian Institution.*

Records and Results of a Magnetic Survey of Pennsylvania and Parts of Adjacent States in 1840, 1841, 1843, and 1862. By A. D. Bache, F.R.S., &c. 4to.—*From the Author.*

Journal of the Scottish Meteorological Society for the Quarters ending 31st March and 30th June 1864. 8vo.—*From the Society.*

Transactions of the Pathological Society of London. Vol. XV. 8vo.—*From the Society.*

List of the Geological Society of London. 1864. 8vo.—*From the Society.*

Light-houses. By David Stevenson, F.R.S.E., &c. Edinburgh, 1864. 8vo.—*From the Author.*

Smithsonian Miscellaneous Collections. Vol. V. 8vo.—*From the Smithsonian Institution.*

Transactions of the Literary and Historical Society of Quebec. 1863–64. 8vo.—*From the Society.*

Forty-sixth and Forty-seventh Annual Reports of the Council of the Royal Geological Society of Cornwall. 8vo.—*From the Society.*

Madras Journal of Literature and Science. Edited by the Honorary Secretary of the Madras Literary Society. Third Series No. 1. 8vo.—*From the Editor.*

Pure Logic, or the Logic of Quality apart from Quantity. By W. Stanley Jevons, M.A. London, 1864. 8vo.—*From the Author.*

Journal of the Royal Asiatic Society of Great Britain and Ireland. New Series. Vol. I. Part I. 8vo.—*From the Society.*

Memoir of Thomas Thomson, Advocate, Edinburgh. 1854. 8vo.—*From J. T. Gibson-Craig, Esq.*

On the Action of Waves upon a Ship's Keel, and the Computation of the Probable Engine Power and Speed of proposed Ships. By W. J. Macquorn Rankine, Esq. 4to.—*From the Author.*

Determination Telegraphique de la Difference de Longitude entre les Observatoires de Genève et de Neuchatel. Par E. Plantamour et A. Hirsch. 1864. 4to.—*From the Authors.*

Memoirs of the Geological Survey of India. Palæontologia Indica. Ser. 3. 4to.—*From Dr Oldham.*

Société des Sciences Naturelles du Grand Duché de Luxembourg. Tomes VI., VII. 8vo.—*From the Society.*

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XVIII. Nos. 7, 8. 8vo.—*From the Academy.*

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti Classe di Lettere e Scienze, Morali e Politiche. Vol. I. Fasc. 1–3. 8vo.—*From the Institution.*

Annalen der Königlichen Sternwarte bei Munchen. Band XIII. 8vo.—*From the Royal Observatory of Munich.*

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nr 531–552. 8vo.—*From the Society.*

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft bei ihrer Versammlung zu Samaden, 24–26. 1863. 8vo.—*From the Society.*

Jahresbericht über die Fortschritte der Chemie, &c. von C. Bohn, A. Knop, u H. Will, für 1863. Heft I. Giessen. 8vo.—*From the Editors.*

Résumé Météorologique de l'Année 1862–63, pour Genève et le Grand St Bernard. Par E. Plantamour. 8vo.—*From the Author.*

Journal of Natural History, containing Papers and Communications read before the Boston Society of Natural History. Vol. VIII. No. 4. 8vo.—*From the Society.*

Proceedings of the Boston Society of Natural History. 1863–64. 8vo.—*From the Society.*

Proceedings of the American Academy of Arts and Sciences. 1863. 8vo.—*From the Academy.*

Bulletin of the Museum of Comparative Zoology, Cambridge, Massachusetts, U.S. 8vo.—*From L. Agassiz, Director of the Museum.*

Annual Report of the Trustees of the Museum of Comparative Zoology, U.S. 1863. 8vo.—*From the Trustees.*

Introductory Report of the Commissioner of Patents for 1863. 8vo.—*From the U.S. Patent Office.*

Proceedings of the American Philosophical Society. Vol. IX. No. 70. 8vo.—*From the Society.*

Della Infezione Biliosa del Sangue (Calemia). Discorse del dott Giacinto Namias. 8vo.—*From the Author.*

A Contribution towards an Index to the Bibliography of the Indian Philosophical Systems. By Fitzedward Hall, M.A. 8vo.—*From the Author.*

Note sur la Succession des Mollusques Gasteropodes pendant l'époque Crétacéen dans la Region des Alpes Suisses et du Jura. Par F. J. Pictet. 8vo.—*From the Author.*

Tre Akademiske Taler paa Universitetets Aarsfest den 2den September. Af M. F. Monrad. 8vo.—*From the Academy.*

Resumen de les Actas de la real Academia de Ciencias Exactas, Fisicas, y Naturales de Madrid. 1861–62. 8vo.—*From the Academy.*

The Truth of the Bible upheld, or Truth *v.* Science. By Lawrence S. Benson. 8vo.—*From the Author.*

On Literary and Scientific Studies in connection with Medicine. By J. H. Balfour, M.A., M.D. 8vo.—*From the Author.*

Catalogue au Cabinet de Monnaies et Médailles de l'Académie Royale des Sciences d'Amsterdam. Redigé par MM. A. J. Enschede et J. P. Six. 8vo.—*From the Authors.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1864–65. No. 66.

Monday, 19th December 1864.

Sir DAVID BREWSTER, President, in the Chair.

The President, on taking the Chair, delivered the following Address:—

In taking the Chair, to which, by your kindness, I have been appointed, it may not be an inappropriate introduction to its duties if, in congratulating you on the prosperous state of the Society, I should refer to some facts in its history, not generally known, which have materially contributed to its prosperity and progress.

In the closing years of the last and in the first decade of the present century, the Society was in a very languid condition. In each of the years 1799, 1802, 1803, 1808, and 1809, only one of the papers read at its meetings was published in the Transactions; and in 1801 and 1806, not a single paper read in these years was published.

While our Transactions were thus scantily supplied with papers, those actually read were few in number, and often too abstruse to excite a general interest. The regular meetings of the Society had frequently no other business than to read the minutes, elect members, and receive donations; and this was sometimes done in the presence only of a Secretary and one or two members of Council. Under such circumstances, the Secretary summoned the members by a billet, printed with *red* ink when a paper was to be read, and one in *black* when he had nothing to communicate.

At this time Sir George Mackenzie, Mr Skene, Mr Allan, and myself—then office-bearers or members of Council, made arrangements that a paper of some kind should be read at every meeting, and in this way a more numerous attendance was obtained.

This abnormal process, however, did not continue long. The Huttonian Theory of the Earth, which its distinguished author promulgated in our Transactions for 1785, had attracted the attention of naturalists. Sir James Hall, then a young man, entered with enthusiasm into its study; and so early as 1790 he laid before the Society certain views on the fusion and subsequent crystallisation of mineral substances, which seemed hostile to the opinions of his master. Having proposed to confirm them by experiment, Dr Hutton, as Sir James says, "gave him little encouragement;" and, under the influence of a false delicacy, he abstained from prosecuting the subject during the life of his friend. In 1798, however, after Dr Hutton's death, he resumed and published his experiments on the fusion of whinstone and lava; and was led to those admirable researches "on the effects of compression in modifying the action of heat," which he communicated to the Society, and published in 1805.

This remarkable paper having removed many of the objections which had been urged against the Huttonian theory, it was eagerly embraced and defended by Professor Playfair, Lord Webb Seymour, Sir George Mackenzie, Mr Allan, Dr Hope, and other geologists. Professor Jameson had about this time returned from Freyberg, imbued with all the doctrines of the Wernerian School, and eager to propagate them among his pupils and friends. Dr Thomas Thomson and Dr Macknight joined his standard; and the rival theories of fire and water were discussed in this Society with all the warmth, I may even say the bitterness, of political or theological controversy. Vanquished by the superior science of their opponents, the Wernerians quitted the field, and the Huttonian theory, illustrated by the eloquence of Professor Playfair, attracted to its study the most distinguished geologists of other lands, and took a high place among the natural sciences.

Several English geologists were thus led to establish the Geological Society of London; and though, with the view of disarming the prejudices which had been excited against the Huttonian doctrines they resolved only "to collect the materials for future generalisations," yet the great truths which had been established in Scotland were soon accepted and confirmed by the most eminent of their number.

If our Society gained in popularity, and increased in numbers, during the controversy to which I have referred, it suffered a serious loss by the retirement of Professor Jameson and his friends to the Wernerian Society which he had established in 1808. But what was a loss to us was a gain to science. The new Society enlisted in its service a number of young and active naturalists, who enriched its Transactions with many papers of great interest and value.

If geology, as a science, drew its first breath within our walls, by the active labours of our colleagues, the kindred science of mineralogy was, at the same time, earnestly studied and greatly advanced. Mr Thomas Allan, who possessed one of the finest collections in Scotland, spared no expense in enriching it with new and rare minerals. In 1808, a Danish vessel, brought into Leith as a prize, was found to contain a small collection of minerals, which was purchased by Mr Allan, and Colonel Imrie, a Fellow of this Society, and a contributor to its Transactions. Among these minerals they found a large quantity of cryolite, a substance so rare that at the market price it would have brought L.5000. They found also crystals of gadolinite, sodalite, and a new mineral, to which Dr Thomson, who analysed it, gave the name of Allanite.

These interesting minerals had been collected in Greenland by Mr (afterwards Sir Charles) Giesecké, during the mineralogical survey which he had made of that country between 1805 and 1813, and were shipped by him for Copenhagen in 1808. Upon his arrival at Hull in 1813, with another and a more valuable collection, he learned the fate of his former specimens, and immediately proceeded to Edinburgh, where he was hospitably received by Mr Allan, Sir George Mackenzie, and other members of this Society. During his residence here he contributed papers to our Transactions, and acquired so high a reputation as a mineralogist, that, through the interest of his friends here, he was appointed to the Chair of Mineralogy in the Royal Dublin Society.

While the study of mineralogy was thus greatly promoted by the labours and liberality of Mr Allan, he had the good fortune, at a later period, to bring to Edinburgh, and receive under his roof for nearly four years, a young German mineralogist of very uncommon acquirements. William Haidinger, a native of Vienna, who had studied mineralogy at Gratz under the celebrated Frederick Mohs, came to Edinburgh in 1823, and resided with Mr Allan till 1826, when he returned to Austria, where he prosecuted with ardour his geological and mineralogical studies, and where he now occupies a high place in the scientific institutions of Vienna.

During his residence in Edinburgh, he published several valuable papers in our Transactions, and delivered a course of lectures on crystallography, at which Dr Edward Turner and other two friends were the audience. In claiming to have been one of his pupils at these lectures, I cannot resist the gratification of claiming him as a pupil in that branch of optics, connected with mineralogy, which was then ardently studied in every part of Europe. When Mr Haidinger returned to Vienna, he prosecuted the study of physical optics with great zeal and success, and had the good fortune to discover one of the most beautiful facts in that branch of science. He was the first who observed that curious property of the eye by which it discovers polarised light, and even the plane of its polarisation, without any instrument whatever. The cause of this remarkable phenomenon, called "Haidinger's brushes," has not been discovered; but there is reason to believe that it is produced by a structure in the retina, immediately behind the *foramen centrale*.

Although the financial state of the Society was greatly improved by the increase in the number of its members, yet its funds were quite inadequate to defray the necessary expenses of such an institution. The annual grant, therefore, of L.300, given in 1836 by the Government of Lord Melbourne, though it enabled the Society to pay the rent of its apartments, left nothing for those special objects which such institutions are expected to promote. When we consider that the Royal Society of London has an annual grant of L.1000, with free apartments in Burlington House, and a sum for the royal medals, we can hardly doubt that an earnest representation to the Government would obtain for us a similar, though, doubtless, a smaller grant.

One of the most effective means by which a society like ours can promote the interests of science, is the adjudication of prizes to its successful cultivators. The first bequest to us for this purpose was made by the late Mr Keith of Ravelston (long an office-bearer, and occasionally a contributor to our Transactions), who left L.600 to found a biennial prize "for the most important discovery in science made in any part of the world, but communicated by its author to the Royal Society of Edinburgh, and published in its Transactions."

In 1855, Sir Thomas Macdougall Brisbane, when President of the Society, gave L.400 to found a biennial prize of L.30 to promote any branch of science to which the President and Council might devote it; and in the following year Dr Patrick Neill bequeathed L.500 to found a biennial or triennal prize, to be adjudicated to the most distinguished Scottish naturalist. These prizes have been gained by some individuals not Fellows of the Society, and have procured for our Transactions many valuable communications which they would not otherwise have obtained.

Unwilling to allow their prizes to remain unappropriated, it has been the practice of some societies to adjudicate them occasionally, contrary to the conditions imposed by the deed of foundation. Such a proceeding cannot be too carefully avoided. It is injurious to the society, by preventing the accumulation of the fund. It is unjust to future competitors, who would otherwise have received a richer prize. It diminishes the importance of the prize by its too frequent adjudication; and it prevents the wealthy patrons of science from intrusting money to an institution that does not respect the conditions upon which it is given.

In calling your attention to some of the leading features in the history of the Society, I cannot avoid expressing the regret which has been very generally felt at the discontinuance of those biographical memoirs of distinguished members, which, during the secretaryship of Professor Playfair, formed such an interesting portion of our Transactions. I take to myself some blame, that when I held the same office, no memoir of Dugald Stewart, Professor Playfair, and Sir James Hall should have been communicated to the Society; and the only apology I can offer is, that the researches in which I was engaged were too engrossing to admit of any other occupation. The evil, however, may yet be remedied, and, as suggested by a former Council, the Macdougall Brisbane prize might be given for important memoirs, such as that of Professor Ferguson, by Mr Small, which has been published in our Transactions.

In calling your attention to the controversy between the Huttonian and Wernerian geologists, as an epoch in the history of the Society, I referred to the prejudices which it awakened, and the bitterness with which it was carried on. The formula of Dr Hutton, that "in the natural history of the earth there was no vestige of a beginning, and no prospect of an end," alarmed the timid, and furnished his opponents with a weapon which philosophers should disdain to wield. Dr Hutton observed, "that the Mosaic history placed the beginning of man at no great distance, and that there had not been found in natural history any document by which a high antiquity might be attributed to the human race." He held no opinions and indulged in no speculations incompatible with revealed truth, and his Scottish disciples, led by Professor Playfair, maintained the doctrines of their master without doing violence to the serious convictions of their countrymen.

It was reserved for another school of geology to array the wisdom of this world—Science falsely so called—against truths eternal and immutable. It was reserved for an unscrupulous philosophy to hold an inquest on the origin of that life which God breathed into man to make him a living soul,—to teach the heresy of the creation and government of the universe by law; thus hurling the Almighty from His throne,—Himself but the first link of the chain of life,—the sovereign of an empire without a sceptre,—the Father of a family, blind to the tears, and deaf to the cries of his children.

Such views of the Divine Government will, I trust, never find acceptance within these walls. In the study of nature there is no forbidden ground. Into its deepest mysteries we are invited to dive, and if we make Reason our guide, and Imagination our footstool, we may rest assured that truths that are demonstrated will never rush into collision with truths that are revealed.

1. On Variability in Human Structure, with illustrations from the Flexor Muscles of the Fingers and Toes. By William Turner, M.B. (Lond.), Demonstrator of Anatomy in the University.

The author, after referring to variations in the external form of the body in different individuals, and to the relations between external form and internal structure, proceeded to discuss the subject of variability in the different organic systems. He showed that internal structural variations conferred upon the individual characters as distinctive as any peculiarities in external configuration. It was argued that in the development of the individual a morphological specialisation occurs, both in internal structure and external form, so that each man's structural individuality is an expression of the sum of the individual variations of all the constituent parts of his frame.

The muscular system was adduced as affording abundant illustration of the specialisation of structure in the individual, and an analysis was given of a number of dissections of the flexor muscles of the fingers and toes. In the long flexors of the thumb and fingers, not only were variations in bulk, extent of attachment, and mode of division described, but the frequent existence and variously modified arrangements of bands connecting together not only the muscles, or divisions of muscles, situated on the same plane, but those situated on different planes were pointed out. A close analysis of the arrangements of the flexor hallucis longus, flexor longus digitorum, flexor accessorius, flexor brevis digitorum, and lumbricales, in thirty dissected feet, was then given, and the extent of variation which these specimens exhibited detailed at considerable length. The necessity of dissecting carefully the soft parts in the different races of men, so as to study the amount of variation which might occur in them, was insisted on in the paper.

2. On the Principle of Onomatopoeia in Language. By Professor Blackie.

Professor Blackie read a paper on Onomatopoeia, or the influence of the imitative principle on the formation of language. Without denying that a number of words in the later development of language were purely notional, that is, intended to represent an idea, not to imitate a sound, he strongly contended, that the whole original stock of language was either direct imitations of natural sounds, or analogical representations of things visible and tangible by things audible. As proofs of this he adduced various illustrations from the Aryan and the Semitic languages. He showed specially that most motions are accompanied by certain sounds or noises, and these sounds are imitated more or less perfectly by the great family of verbs which express motion in all languages; that objects which are sharp or blunt, rough or smooth to touch, are expressed by words which have the same character to the organs of speech and to the ear; and that there is a distinct correlation between all outward sensuous impressions and the emotions thereby excited in our minds and nervous system, which necessarily causes the vocal expression of any feeling to bear a likeness to the external impression from which it proceeded. He did not consider the scientific truth of this matter to be in any way affected by the vexed question, whether man was created originally an infant or full-grown; and the disownment of the imitative principle in the formation of language by Professor Max Müller, in his recent work on the science of language, he considered as the result of a German prejudice against even the appearance of sensationalism, a fondness for the abstract in preference to the concrete in philosophy, and a delight in the mysterious.

3. Note on the Phlogistic Theory. By Alexander Crum Brown, M.D., &c.

When we consider that the Phlogistic Theory formed, as it were, the central point round which the facts of chemistry first crystallized into regular scientific form, and that for more than a hundred years it was recognised by all as the foundation of the science, we might reasonably suppose that it should contain at least some germ of truth.

I think I shall be able to show in the following note that not only is this the case, but that the theory itself, as stated by its founders, Beccher and Stahl, is, if not strictly true, a very close approximation to what we now recognise as truth.

According to Stahl, all combustibles contain one and the same substance in different proportions, according to the degree of their combustibility. That substance is phlogiston; and when a combustible is burnt, or a metal calcined, its phlogiston is given out. When charcoal or oil is heated with a metallic calx, the phlogiston leaves the former, and is found in combination in the metallic regulus.

Now, if we consider the facts of the case in an unprejudiced way, we must admit that a combustible loses something when it is burnt, it loses combustibility, or the capability of being burnt. In the same way, in the preparation of phosphorus, or the reduction of a metallic calx, the charcoal loses this capability, while the phosphorus or metal acquires it.

The capability of being burnt is essentially the power of emitting a certain quantity of heat, and, as we know from the researches of Rumford, Davy, and others, and from the later and more accurate determinations of Joule, that heat is a particular form of what has been called kinetic energy, we can have no difficulty in admitting that the power of emitting a certain quantity of heat is a particular form of potential energy.

If, in the statement of the phlogistic theory, we read potential energy for phlogiston, and understand that when phlogiston is separated from one body and not taken up by another, as in combustion, this potential energy is converted into kinetic energy, we have a tolerably complete account of what we now know of the matter.

Whether we choose, with Beccher and Stahl, to call phlogiston a substance or not, depends on our definition of what a substance is, If we restrict that name to ponderable matter, of course it is not a substance, but when we consider that energy is as indestructible as matter, that we can trace it through its various combinations and double decompositions, and that we are in a fair way to discover, not, indeed, its atomic weight, for it has none, but its chemical unit, it does not seem very absurd or unreasonable to class it along with the ordinary chemical elements.

It may be objected to the phlogistic theory, as thus explained, that it is not the combustible alone, but the combustible and oxygen, that have potential energy, and that it is only when the two unite that this potential energy is transformed into kinetic. This objection is equally valid against the statement, that a clock, when wound up, contains potential energy, it is not the clock, but the clock and the earth, which contain this, and it is transformed when the clock weight and the earth approach each other.

In fact, energy is not conceivable without a system of at least two bodies.

We must, of course, recollect that the phlogistic chemists were ignorant of the existence and nature of oxygen, and it is to this ignorance that we must ascribe the downfall of the theory of phlogiston. They attempted to explain, by means of this theory, facts (such as the increase of the weight of a combustible when burnt) depending on a totally different cause. They were thus led to modify the theory, and ascribe to phlogiston negative weight, and to identify it sometimes with carbon and sometimes with hydrogen gas.

It is not surprising that the theory, thus mutilated, should have been overthrown, and we have only to regret that the valuable truth embodied in it should have been lost sight of; that the antiphlogistic chemists, like other reformers, destroyed so much of what was good in the old system, and that, in consequence of this, we are only now beginning to see what was obvious to such a man as Stahl, that oxide of iron does not contain metallic iron; that no compound contains the substances from which it is produced, but that it contains them minus something. We now know what this something is, and can give it the more appropriate name of potential energy; but there can be no doubt that this is what the chemists of the seventeenth century meant when they spoke of phlogiston.

The following Donations to the Library were announced:—

Transactions of the Linnean Society, London. Vol. XXIV. Part 3. 4to.—*From the Society.*

Journal of the Linnean Society, London. Vol. VIII. No. 31 (Botany). 8vo.—*From the Society.*

List of the Linnean Society, London. 1864. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XIII. No. 69. 8vo.—*From the Society.*

Proceedings of the Royal Institution of Great Britain. Vol. IV. Parts 3 and 4. 8vo.—*From the Institution.*

Journal of the Asiatic Society of Bengal. No. 3. 1864. 8vo.—*From the Society.*

Transactions of the Royal Medical and Chirurgical Society of London. Vol. XLVII. 8vo.—*From the Society.*

Transactions of the Historic Society of Lancashire and Cheshire. New Series. Vol. III. 8vo.—*From the Society.*

Journal of the Royal Geographical Society. Vol. XXXIII. 8vo. —*From the Society.*

Thirty-seventh Annual Report of the Council of the Royal Scottish Academy. 1864. 8vo.—*From the Academy.*

The Design and Construction of Harbours. By Thomas Stevenson, F.R.S.E. 8vo.—*From the Author.*

Memoirs of the Royal Astronomical Society. Vol. XXXII. 4to. —*From the Society.*

Transactions of the Royal Scottish Society of Arts. Vol. VI. Part 4. 8vo.—*From the Society.*

Quarterly Return of Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland, for the Quarter ending 30th September 1864. 8vo.—*From the Registrar-General.*

Monthly Returns of Births, Deaths, and Marriages registered in the Eight Principal Towns in Scotland—September, October, and November 1864. 8vo.—*From the Registrar-General.*

Monthly Notices of the Royal Astronomical Society, November 1864. 8vo.—*From the Society.*

Entoptics—Letter to Dr Iago from Dr Mackenzie. 1864. 8vo. —*From the Author.*

On the Distribution of Rain over the British Isles during the years 1860–63. By G. I. Symons. 8vo.—*From the Author.*

Proceedings of the Geologist's Association. 1863–64. 8vo.—*From the Association.*

On the Wet Dock and other Works about to be constructed by the Commissioners for the Harbour and Docks of Leith. By George Robertson, F.R.S.E., &c. 8vo.—*From the Author.*

Geometrical Disquisitions. By Lawrence S. Benson of South Carolina. 8vo.—*From the Author.*

On the Circle-Area and Heptagon-Chord. By S. M. Drach, F.R.A.S. 8vo.—*From the Author.*

Journal of the Geological Society of Dublin. Vol. X. Part 2. 8vo.—*From the Society.*

Journal of the Chemical Society of London. New Series. Vol. II. 8vo.—*From the Society.*

Report read by the Astronomer-Royal for Scotland to the Special Meeting of Her Majesty's Government Board of Visitors of the Royal Observatory, Edinburgh, on the 4th, and issued on the 11th November 1864. 4to.—*From the Author.*

Bulletin de la Société de Géographie, Paris. Tome VII. 8vo.—*From the Society.*

Bulletins de l'Académie Royale de Belgique. 2me Sér. Tomes XV.-XVII. 8vo.—*From the Academy.*

Mémoires Couronnés et autres Mémoires publiés par l'Académie Royale de Belgique. Tomes XV., XVI. 8vo.—*From the Academy.*

Annales de l'Observatoire Physique Central de Russie, publiées par ordre de sa Majesté Impériale. Par A. T. Kupffer. 1860, 1861. St Petersburg. 4to.—*From the Observatory.*

Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XXXIV. 4to.—*From the Academy.*

Mémoires Couronnés et Mémoires des Savans Etrangers, publiés par l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XXXI. 4to.—*From the Academy.*

Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Vol. V. Fasc. 1. 4to.—*From the Society.*

Annales de l'Observatoire Royal de Bruxelles. Tome XVI. 4to. —*From the Observatory.*

Annuaire de l'Observatoire Royal de Bruxelles. 1864. 16mo.—*From the Observatory.*

Glossaria Linguarum Brasiliensium, Glossarios de diversas lingoas e dialectos que fallao os Indios no Imperio do Brazil. Von Dr Carl F. Phil. von Martius. Erlangen, 1863. 8vo.—*From the Author.*

Compte-Rendu de la Commission Impériale Archéologique pour l'année 1862. With Atlas. St Petersburg. 4to.—*From the Russian Government.*

Annuaire de l'Académie Royale des Sciences de Belgique. 1864. 16mo.—*From the Academy.*

L'Homme Fossile des Cavernes de Tombrive et de Therm, avec une Introduction Historique et Critique. Par J. B. Rames, F. Garrigon, et H. Filhol. 1862. 8vo.—*From the Authors.*

Etude Chimique et Medicale des Eaux Sulfureuses d'Ax (Ariége), précédée d'une Notice Historique sur cette Ville, et suivie de l'Analyse des Sources Sulfureuses Chaudes de Méreus. Par Felix Garrigon. 1862. 8vo.—*From the Author.*

Lettre à M. le Professeur N. Joly, présentée par lui à l'Académie des Sciences de Toulouse. Par le Docteur F. Garrigon. 1862. 8vo.—*From the Author.*

Mémoire sur les Cavernes de Therm et de Bonicheta (Ariége). Par le Docteur Felix Garrigon de Tarascon (Ariége). 8vo. *From the Author.*

L'Age de le Pierre dans les Cavernes de la Vallée de Tarascon (Ariége). Par MM. F. Garrigon et H. Filhol. 8vo.—*From the Authors.*

Note sur Deux Fragments de Machoires humaines trouvés dans la Caverne de Bruniquel (Tarn-et-Garonne). Par MM. F. Garrigon, L. Martin, et E. Trutal. 4to.—*From the Authors.*

Tableau des Donnés Numériques qui fixent 159 Cercles du Réseau Pentagonal. Par M. L. Elie de Beaumont. Paris, 1863. 4to. —*From the Author.*

Considérations sur la Prévision des Tempêtes, et spécialement sur celles du 1 au 4 Decembre 1863. Par Ferdinand Muller. 4to.—*From the Author.*

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XVIII. Nos. 9, 10, 11. 8vo. —*From the Academy.*

Statistique et Astronomie—Sur la Mortalité pendant la Première Enfance. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Sur le Cinquième Congrès de Statistique tenu à Berlin du 4 au 12 Septembre 1863. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Phénomènes Périodiques—Des Phénomènes Périodiques en général. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Notice sur la Périodicité des Etoiles Filantes du mois de Novembre. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Sur les Etoiles Filantes et leurs lieux d'Apparition. Par MM. Ad. Quetelet, Le Verrier, Haidinger, et Poey. 8vo.—*From the Authors.*

Physique du Globe—Etoiles Filantes; Aérolithe et Ouragan en Decembre 1863. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Etoiles Filantes de la Période du 10 Août 1863. Par M. Ad. Quetelet. 8vo.—*From the Author.*

Orage du 10 Septembre 1863, observé à Bruxelles. Par M. Ernest Quetelet. 8vo.—*From the Author.*

Résumé des Observations sur la Météorologie et sur le Magnétisme Terrestre. Par M. Ad. Quetelet. 4to.—*From the Author.*

Physique du Globe. Mémoire sur les relations qui existent entre les Etoiles Filantes les balides et les essaims de Météorites. Par M. Haidinger, de Vienne. 8vo.—*From the Author.*

Memorie del Nuovo Osservatorio del Collegio Romano D. C. D. G. dall' Aprile 1856 al Settembre 1857. Pubblicate dal Direttore P. A. Secchi, D.C. D.G. 4to.—*From the Observatory.*

Memorie dell' Osservatorio del Collegio Romano D.C. D.G. Nueva Serie, 1857–59, 1860–63. Pubblicate dal P. A. Secchi. 4to.—*From the Observatory.*

Bullettino Meteorologico dell' Osservatorio del Collegio Romano con Corrispondenza e Bibliografia per l'Avanzamento della Fisica Terrestre, compilato dal P. A. Secchi, D.C. D.G. 4to. —*From the Observatory.*

Misura della Base Trigonometrica eseginta sulla Via Appia, per ordine del Governo Pontificio nel 1854–55. Dal P. A. Secchi, D.C. D.G. 4to.—*From the Observatory.*

Sur le Mouvements propre de quelques Etoiles. Par Ern. Quetelet. 4to.—*From the Author.*

Compte-Rendu Annuel adressé à S. Exc. M. de Reutern, Ministre des Finances, par le Directeur de l'Observatoire Physique Central, A. T. Kupffer, 1861–62. 4o.—*From the Author.*

Schriften der Universität zu Kiel aus dem Jahre 1863. Band X. 4to—*From the University.*

Preussische Statistik die Witterungserscheinungen des Nördlichen Deutschlands in Zietraum von 1858–63. Von H. W. Dove. 4to.—*From the Author.*

Tuesday, 3d January 1865.

PROFESSOR CHRISTISON, V.P., in the Chair.

The Chairman delivered the Makdougall-Brisbane Medal, which had been awarded to Mr J. Denis Macdonald, R.N.

The following Communications were read :—

1. A Map of Taranaki, New Zealand, executed by a Maori, was exhibited, and remarks on it by Dr Lauder Lindsay were communicated by Mr A. Keith Johnston.

2. Professor Tait read a note on the various investigations of the Law of Frequency of Error; in which he pointed out that the difficulty was really a logical, not an analytical one; and showed how from *à priori* principles, somewhat different from those of Laplace, it was easy to obtain the received result without the formidable analysis of Laplace and Poisson. Some curious consequences were shown to follow from the principles adopted.

3. Notice respecting Mr Reilly's Topographical Survey of the Chain of Mont Blanc. By Principal Forbes.

On the 6th February 1843, or almost twenty-two years ago, I had the honour of laying before this Society an account of a topographical survey of the Mer de Glace of Chamouni and its neighbourhood, together with the detailed map founded upon it, being probably the first map of a glacier on such a scale ever constructed. Since that time I have never ceased to interest myself in the improvement and extension of this survey. Two subsequent editions of the map appeared, containing the results of my continued observations with the theodolite in 1843, 1844, 1846, and 1850. The last edition (on a reduced scale), in 1853, included the whole of the glacier of Bossons and the results of an extended triangulation, in which the Flegère and the Breven formed the extremities of a new base connected with the stations L, M, and I of my former survey.

Since 1851 the state of my health has put a bar in the way of any farther personal exertions in elucidating the topography of the chain of Mont Blanc. But as opportunity served, I have not ceased to urge the younger generation of Alpine travellers to extend our knowledge of its details, and, by making the theodolite their companion, and multiplying panoramic views of all intricate mountain groups, to obtain valuable topographical knowledge, at the same time that they enjoy the luxury of Alpine rambling. The south-western part of the chain of Mont Blanc, which really was very much a *terra incognita* as to its interior conformation (though perpetually visited on its outskirts by all who passed the Col du Bonhomme), was partially explored and sketched by Mr Tuckett, an active member of the Alpine Club; but the district to the east of the Mer de Glace, stretching towards the Col de Balme and the Swiss Val Ferret, remained a complete enigma, the intricacy and obscurity of which appeared more and more as its recesses were successively invaded by the adventurous inroads of members of the Alpine Club. For years I had been urging my mountaineering friends to carry a theodolite to the summit to the east of the Jardin, marked in my map as "Nameless Peak A," from whence I knew that the debatable land to the eastward would probably be overlooked; but it was not attempted till 1863. The year before, Sheet xxii. of the Swiss Federal Survey had been issued, and was looked for with great interest by myself and others as likely to clear up at least a part of the mystery of this Gordian knot of peaks and glaciers. So far as it was included within the rigorous limits of the Swiss Confederation, it was as completely satisfactory as that survey has everywhere else been acknowledged to be. But the Federal boundary once passed, it was evident that the topography of the adjacent part of Savoy included in the Swiss sheet was far less reliable, if indeed worthy of any confidence at all. The persuasion of the uncertain state of the geography of this interesting portion of the most important mountain group in Europe was common to myself and others who had visited or crossed that part of the chain. Early in 1863 I had the good fortune to make the acquaintance of Mr Reilly, who was already interested in the problem, and who shewed me panoramic drawings of different parts of the range, executed with remarkable facility and correctness. He readily agreed to return to the spot and take a theodolite with him. The map which I now have his permission to exhibit to the Society is the result of his labours in 1863, with some corrections and additions in 1864. It starts fundamentally as a base with my triangulation of the Flegère and Breven stations, and thus connects itself immediately and accurately with the whole of my map so far as it extended, that is, from the top of Mont Blanc to the "Nameless Peak A," parallel to the chain, and from the Jorasses to the Flegère in a perpendicular direction. Mr Reilly carried forward the main triangulation up the valley of the Arve to the Col de Balme, and thence to the very recesses of the Glacier du Tour, which was the seat of at least one part of the "Gordian knot" already referred to. He gradually found himself led to the conclusion that the Sardinian surveyors, on whose authority the Swiss map beyond the limits of the Confederation was probably constructed, had made a mistake of an almost incredible kind, representing *one and the same mountain* under the names of *Aiguille d'Argentière* and *Pointe des Plines* in *two* different places a mile and a-half apart, and separated by a vast ice-field communicating with the Glacier du Tour, which ice-field has of course no existence, as the two mountains, by which it was represented as being bounded, are, as already stated, absolutely identical. The portion of glacier thus annihilated was represented as two and a quarter English miles in length. Mr Reilly, whose activity as a pedestrian is equal to his skill as a draughtsman, put the seal on his topographical discovery by passing for the first time the elevated col between the Aiguilles of Argentière and Chardonnet, starting from the side of the glacier of Argentière. Had existing maps been correct, he would have alighted on the glacier of Tour within the frontier of Savoy; but in effect he found himself on the glacier of Salena in Swiss territory.

The western portion of the chain of Mont Blanc next engaged his attention. He was enabled by his extraordinary activity, and his skill in mountain drawing, to lay down with an accuracy far beyond any thing previously attained in that quarter, the whole western and southern faces of the chain, with the numerous vast glaciers which intersect these. On the whole, the position of about 200 points was fixed by the theodolite, the position of one or two fundamental stations (especially of Mont Joli) having been obtained from the French engineers.

In the summer of 1864, Mr Reilly revisited the chain of Mont Blanc with his map and theodolite, and was able to improve the former at several points formerly obscure, particularly in the neighbourhood of the southern glacier of Miage. He gained great additional insight into the details of the very heart of the wildest parts of the range by ascending, all for the first time, three lofty peaks previously unattained, the Aiguille d'Argentière and the Mondelant to the eastward, and the magnificent Aiguille de Trelatête, which closely approaches Mont Blanc on the south-west. In addition to this, he traversed this most difficult chain in two new directions from the Jardin to the Glacier of Triolet on the Italian side, and again from the Col de Miage to the glacier of Bossons by the Dôme de Gouté.

Altogether, Mr Reilly has achieved the remarkable distinction of presenting for the first time to the eye of the tourist and the physical geographer a correct and skilful delineation of the most remarkable and most elevated mountain chain in Europe. Three different states, France, Sardinia, and Switzerland, divide the chain between them. Of these, Switzerland alone has given anything to the world in the least degree worthy of the spot, and that unfortunately only embraces a secondary part. It is a singular chance which has enabled a British amateur to produce a work so creditable and so long desired. Let us hope that no delay will take place in its publication.

4. On the Solution of Perigal's Problem concerning the contact of Epicycloidal Curves. By E. Sang, Esq.

If the centre of a revolving wheel be carried with a uniform velocity, along a line; and if a tracing-point be fixed to an arm of the wheel, that point will trace out a curved line; to which the general name *cycloid* or *trochoid* has been given; the former appellation being often restricted to those cases in which the centre of the wheel moves in a straight line, while the name *epicycloid* is given when the same centre moves along the circumference of a circle.

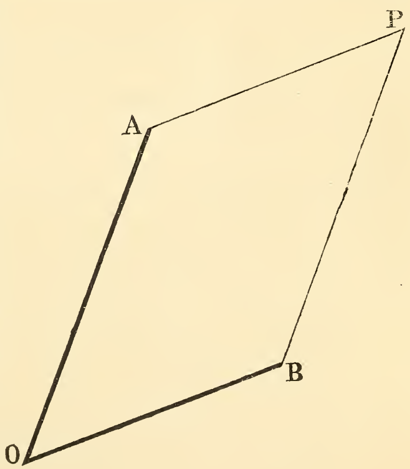
When the tracing-point is placed very close to the centre of the wheel, the curve is slightly undulated; the depth of the waves, other things remaining the same, increases with the distance of the tracing-point from the centre. As that distance is augmented the curve at last becomes cusped as in the common cycloid traced by a nail in the tire of a cart wheel. If the distance of the tracing-point be still farther augmented, the cycloid becomes looped; the loops become wider, and come each to touch that loop adjacent to it on either side.

Mr Perigal's problem is, to determine the conditions under which this contact of the loops takes place.

If the arm of the revolving wheel be still farther lengthened, the loops come to touch those removed from them by two, by three, or by any number of steps, so that the problem may admit of many solutions.

Mr Perigal has obtained the solution of this problem in a considerable variety of cases, by help of mechanical appliances, and has exhibited them in his beautiful series of machine-engraved epicycloids, or bi-circloids, as he calls them.

The most comprehensive view of the genesis of epicycloidal curves is obtained by supposing two arms, OA and OB, to turn with uniform velocities on a common centre O, just as do the two hands of a watch, and by supposing the rhomboid OAPB completed at each instant; the point P then traces an epicycloid.



If the angular velocities of the two arms be represented by α and β, while the lengths are A and B, the directions of these arms at any instant of time t, are represented by αt and βt. It is shown that if T be the time corresponding to the contact of one loop with another, we must have the proportions

$$\alpha : \beta :: \tan \alpha T : \tan \beta T$$
$$A : B :: \sin \beta T : \sin \alpha T$$

so that the solution of the problem resolves itself into that of this trigonometrical question, "*To find two circular arcs in a given ratio and of which the tangents are in the same ratio.*"

The solution of this question, again, resolves itself into that of algebraic equations of the order $\frac{1}{2}(\alpha+\beta-3)$ or $\frac{1}{2}(\alpha+\beta-4)$, when α and β are represented by integer numbers prime to each other. A table of the solutions for all possible values of α and β up to *ten* is given; and it is remarkable that these solutions apply whether the motions of the two arms be in the same or in opposite directions.

The problem is then extended to the case of the common cycloid in which the centre of the revolving wheel moves along a straight line. Here it is shown that we have to discover those arcs which are equal in length to their own tangents; and that the revolving arm must be made proportional to the secants of these arcs. A table of the first ten solutions is appended to the paper.

The following Gentlemen were duly elected Ordinary Fellows of the Society.

Alfred R. Catton, B.A.
Rev. Francis Redford, M.A.

The following Donations to the Library were laid on the table.

Descriptive Catalogue of the Pathological Specimens, contained in the Museum of the Royal College of Surgeons of England. London. Supplement II. 4to.—*From the Council of the College.*

The Stereoscope, its History, Theory, and Construction, with its application to the Fine and Useful Arts, and to Education. By Sir David Brewster, K.H., D.C.L., &c. London, 1856. 8vo. —*From the Author.*

The Kaleidoscope, its History, Theory, and Construction, with its application to the Fine and Useful Arts. By Sir David Brewster, K.H., D.C.L., &c. Second Edition. London, 1858. 8vo.—*From the Author.*

A Treatise on New Philosophical Instruments for various purposes in Arts and Sciences, with Experiments on Light and Colour.

By David Brewster, LL.D. 2 Vols. Edinburgh, 1813. 8vo.—*From the Author.*

Photo-Lithographic Impressions of Traces produced simultaneously by the Self-recording Magnetographs at Kew and Lisbon (Atlas).—*From the Royal Society, London.*

Proceedings of the British Meteorological Society. London. Vol. II. No. 15. 8vo.—*From the Society.*

The Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. Edinburgh. No. 87. January 1865.—*From the Society.*

The Canadian Journal of Industry, Science, and Art. Toronto. New Series, Nos. 53, 54. 8vo.—*From the Canadian Institute.*

Sveriges Geologiska Undersökning pa Offentlig Bekostnad Utförd under Ledning. Af A. Erdmann. Nos. 6–13. Stockholm. 8vo. With Atlas.—*From the Author.*

Rendiconto della Reale Accademia di Archeologia, Lettere e Belle Arti. Napoli. Anno 1864. 4to.—*From the Academy.*

Sitzungsberichte der Königl. bayer. Akademie der Wissenschaften zu München. Hefte I. III. V. 8vo.—*From the Academy.*

Rede gehalten in der Festsitzung der köniģ. Akademie der Wissenschaften zu München am 30 Marz 1864. Von T. v. Dollinger. 8vo.—*From the Author.*

Uebersichten der Witterung in Oesterreich und Einigens auswärtigen Stationen im Jahre 1859. Zusammengestellt von C. Laurent. Wien, 1861. 4to.—*From the Author.*

Monday, 16th January 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. Exhibition of Three Skulls of the Gorilla, received from M. Du Chaillu, with Observations relative to their Anatomical Features. By Dr Burt and Mr W. Turner.

After placing on the table a series of three crania of the gorilla (*Troglodytes gorilla*), which he had a short time ago received from

M. Du Chaillu, Dr Burt proceeded to relate to the Society several facts, recently come to light, in support of various of the statements of that traveller which had been called in question. He alluded to the doubts which had been cast on several of the statements of M. Du Chaillu, and to the uncourteous treatment he had received at the hands of some of his detractors, and enumerated some of the proofs since produced by that gentleman, which are now to be found in the British Museum, and in the possession of men of distinction in science, illustrative of the natural history and the habits of the people of Equatorial Africa, which confirmed the veracity of that gentleman's observations. The last letters received from M. Du Chaillu were written from Fernand Vaz previous to his departure for the interior.

In giving an account of the anatomical features of the crania which Dr Burt had entrusted to him for examination, Mr Turner stated, that as the elaborate memoirs of Professor Owen, Dr Wyman, MM. Duvernoy and I. G. St Hilaire, were within the reach of every comparative anatomist, it was needless for him to go into any detailed description of the characters of the skull of the gorilla. But as the crania were those of an adult male, an adult female, and a young female, it might be interesting to record the specific and sexual characters, and the differences between the young and adult forms, and so assist in establishing the relative constancy and variability of some of the most important anatomical features. The skulls of an adult male and female, and a younger chimpanzee (*Troglodytes niger*), were at the same time exhibited, and compared with those of the gorilla.* The description, unless when otherwise stated, applied to crania personally examined.

In size, the skulls of the adult male and female gorilla were larger than those of the corresponding sex in the chimpanzee, and the adult female gorilla was larger than the adult male chimpanzee.

* The crania of the adult male and younger chimpanzee are in the Anatomical Museum of the University; that of the adult female is in the possession of Dr John Alexander Smith. In the adult and apparently aged chimpanzee crania the sutures were all ossified. In the younger animal, although all the permanent teeth had erupted, yet the sutures of the cranial vault were unossified, and the basi-cranial synchondrosis, though ossified, had its position marked by a transverse bony ridge.

The massiveness of the supra- and inter-orbital ridges, and their greater size even in the female gorilla than in the male chimpanzee, and the influence which their great elevation exercised in concealing the frontal part of the cranial vault, were pointed out: only in the young gorilla, and that very slightly, did the frontal vault come into view, when the skull was looked at from before; in all the three chimpanzee crania the frontal vault could be seen from that point of view. The sagittal and occipital crests were absolutely and relatively larger in the adult male than in the female gorilla. These three massive ridges mounted up and converged at the summit of the posterior end of the cranium. The original bilaterality of the sagittal crest was marked in the male by a median depression in its anterior third, subdividing it into two parallel ridges; and quite at its posterior end it bifurcated, where it became continuous with the two halves of the lambdoidal crest, and when seen from the basal aspect, it seemed like a beak in the centre of the rounded occipital outline. The great projection of the lambdoidal crest rendered the under surface of the occipital bone concave, though it was traversed by strong ridges, evidently for the attachment of powerful muscles. The posterior margin of the foramen magnum was $3\frac{1}{2}$ inches from the posterior end of the sagittal crest. In the female the sagittal crest was very little raised above the surface of the conjoined parietals: the lambdoidal crests were much smaller than in the male gorilla, but larger than in the male chimpanzee; the occipital outline rounded, but with no central projecting beak. In the young gorilla the two temporal ridges did not meet in the middle line: at their point of closest approximation they were one inch apart; hence there was no sagittal crest. The occipital crest was feeble, and was joined somewhat more than one inch to the outer side of the middle line by the faintly-marked temporal ridge. Occipital outline rounded, under surface of the bone convex, approaching in form to that of the chimpanzee; posterior margin of foramen magnum 1·9 inch from centre of the occipital crest. In all the three chimpanzee crania the temporal ridges never coalesced: in the adult male, in which they most closely approximated, their nearest points were upwards of an inch apart.

In the adult male and female gorilla the cranial sutures were almost entirely obliterated. In the young animal they were all very distinct. The ali-sphenoid was pointed superiorly, and separated from the parietal by the articulation of the squamous part of the temporal with the frontal. This arrangement was also traced in the chimpanzee, and seems to be the rule in the crania of these anthropoid apes. In the orang, on the other hand, the articulation of the ali-sphenoid superiorly varied in different specimens. Of four crania examined,—in one the ali-sphenoid on each side articulated with the corresponding parietal; in one a tongue-shaped process of the squamous part of the temporal articulated with the frontal, and cut off the ali-sphenoid from the parietal; whilst in the other two crania, the ali-sphenoid articulated with the parietal on one side of the skull only, for on the other side a tongue-shaped process of the temporal was intercalated between them. In two crania of the gibbon, again, a well-marked articulation existed between the ali-sphenoid and the parietal on both sides of each skull; whilst in a third, on the left side, a narrow tongue of the temporal, reaching the frontal, was intercalated between the ali-sphenoid and the parietal, and on the right side the tongue of the temporal projected into, but not quite across, the ali-sphenoid, so that the latter was still, though slightly, in communication with the parietal. If the tongue of the temporal had passed quite across the ali-sphenoid, then the upper end of this bone would have been cut off, and would have formed a triquetral bone in the temporo-parietal suture. In man, the rule is for the ali-sphenoid to articulate with the anterior inferior angle of the parietal, and thus to cut off the frontal from the squamosal; but exceptions not unfrequently occur, and crania seen by the author were referred to, not only in the Negro, Hottentot, Caffre, Bushman, Sandwich Islander, and Australian races, but also in Hindoos, Ceylonese, and Europeans (French, Scotch), in which a tongue-like process of the squamosal passed between the ali-sphenoid and parietal to articulate with the frontal.*

* Although it would appear from an examination of a considerable number of crania of old-world monkeys that the rule is in them for a tongue-shaped process of the temporal to articulate with the frontal, and consequently to cut off the ali-sphenoid from the parietal, yet several crania have been noted in which the ali-sphenoid and parietal had a well-marked articulation with each other. Some of these skulls had unfortunately not been named, and it was difficult exactly to identify them; but in a skull of *Semnopithecus entellus*, and in one of *Macacus cynomolgus*, the ali-sphenoid articulated on both sides with

In the young gorilla, the squamous part of the occipital bone curved upwards and forwards for more than one inch beyond the rudimentary occipital crest, and contributed therefore to the formation of the posterior part of the vault of the skull. In the adult animal the whole of this part of the bone was overlaid with the bony growth met with at the junction of the sagittal and occipital crests. The angle formed by the junction of the two sides of the lambdoidal suture was well marked in the young gorilla. In the younger chimpanzee a small fontanelle bone existed at each of the two extremities of the sagittal suture,* the squamous part of the occipital bone scarcely extended above the rudimentary occipital crest, and the lambdoidal suture passed across the back of the head in a line approaching much more closely to the horizontal than in the gorilla. The basi-cranial synchondrosis was ossified in the adult animals, but not in the young gorilla. The zygomatic arches and mastoid processes closely corresponded with the descriptions given by Professor Owen. In the adult male and young gorilla the eustachian process of the petrosal (marked *e* in Owen's figure, plate lxiii.) was little more than a well-marked tubercle; but in the adult female it was prolonged downwards for half an inch as a well-formed styliform process.

the parietal; and though in two crania of Cynocephali the temporal and frontal articulated, yet in a third, whilst they articulated on the right side, on the left the ali-sphenoid joined the parietal. In crania of the following American monkeys,—Ateles, Cebus, Hapale,—the parietal bone not only articulated with the ali-sphenoid, but with the protuberant malar bone. Various anatomists (Owen, Humphry, &c.) have referred to Negro and Australian crania in which the temporal and frontal articulated. Barnard Davis has also figured an Anglo-Saxon skull from Ozingell, Kent (Crania Britannica, pl. 38), in which the same arrangement occurred. From the number of human crania referred to in the text in which this articulation was seen, it may apparently exist in the skulls of any race as an individual peculiarity. The triquetral bone, not unfrequently met with in the sphenoido-parietal suture by separating these bones from each other, may be regarded as an approximation to this arrangement. The occasional occurrence, therefore, of the articulation of the frontal with the squamous part of the temporal bone in human skulls, and the extent of variation the ali-sphenoidal articulation exhibits in the crania of apes, gives to this feature but little value in the discrimination of the diagnostic characters between the crania of men and monkeys.

* Dr Traill and Professor Owen observed in each of the crania of three young chimpanzees, at the posterior end of the sagittal suture, an *os triquetrum*.

The anterior nostrils in the gorilla in form approached a four-sided figure, with the angles rounded off. The boundary between the nostril inferiorly, and the alveolar part of the premaxillæ was not very sharply defined. In the young gorilla, also, the lateral boundaries formed by the ascending processes of the premaxillæ were much more rounded than in the adult. In the chimpanzee the anterior nares were triangular in form. The difference in shape in these two species of anthropoid apes was due to the different mode of termination of the ascending processes of the premaxillæ superiorly; and as this is a character on which Professor Owen has laid great stress, it is as well to note, that in all these gorilla's crania, as in those which he has described, the upper end of the ascending process of each premaxilla was intercalated as a triangular plate of bone between the nasal and superior maxilla. This could be readily traced both in the young skull and in that of the adult male, in which the naso- and maxillo-premaxillary sutures were visible, and in the adult female though the sutures were ossified, for lines on the bones indicated their original position. In the skull of the younger chimpanzee, in which alone the sutures persisted, and that, too, only at the ascending part of the premaxilla, the upper pointed end of that bone articulated with the lower end of the nasal, and was not intercalated between it and the superior maxilla.*

In the gorillas' crania the nasal bones were narrow, compressed, and projecting superiorly, and raised along their line of coalescence into a crest. In the young animal it could be seen that they projected upwards into the interorbital process of the frontal; and in this specimen a line, looking at first like a suture, but really only a groove, probably for an artery or a nerve, seemed to cut off

* In the crania of the orangs and of the gibbons an arrangement of the upper end of the premaxillæ, closely similar to that described in the chimpanzee, was seen. In only one skull of the orang did a linear process of the premaxilla pass upwards for $\frac{3}{10}$ths of an inch between the nasal and superior maxilla. Hence the intercalated triangular plate at the upper end of the premaxilla of the gorilla is valuable as a diagnostic character to distinguish the skull of that animal not only from the skull of the chimpanzee, but from those of the other anthropoid apes. In the mode of termination, however, of its premaxillæ superiorly the gorilla closely corresponds with the arrangement seen in the skulls of many of the tailed apes, *e. g.*, Cynocephalus, Semnopithecus, Cercopithecus.

the more expanded interorbital part from the narrower crest-like portion.* In the chimpanzee the nasal region was much flattened.

The interorbital region was in the gorilla wider near the floor than the roof of the orbit, and the fossa for the lachrymal sac was directed forwards. In the chimpanzee there was little difference in the width of the interorbital region at the floor and at the roof, the fossa for the lachrymal sac was directed outwards, and was concealed by the sharp edge of the inner end of the lower margin of the orbit. In the gorilla the os planum of the ethmoid was an elongated triangular plate of bone: in the young skull its apex did not reach the lachrymal bone, so that the orbital plate of the superior maxilla articulated with the frontal. In the adult crania the ossa plana articulated with the lachrymal bones.†

In all the crania of the gorillas the infra-orbital canals, as was first noticed by Agassiz, shallowed, and almost disappeared as they approached the spheno-maxillary fissures: in the chimpanzee they remained deep throughout, and in the male were quite, and in the younger animal almost, bridged over by a plate of bone posteriorly.

Owing to the comparative straightness of the alveolar portion of the premaxillæ, and the more elevated and elongated nasal bones of the gorilla, the profile outline of its face may be represented by a much more direct line than is possible in the chimpanzee, in which the deep nasal depression, lying between the interorbital and alveolar projections, gives a deeply concave character to the profile outline. In the profile view of all these gorillas' crania, not only was the outline of the nasal bones visible, but the lachrymal fossa, and a portion of the inner wall of the orbit behind the fossa.

In the skulls of the gorilla the emarginate form of the posterior

* Dr Wyman states that in the crania he has examined there are indications of a suture separating the lower part of the nasals from the inter-orbital part, the latter of which he looks upon as an additional osseous element intercalated between the frontals. May not such a groove as the one described in the text have been regarded as a suture?

† So far as could be judged from the skull of the younger chimpanzee, in that animal the ethmoid did not articulate with the lachrymal by its anterio margin, the superior maxillary and frontal having processes intercalated between. In the orangs and gibbons, again, the ossa plana were quadrilateral plates, and articulated by their anterior margins with the posterior margins of the lachrymal bones.

margin of the hard palate was well seen. In the male gorilla, the depth of the posterior nares was almost twice as great as the breadth: in the female the vertical diameter was not so great as the transverse. In the young, one diameter almost equalled the other. In the adult male, and younger chimpanzee, the breadth exceeded the depth; in the female the two diameters were equal. The ratio of depth to breadth at these orifices was not, therefore, so definite as in the skulls described by Professors Owen and Wyman.

In the lower jaws the following leading characters were noted:—Absence of chin; backward and downward slope of jaw from its incisive margin; presence of a strong buttress of bone on the inner aspect of symphysis; passage of horizontal into ascending ramus by a gentle curve; alveolar margins for molar and premolar teeth almost parallel; long axes of condyles almost transverse.

In the skull of the young gorilla various points illustrating peculiarities in the dentition were noticed. In the upper jaw the permanent incisors had emerged, the central pair being larger than the lateral pair. The milk canines were shed, but the apices of the permanent canines had only reached the orifices of their alveoli, the teeth being still buried in the jaw; the septum originally situated between the sockets for the temporary and permanent canines was in a great measure absorbed: the diastema between the lateral incisor and canine, so strongly marked in the adult male and female, but more especially in the former, had not yet originated; the septum between the sockets for those teeth was but little thicker than that between the alveoli for the lateral and central incisor, and the maxillo-premaxillary suture passed along the middle line of this septum.* The premolars had each two cusps, the external of the anterior, and the internal of the posterior being the larger: each premolar had three fangs, a larger internal and two smaller

* In the formation of the diastema in the crania of some apes, it would appear as if the premaxilla and the canine portion of the superior maxillary bone participated in an equal degree, for the maxillo-premaxillary suture was mostly situated, in the adult jaw, about midway between the canine and lateral incisor teeth. In others, however, *e. g.*, several cynocephali, the suture was placed much nearer the canine tooth, and the interval was occasioned by an increased growth of the premaxilla between that suture and the socket for the lateral incisor.

external. In the chimpanzee crania the fangs of the premolars differed somewhat from those of the gorilla, for though each of the first pair possessed three fangs, those of the second had only two fangs, an external and an internal; and in this respect, therefore, they presented a closer approximation to the arrangement of the fangs of the premolars in man than did the gorilla.

In the young gorilla the first and second pairs of true molars were fully erupted; each tooth was quadricuspid; the anterior internal was connected to the posterior external cusp by an oblique ridge. The third true molars were concealed within their alveoli.

In the lower jaw of the young gorilla the permanent incisors were erupted: the left milk canine was in its socket, and close to it, on its lingual side, was a foramen which led into a canal that communicated with the crypt containing the permanent canine; the foramen and canal marked the position of the gubernaculum. The right milk canine was shed, but the permanent tooth was deep in its alveolus, and the bony septum between the socket for the milk tooth and the gubernacular canal was still unabsorbed. The diastema which existed on each side of the canine, but more especially on the premolar aspect in the adult crania, had not been developed in the young skull. The first pair of premolars was considerably larger than the second, each tooth possessed an anterior and a posterior fang. The first and second pairs of true molars were erupted, each tooth was quinquecuspid; the third pair of true molars was still concealed within the jaw. The eruption of the permanent canines in the upper jaw precedes, therefore, their appearance in the lower jaw; but in both the upper and lower maxillæ the permanent canines follow in their eruption the first and second pairs of true molars.

The internal capacity of the crania was as follows:—

	Cubic Inches.
Adult male gorilla, ...	28·
Adult female ,, ...	26·5
Young female ,, ...	23·
Adult male chimpanzee, ...	22·
Adult female ,, ...	24·
Younger ,, ...	21·

Extreme length between the alveolar margin of the intermaxillary suture and middle of lambdoidal crest, measured in a straight line, was in the adult male gorilla 10·7 inches; in the adult female, 8·9 inches; in the young female, 7·5 inches. The length, measured in a straight line, between the interorbital ridge and the middle of the lambdoidal crest, was in the adult male gorilla 6·9 inches; in the adult female, 6 inches; in the young female, 5·1 inches.

2. Notice of a Remarkable Piece of Fossil Amber. By Sir David Brewster, K.H., F.R.S.

The piece of amber, now on the table, was found in the kingdom of Ava, and sent to me from India by the late Mr George Swinton, to whom the Society was indebted for many interesting objects of natural history from that country. It weighs $2\frac{1}{2}$ lbs., and in its general aspect seems to differ considerably from the ordinary specimens of amber. The remarkable fact, however, which distinguishes it from all the specimens of amber I have seen or read of, is, that it is intersected in various directions by thin veins of a crystallised mineral substance. These veins are in some parts of it as thin as a sheet of paper, and in other parts about the twentieth of an inch thick. In order to determine the nature of the mineral I extracted a portion of the thickest vein, and having obtained, by cleavage, a small rhomb, I succeeded in measuring the inclination of its planes, and found it to be carbonate of lime.

Pieces of amber of 2 or 3 lbs. weight are very rare. A specimen weighing 1 lb. is valued in Prussia at 50 dollars. The largest piece yet found is in the Royal Museum at Berlin; it weighs 18 lbs., and is said to be worth upwards of 7000 dollars.

3. On the Cause and Cure of Cataract. By Sir David Brewster, K.H., F.R.S. Lond. and Edin.

The author's attention was called to this subject in consequence of having had an attack of incipient cataract forty years ago. The laminæ of the lens had separated so much as to exhibit rays of light, and the prismatic colours, round every source of light. At the end of eight months the laminæ came into optical contact, the rays and colours disappeared, and the eye became as perfect as the other, —a proof that cataract, in its incipient stage, may be discovered optically, and may be cured. During a series of experiments on the changes in the crystalline lenses of animals after death, the author observed that the capsule of the lens transmitted water into the lens till it burst; and hence he concluded that cataract might arise from an unhealthy state of the aqueous humour,—hard cataract from too much albumen in the aqueous humour, and soft cataract from too much water. The aqueous humour should therefore be evacuated, in order that nature might supply a more healthy secretion, or an artificial aqueous humour should be injected into the aqueous chamber,—operations that may be easily and safely performed. The evacuation of the aqueous humour was long ago tried with safety forty times on the same patient, in the Manchester Infirmary, for conical cornea; and the author of this paper has learned, since it was read, that M. Casimir Spirone of Turin has cured numerous cases of cataract by the evacuation of the aqueous humour, repeated thirty, forty, and even ninety times.

4. On the Hill Forts, Terraces, and other remains of the Early Races in the South of Scotland. By W. Chambers, Esq. of Glenormiston.

The district referred to included Roxburghshire, Selkirkshire, and Peeblesshire, in which Mr Chambers had visited and examined about 200 hill forts. These ancient works are found on the tops of hills of moderate elevation, and are of different classes, shewing a progressive improvement in construction. Those of the smaller kind consist of one or two concentric rings of earth and stone, with a clear space in the centre, and measure from 150 to 250 feet across. Such are considered to be the earliest in construction, and are at the least 2000 years old, though they may have been kept in use later. Their first constructors were unquestionably the aboriginal Celtic tribes, to whom they served as places of refuge and defence in petty local wars, or on the occasion of invasion. Originally, the entrenchments or rings may have been ten to fifteen feet in height, but now lying in ruins and covered with sward;

their height is seldom more than four or five feet. Between these very ancient forts and those in other parts of Scotland there is so little difference, that they may all be imputable to the same early races.

The hill forts of a more advanced kind demonstrate such skill in construction, that they may fairly be referred to a period coeval with and subsequent to the Roman invasion. Like the lesser forts, they are all circular or oval in form, but they comprehend four or even five concentric entrenchments with deep intervening ditches, and zigzag entrances, which an enemy would find it difficult to penetrate in the face of a body of defenders. The height of the still surviving rings in some of these forts is as much as twenty-five feet. When constructed, the walls would of course be much higher, and supplemented with stockades of wood, wattle, and the skins of animals, as was the case with the hill forts of the Gauls, described by Cæsar. In several instances, Mr Chambers had found exterior defences, in the form of high ramparts, making an irregular sweep, so as to enclose six or seven acres. Such enclosures were probably designed for the reception of cattle. Two of the more remarkable of these elaborate forts are Milkiston Rings, near Eddleston, and Henderland-hill Rings, parish of Newlands; both had evidently been designed to guard the great passes from the east—that is, to stem the tide of invasion of Angles, Frisians, and others approaching from the German Ocean.

Of the origin of the hill forts in the south of Scotland, the present inhabitants can give no account. Generally they are spoken of as being *Danish*—a curious error arising from a misapprehension of the legendary term *Dinas*, which in the original British signified fortress, and is still so applied in Wales. This word *Dinas* is found under varying forms in many ancient languages, and is the original of the names of places in Scotland corruptly called *Tinnies*. While the forts in question are not Danish, neither are they Roman, as is evident from their peculiar form. After comparing them with a Roman camp—a *castra stativa*—at Lyne, Mr Chambers proceeded to describe the Catrail, or great barricade which stretches across the country from near Galashiels to the mountains of Northumberland, a military work also designed to check invasion from the east.

He then gave some account of the hill terraces of the early races, of which there had been numberless speculations; he agreed with recent inquirers in thinking that they were simply designed for horticultural and agricultural purposes. Mr Chambers, lastly, drew attention to the rudely shaped monumental stones in the Vale of Tweed, on which he had found no elaborate or artistic sculptures, such as occurred in northern districts. Recent investigations concerning upright stones have happily put to flight a variety of those mythic legends and fables which were at no distant date the reproach and pollution of our topographic literature. As regards the whole of the interesting memorials of past times which had been adverted to, Mr Chambers trusted that the Society would join with him in the wish that land proprietors would, as far as practicable, make some effort for their preservation.

[The paper was illustrated with a number of large pictorial drawings.]

5. On the Molecular Constitution of Organic Compounds, No. I. By Alfred R. Catton, B.A., Fellow of St John's College, Cambridge, Assistant to the Professor of Natural Philosophy.

The author stated this to be the first of a series of papers, in which he intended to develop in detail a new theory of the molecular constitution of organic and inorganic compounds.

In this paper the author considers the constitution of the olefines $C_{2n}H_{2n}$, aldehyds $C_{2n}H_{2n}O_2$, fatty acids, hydrides of alcohol radicles $C_{2n}H_{2n+2}$, alcohols $C_{2n}H_{2n+2}O_2$, glycols $C_{2n}H_{2n+2}O_4$. $(C = 6, O = 8.)$

The following Donations to the Library were announced:—

Jahresbericht über die Fortschritte der Chemie und verwandter Theile anderer Wissenschaften für 1863. II. Heft. Giessen, 1864. 8vo.—*From the Conductors.*

Annual Report for 1864 of the Geologists' Association. London. 8vo.—*From the Association.*

Monthly Notices of the Royal Astronomical Society. Vol. XXV. No. 2. London. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XXVII. Part 4. London. 8vo.—*From the Society.*

Memoirs of the Geological Survey of India. Vol. III. Part 2. Vol. IV. Part 2. Calcutta. 8vo.—*From Thomas Oldham, LL.D.*

Annual Report of the Geological Survey of India, and of the Museum of Geology. Calcutta, 1863–64. 8vo.—*From the same.*

Astronomical Observations made at the Observatory of Cambridge. By the Rev. James Challis, M.A., F.R.S., &c. Vol. XX. Cambridge. 4to.—*From the Observatory.*

Kongliga Svenska Vetenskaps-Akademiens handlingar. Band IV. Heft 2. Stockholm, 1862. 4to.—*From the Royal Academy of Sciences, Stockholm.*

Meteorologiska Iakttagelser Sverige utgifna af Köngl. Svenska Vetenskaps-Akademien Anställda och Bearbetade under inseende af Er. Edlund. Band IV. Stockholm, 1862. 4to.—*From the same.*

Oefversigt af Kongl. Vetenskaps-Akademiens Forhandlingar. Band XX. 1863. Stockholm, 1864. 8vo.—*From the same.*

Mémoires de l'Académie Impériale des Sciences de St Pétersbourg. VII[e] Serie. Tome V. Nos. 2–9. Tome VI. Nos. 1–12. St Petersburg. 4to.—*From the Academy.*

Bulletin de l'Académie Impériale des Sciences de St Pétersbourg. Tome V. Nos. 3–8. Tome VI. Nos. 1–5. Tome VII. Nos. 1, 2. St Petersburg. 4to.—*From the same.*

Proceedings of the Royal Society. Vol. XII. No. 70. London. 8vo.—*From the Society.*

A New General Theory of the Teeth of Wheels. By Edward Sang, Hon. F.R.S.S.A., &c. Edinburgh, 1852. 8vo.—*From the Author.*

A Treatise on the Valuation of Life Contingencies, arranged for the use of Students. By Edward Sang, F.R.S.E. Edinburgh, 1864. 8vo.—*From the Author.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, December 1864. 8vo.—*From the Registrar-General.*

Redevoering ter Aanvaarding van het ambt van Buitengewoon Hoogleeraar aan de Hoogeschool te Leiden, den vijf en Twintigsten September 1863, uitgesproken door Dr D. Bierens de Haan. Deventer, 1863. 8vo.—*From the Author.*

Godefroid de Bouillon à Boulogne-sur-mer, à Bruxelles, et à Jerusalem—Lettre à M. le Comte d'Hericourt, par le Baron de Hody. Bruxelles, 1863. 8vo.—*From the Author.*

Coup-d'œil sur l'Eploitation de la Houille en Angleterre et sur les derniers perfectionnements qui y ont été introduits par M. Guillaume Lambert. Bruxelles, 1864. 8vo.—*From the Author.*

Proceedings of the Royal Horticultural Society. Vol. V. No. 1. London, 1865. 8vo.—*From the Society.*

The Journal of the Chemical Society, London. December 1864. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society, London. Vol. IX. No. 1. 8vo.—*From the Society.*

Journal of the Proceedings of the Linnean Society, London. Vol. VIII. No. 30, Zoology. 8vo.—*From the Society.*

Monday, 6th February 1865.

Sir DAVID BREWSTER, President, in the Chair.

At the request of the Council Mr Geikie gave the following Account of the Progress of the Geological Survey in Scotland, illustrated by Maps and Sections:—

The object of the Geological Survey is to ascertain in detail the geological structure of the United Kingdom, and to publish the results in maps, sections, and descriptive memoirs. The Ordnance maps form the groundwork on which these geological investigations proceed; and as no district is examined until these maps are ready, the progress of the Geological Survey is guided in no small degree by that of the Ordnance engineers. In Scotland, the geological mapping has hitherto been conducted wholly upon the county maps on the scale of six inches to a mile, and the advantages of so large a scale are such, that although the work is finally reduced and published on the scale of one inch to a mile, no county is surveyed until its six-inch maps are ready for use. By this means a much more detailed and accurate map is given than if all the minutiæ of a difficult district had to be surveyed upon so small a scale as that of one inch to a mile.

The survey of Scotland was begun by Professor A. C. Ramsay, the local director, towards the close of 1854. East Lothian was selected as the point of commencement best suited for the investigation of the Lothian coal-fields, and the work was carried steadily westward from the older Silurian rocks into the coal-basin. Much inconvenience arose, however, from the backward state of the Ordnance maps. In Haddingtonshire, all the sheets were unfinished, and those of Berwickshire were not even engraved. Hence the map containing the earliest labours of the survey—the geology of East Lothian—had to lie aside for several years until the Ordnance sheets of Berwickshire could be obtained to complete it. The westward progress of the survey was at last abruptly stopped by the want of the maps of Stirlingshire. The work was then transferred to Fife, and nearly the whole of that county and of Kinross was completed by the end of the year 1861. But only the eastern part could be published; nor was it until last spring that the sheets of Perthshire, still far from being complete, were obtained to allow of the Fife work being finished. That map is now in the hands of the engraver.

As no further advance could be made either to the north or west, the only available direction was the south. Accordingly, in the early part of 1862, the survey of Peeblesshire and Lanarkshire was begun, and at the end of 1863, an area of 432 square miles was ready for the engraver, including Peeblesshire, with parts of Lanark and Selkirk. On application to the Ordnance Survey, however, it was found that though all the six-inch maps of the county of Peebles had been some time published, and an outline map on the one-inch scale was also engraved, the one-inch shaded map, on which the geological information is inserted, would not be ready for two years. This large area, therefore, remains unpublished, and cannot make its appearance until the one-inch shaded map is completed.

It had been earnestly desired that the surveys of the great central coal-fields should first be prosecuted, but the delay in the completion of the Ordnance maps made it at last necessary to stop altogether the examination of the midland counties. The geological survey was then, in the autumn of 1863, transferred to Ayrshire, of which the county Ordnance map is published. Considerable progress has been made there, and it is intended to work northward from the Silurian boundary, so as to complete the survey of the Ayrshire coal-fields with as much speed as the nature of the work will permit.*

The staff of the Geological Survey in Scotland has always been very small. For the first seven years, there were only two geologists, their labours being aided by a yearly visit from Professor Ramsay, and by the occasional personal assistance of the palæontologist. One of them, Mr Howell, whose experience, especially in the details of coal-field surveying, was of essential service, then left, and three surveyors were successively appointed. Some time, however, had necessarily to elapse before they were able to carry on independent work. This they are now doing; and as, in the south-west of Scotland, the Ordnance maps have all been published, it is believed that the Geological Survey will now be enabled to advance with greater comfort and speed. †

Notwithstanding the hindrances which have impeded progress hitherto, a considerable area of the country has been examined. The state of the survey at the end of last year was as follows :—

	Square Miles.
Area published on the one-inch scale, .	963
Area engraving on the one-inch scale, .	382
Area surveyed but not engraved, . .	1169
Total area surveyed, .	2514

* It is right to state that the above remarks are not intended to impute any blame to the way in which the Ordnance Survey has been conducted, but simply to explain why the Geological Survey has hitherto been able to do so little in the great coal-fields.

† From what has been said above relative to the state of the Ordnance Survey, it will be seen that though the staff of geologists has been small, it has been quite large enough for the number of maps available for geological purposes. The geologists have been all along treading closely on the heels of the Ordnance surveyors, and, to have increased the staff, would soon have brought the Geological Survey to a stand. What has been needed has not been more geologists, but more maps.

Besides the one-inch maps, however, there have been published detailed maps on the scale of six inches to a mile of the coal-fields of Edinburgh, Haddington, and part of Fife, and it is intended to continue the series through the other coal-basins. Horizontal sections, on the same large scale, have likewise been issued; one of these stretches from Edinburgh, through Arthur Seat and the Garlton Hills, to the coast near Dunbar; two others cross Mid-Lothian to the Lammermuir Hills, showing the structure of the Pentland Hills and of the Edinburgh coal-field. Descriptive memoirs of the neighbourhood of Edinburgh and of the East of Berwickshire have been published to illustrate sheets 32 and 34 of the geological map, and others of Fife and East Lothian are in preparation. A large collection of specimens of the rocks and fossils of the Lothians, Fife, and the south-west of Ayrshire has been made in duplicate, one series being deposited in the Industrial Museum, Edinburgh, the other in the Museum of the Geological Survey, London.

Among the scientific results of the survey, by which fresh light has been thrown on the geological structure of Scotland, mention may be made of the discovery of well-marked graptolites (*Graptolithus priodon* and *Diplograpsus pristis*) among the Silurian rocks of the Lammermuir chain, shewing that these strata are probably the equivalents of the Llandeilo and Caradoc formations of Wales. A considerable addition has likewise been made to the known list of fossils from the lower Silurian limestones and shales of Peeblesshire, while in Ayrshire, a large suite of shells, trilobites, corals, and other organic remains, has recently been made from the lower and upper Silurian rocks, and is now under examination in the Museum, Jermyn Street. The discovery of a numerous group of well-preserved fossils in the shales and mudstones of the Pentland Hills proved these strata to be of the age of the Ludlow rocks, a position much higher than had before been given to them.

In the Old Red Sandstone, much interesting work has been accomplished. It has been ascertained that this formation in the Lowlands of Scotland is capable of subdivision into three zones. The lowest of these is well seen between Tinto and the confines of Ayrshire. It merges into the upper Silurian shales of Lesmahagow, and is covered unconformably by all later rocks. In the

Pentland Hills, the Upper Silurian beds pass upward into certain red conglomerates and sandstones, which are supposed to be the base of the Lower Old Red Sandstone. This same lower member of the formation occurs in the east of Berwickshire, where it consists, to a large extent, of volcanic ash and conglomerate, but it has yielded fragments of *Pterygotus* and plants.* The Ochil Hills are formed of a series of felspathic lava-beds, with interstratifications of sandstone and volcanic conglomerate, the whole belonging to the Lower Old Red Sandstone. The structure of the hills, as made out by the Survey, is shown in the subjoined sketch (fig. 1).†

The middle division of the Old Red Sandstone is seen in the chain of the Pentland Hills, where it consists of a mass of coarse conglomerate and grit, overlaid with a great thickness of felspathic lava-form and ashy rocks. It lies on the worn edges of the Upper Silurian and of the red-coloured strata, which are supposed to indicate the bottom of the Lower Old Red Sandstone. No fossils have yet been detected in any part of it, so that no means exist of deciding how far it represents the great Caithness flagstone series. On the denuded ends of the rocks of this central group come the conglomerates and sandstones of the upper division, which pass upward into the Carboniferous system. In the accompanying diagram across the Cairn Hills in the Pentland Chain, the gene-

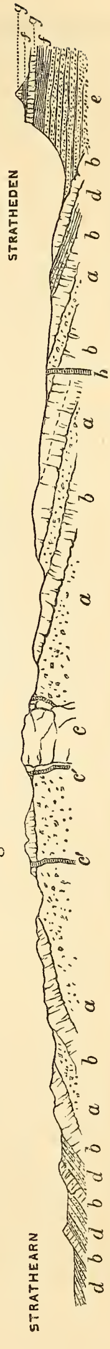


Fig. 1.—Sketch-section across the Ochil Hills.

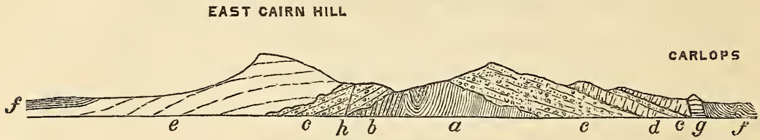
a, Volcanic ash and conglomerate; *b*, Felstone lava-beds; *c*, Intrusive felstone, like old volcanic "neck;" *c'*, Dykes of felstone most abundant round these "necks;" *d*, Sandstones, shales and conglomerates of the Lower Old Red Sandstone; *e*, Upper Old Red Sandstone; *f*, Carboniferous shales, limestones, &c.; *g*, Intrusive greenstone of the Lomond Hills; *h*, Greenstone dyke.

* See "The Geology of Eastern Berwickshire," Mem. Geol. Survey, p. 27.

† This section combines in a generalised form the result of the survey made in concert by my colleagues, Dr John Young, Mr James Geikie, Mr B. N. Peach, and myself.

ral relation of the rocks between the Carboniferous and Upper Silurian formations in the middle of Scotland is shown.

Fig. 2.—Sketch-section across the Cairn Hills, Pentlands.



a, Upper Silurian shales; *b*, Red sandstones and conglomerates, supposed to be the base of the Lower Old Red Sandstone; *c*, Thick conglomerates and grits, forming a Middle division of the Old Red Sandstone; *d*, Felstone lava-beds, interbedded with *c*; *e*, Upper Old Red Sandstone; *f*. Carboniferous sandstones, shales, &c.; *g*. Intrusive greenstone coming up along a line of fault; *h*, Fault.

The Upper Old Red Sandstone has been mapped by the Survey throughout the Lothians and Fife, and has been traced southwards far into Berwickshire, and south-westwards into the uplands of Lanark. Traces of contemporaneous volcanoes at the top of the Old Red Sandstone have been found near Dunse, in Berwickshire,* and near Dunsyre in Lanarkshire.

The mapping out of the various subdivisions of the Carboniferous rocks has opened up some curious questions regarding the ancient physical geography of the country, and unequal oscillations of level during the Carboniferous period. It has likewise shown that, during the earlier half of that period, the basin of the Forth was dotted over with little volcanic cones, which sometimes threw up each its mound of ash or current of lava, and sometimes coalesced to form long banks of volcanic ejections, over which the limestones and coals were slowly elaborated. The subdivisions of this formation adopted by the Survey in the districts yet examined are—

	English Equivalents.
Coal-measures	= Lower part of English Coal-measures.
Millstone grit, or "Moor rock"	= Millstone grit.
Carboniferous limestone series. A group of sandstones, shales, and coals, with several bands of limestone in the upper part, and some thicker beds below	= Rocks between the millstone grit and the lower limestone shales.
Calciferous sandstones	= Lower limestone shales.

* I may mention in passing, that Ruberslaw, and perhaps some of the felspathic hills of that district, seem to mark the site of volcanoes of the time

Much attention has been paid to the drift and superficial deposits. The subjoined table shows the subdivisions which are at present followed in mapping these formations on the ground :—

Alluvium.

Blown Sand.

Peat.

Raised Beach deposits.

Old River-terraces.

"Surface-wash,"—a deposit of sand, clay, gravel, or shingle, frequently containing scratched stones, and found on the high grounds of the southern uplands.

Moraine rubbish of valley glaciers.

Erratic blocks.

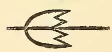
Re-formed Drift. Sands and gravels of the *Kame* or *Esker* series. Brick-clays, with Arctic shells.

Upper Boulder-clay.

Lower Boulder-clay.

Roches moutonnées (striæ effaced), are marked . 

Do. do. striated, but not showing distinctly from which quarter the ice moved . . . . 

Do. do. showing direction of ice-flow . 

Flat surface of striated rock, such as is often seen under the Boulder-clay . . . . . 

Do. showing the direction of ice-flow . . 

The subdivision of the Boulder-clay into two zones was decided upon in the autumn of 1863, and since then the division has been carried out wherever practicable. The upper Boulder-clay is a looser, more gravelly deposit than the lower, and seems to have suffered a greater denudation. It has usually a more or less obscure stratification, contains a considerable admixture of travelled stones, with occasional fragmentary shells, and is regarded as having been formed in the sea, a short way off the land, by bergs from a dis-

of the Upper Old Red Sandstone. The hills to the south-west of the town of Ayr are formed of felstones and ashy conglomerates, which appear to belong to some part of the Old Red Sandstone period. They are at present under investigation by the Geological Survey.

tance, as well as by masses of ice from the adjacent shores dropping their loads of mud, earth, and stones to the bottom. The lower Boulder-clay or *till*, on the other hand, seems to have gathered partly on the land, and partly under the ice-sheet which pushed its way out to sea.* This took place when the land was undergoing a submergence, so that the lower Boulder-clay might be accumulating on the land and along the coast-line, while the upper part of the deposit was being formed from the droppings of floating ice some way further out at sea. The following tables give the percentage of stones in the two clays on the line of the new railway near Newhaven, and show the markedly local character of those in the lower zone, and the mixture of erratic boulders in the upper :—†

Upper Rudely Stratified Clay (near Man-Trap).

From the Highlands, 9 per cent.	Per cent.
Mica-schist,	6
Purple cleaved slate,	1
Metamorphic grit,	2
From the Ochil Hills, 16 per cent.	
Red felstone,	2
Pink ,,	2
Blue ,,	1
Purple ,,	1
Pink porphyry,	4
Purple ,,	2
Green ,,	1
Red felspathic sandstone,	2
Felspathic conglomerate,	1
Doubtful; either from the Ochils or from the Lower Carboniferous rocks, 12 per cent.	
Quartz pebbles,	9
Quartz-rock pebbles,	3

From the Carboniferous rocks of the Basin of the Forth, 63 per cent.	Per cent.
White and grey sandstone,	25
Black shale,	8
Ironstone,	8
Coal,	6
Basalt,	2
Greenstone,	9
Ash,	1
Cement stone,	1
Cyprid limestone (= Queensferry or Burdie House),	1
Cyprid shale,	2
	100

* This view of the origin of the till was proposed by me in October 186 and published in the following spring in my "Memoir on the Phenomena of the Glacial Drift of Scotland," and a woodcut was there given (p. 99) to show how the deposit might contain the remains both of land plants and of sea-shells.

† These percentages were taken in September 1863, in company with my colleague, Dr Young.

Lower Boulder-Clay or True Till.

	Per cent.		Per cent.
White and grey sandstone,	30	Encrinite limestone,	3
Corstorphine greenstone,	22	Ironstone,	2
Common greenstone,	12	Felspathic greenstone,	2
Shale of the calciferous sandstone series,	12	Greenstone of Mons Hill,	1
Basalt,	6	Cement stone,	1
Quartz pebbles,	4	Ash,	1
Cyprid limestone,	4		100

The list of stones from the lower clay shews with clearness the easterly movement of the ice. The most abundant are from rocks that occur *in situ* immediately to the west, and the further removed the parent mass, the smaller and rarer are the fragments of it in the clay. It is to be noted that all the stones are derived from rocks that occur in the district; even those which have come furthest need not have travelled more than eight or ten miles. In the railway cutting, this lower clay had its upper limit marked off by a band of large boulders, chiefly of greenstone, sometimes measuring a yard across, and occasionally well striated. The rock of Corstorphine Hill was well represented among these boulders, and there were likewise blocks of porphyritic felstone and encrinite limestone. Above the line of boulders lay an extensive deposit of gravel and sand, which, eastward, nearer the Man Trap, gave place to an upper sandy clay, in which the stones were found to be more rounded than in the lower clay, comparatively seldom striated, and to bear evidence of having come from longer distances. In the list above given, it will be seen that more than three-fifths of these stones come, like those in the till below, from the carboniferous rocks of the basin of the Forth; that sixteen per cent. have travelled across that basin from the chain of the Ochils, a distance of at least five-and-twenty miles, while a still smaller number, nine per cent., has been carried from the flanks of the Highland mountains not less than five-and-forty miles away. Where the upper and under clays came together in the section, the band of boulders had disappeared, and the two deposits had no very marked line of demarcation between.

Although the sands and gravels of the Kame series have been traced and mapped by the Survey over a considerable area, their origin is still involved in great uncertainty. In the uplands of Peeblesshire, beautiful glacier moraines have been found, shewing the existence in these high grounds of a group of valley-glaciers after the re-elevation of the land.* Others, on a still larger scale, occur among the high grounds of the south-west of Ayrshire.

In the course of the explorations of the Survey, proofs of vast denudation have everywhere been met with, leading to the conclusion that the present inequalities of the surface—our hills and valleys, plains and river-gorges, are not directly due to upheaval and subsidence, or to fractures of the earth's crust, but must be attributed mainly to the unequal wearing away of the rocks by the sea, rain, springs, streams, and glacier-ice.

This address was illustrated by an exhibition of all the published maps, sections, and memoirs made by the Geological Survey in Scotland, by a large map, on the scale of one inch to a mile, shewing all the work which has been done, both published and unpublished, and by enlarged sections to explain the structure of the Ochil and Pentland Hills.†

The following Communication was read :—

On a New Bituminous Substance, imported under the name of Coal from Brazil. By T. C. Archer, Esq.

This material was brought from Brazil to Liverpool, for the purpose of ascertaining its commercial value in this country. The importers submitted it to Dr Edwards, who reported that it yields a much larger percentage of oil than even the celebrated coal of Torbane Hill.

The crude oil of the first distillation has a sp. gr. of ·859.

On redistillation, a light and heavy oil are obtained from the crude oil.

* They have been carefully examined by Dr Young, who has given an account of them in the Quarterly Journal of the Geological Society for 1864.

† It is not usual to publish the results of the Geological Survey until they appear in the authorised and official form. In the present instance, I am indebted to the courtesy of the director-general, Sir Roderick I. Murchison who at once most cordially gave his sanction to the publication of the above abstract in the Proceedings of the Society.

The sp. gr. of the lighter is ·768.
Of the heavier „ ·858.

The lighter oil, when refined, is colourless, and resembles the oils obtained from coal, petroleum, &c.

Its sp. gr. is ·753.

The substance itself resembles, in general appearance, dried clay; but it is very light, being extremely buoyant in water. It breaks with a conchoidal fracture, and in some portions there are bands of minute striæ, indicating sedimentary deposition. Thin sections, which I have prepared with difficulty, show no trace of organic structure under the miscroscope.

No information was received with it as to the exact locality whence it was obtained, but in the Exhibition of 1862 similar substances were shown in the Brazilian collection, under the following titles :—

1. Schistos betuminosos calcareos—from the Serra de Araripe, in the Province of Ceara.

2. Schisto argilo-calcareo betuminoso—from Chapad, in the Province of Maranham.

3. Schisto betuminoso—from Pirapora, Province of S[to] Paulo.

4. Schisto betuminoso—from the Morro do Taio, Province of Santa Catherina.

5. Schisto betuminoso—from Camaragibe, Province of Alagoas.

In all probability the specimen before this Society is from one of these localities; and the fact that it is so widely distributed in Brazil will stimulate further inquiry about so valuable a substance.

The following Donations to the Library were announced:—

Transactions of the Botanical Society of Edinburgh. Vol. VII. Part 1. 8vo.—*From the Society.*

General Index to the first 15 vols. of the Transactions of the Pathological Society of London, 1864. 8vo.—*From the Society.*

Abstracts of the Meteorological Observations made at the Magnetical Observatory, Toronto, C.W., during 1854 to 1859. 4to. Toronto, 1864.—*From the Observatory.*

Results of the Meteorological Observations made at the Magnetical Observatory, Toronto, C.W., during 1860, 1861, and 1862. 4to. 1864.—*From the Observatory.*

Philosophical Transactions of the Royal Society of London. Vol. CLIV. Parts 1 and 2. 4to. 1864.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XIV. No. 71. 8vo.—*From the Society.*

Astronomical Observations made at the Royal Observatory, Greenwich, 1862. 4to.—*From the Observatory.*

Die Zeitbestimmung vermittelst des Tragbaren, Durchgangsinstruments im Verticale des Polarsterns, von W. Dollen. 4to. St Petersburg, 1863.—*From the Author.*

Preussische Statistik herausgegeben in Zwanglosen Heften, vom Königlichen Statistischen Bureau in Berlin, VI. 4to. Berlin 1854.—*From H. W. Dove.*

Materiaux pour la Carte Geologique de la Suisse, publiés par la Commission Geologique de la Société Helvetique des Sciences Naturelles aux frais de la Confederation, Deuxieme livraison. 4to. Berne, 1864.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt Band XIV. Nr. 2, 3. 8vo. Wien, 1864.—*From the Society.*

Bulletin de la Société Imperiale des Naturalistes de Moscou, publié sons la Redaction du Docteur Renard. Nos. III. IV. 1863; No. 1. 1864. Moscow. 8vo.—*From the Society.*

The Mâhâbhashya of Pantanjali; a Commentary on the Grammatical Aphorisms of Panini, with the Glosses of Kailjata and Nâgogi Bhatta. Fol.—*From the Author.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1864–65. No. 67.

Monday, 20th February 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. Experimental Inquiry into the Laws of Conduction of Heat in Bars. Part II.—On the Conductivity of Wrought Iron, deduced from the Experiments of 1851. By Principal Forbes.

This is a sequel to a paper read 28th April 1862 (See "Proceedings," vol. iv. p. 607), and contains the results of the complete reduction of the observations on the conductivity of iron, by the application of the method there described. The thermometric readings are now rigorously corrected for scale errors, and for the difference of temperature between the bulb and the stem.

The methods of reduction, consisting of a combination of calculation and graphical projection, are the same as have been described in the first part of the paper. But the whole has beeen executed with minute attention to accuracy, and the avoidance of error of every kind.

Three cases are distinguished in the experiments and reductions, each complete in itself.

In Case I. a wrought-iron bar, fully 8 feet long and $1\frac{1}{4}$ inch square, heated at one end, had its temperature observed at different points. The surface was moderately polished.

In Case II. the same bar was employed in a similar way, except that the surface was covered with paper, by which the superficial radiation was greatly increased.

In Case III. an iron bar, one inch square, was used. The iron was from a different manufactory. The surface was moderately polished.

The two first cases correspond to those worked out in the former paper. ("Transactions," vol. xxiii. p. 145. "Proceedings," vol. iv. p. 609.) The results obtained in the present paper, after all corrections are applied, differ but slightly from those previously given. The conductivities deduced from the two first cases coincide with one another remarkably well, although the data are perfectly distinct. In Case III., that of the thin bar, the numerical values of the conductivity are considerably smaller than in the former instances, which is attributed to the different quality of the iron. In all the cases the conductivity diminishes as the temperature increases, and diminishes more rapidly in the lower part of the scale of temperature. The following numbers will be found (for Cases I. and II.) to be nearly identical at 0° and 150° with those previously published from less accurate data :—

Temperature, Centigrade.	Conductivity of Wrought Iron.			
	Units, the Foot, Minute, and Cent. Degree.		Units, the Centimètre, Minute, and Cent. Degree.	
	Cases I. and II.	Case III.	Cases I. and II.	Case III.
0°	·01337	·00992	12·42	9·21
50	·01144	·00904	10·63	8·37
100	·01012	·00835	9·40	7·76
150	·00934	·00795	8·68	7·38
200	·00876	·00764	8·14	7·10
250	·00826	·00736	7·67	6·84

2. On the Chemical Composition of the Waters of the Beauly, Inverness, and Moray Firths. By Dr Stevenson Macadam.

These three firths denote different parts of an arm of the sea which has two constrictions;—one between Craigton Point and Longman Point, and the other between Fort George and the

Chanonry Point. The upper part is known as the Beauly Firth, the intermediate portion as the Inverness Firth, and the outer part as the Moray Firth. Two rivers discharge their contents into this arm of the sea; the Beauly River, which flows in at the head of the Beauly Firth, and the River Ness, which joins at the head of the Inverness Firth. The waters of those rivers are comparatively free from saline matter, as during the dry season of the summer of 1863 the water of the Ness contained only 2·48 grains of saline matter dissolved in the imperial gallon, and the water of the Beauly only yielded 3·76 grains of saline matter. Besides these sources of fresh water, there are numerous burns which convey water, the composition of which is not essentially different from that of the Rivers Ness and Beauly.

Whilst the fresh water flows in at the upper parts, there is sea water rolling in and out at the lower part during every flood and ebb-tide, and in quantity sufficient to give rise to tides of the average height of eleven feet at certain parts, as at the narrowed channel connecting the Firths of Beauly and Inverness.

The special object of inquiry was to learn the influence of the fresh water upon the salt water, and the examination was restricted to the determination of three points:—

1*st*, The specific gravity or density of the water, as compared with distilled water, taken as 1000· at 60° Fahr.

2*d*, The total amount of saline matter dissolved in 1000 parts of the water collected at different stations; and

3*d*, The proportion of chlorine present in the various samples of water.

The principal compound of chlorine present in sea water is the chloride of sodium (common salt), and there are smaller proportions of chloride of magnesium and chloride of potassium; but, in an inquiry as to the relative saltness of samples of water from the same locality, it is sufficient to determine the amount of chlorine, and the calculation of chlorine into chloride of sodium affords the most convenient method of recognising the relative amount of fresh water which has commingled with the sea water.

The samples of water employed in these investigations were generally collected from a depth of three feet from the surface, but other samples were taken from the surface, and from a depth of six feet.

In reviewing the results of the determination of the specific gravities of the samples of water, it was observed that the fresh water supplied by the Ness and Beauly Rivers possesses the mean specific gravity of 1000·44; and the strongest sea water—viz., that of Burghead—shows a specific gravity of 1025·13. The many samples of water collected from the Firth of Inverness have a specific gravity which is considerably beyond the mean of fresh and salt water, and in the majority of instances closely approaches the specific gravity of the sea water taken off Burghead, and which is undoubtedly sea.

The results of the determination of the respective amounts of saline matter dissolved in the various waters entirely corroborates the conclusions arrived at from the consideration of the specific gravities,—viz., that each sample of water, as collected from the Firth of Inverness, is decidedly more salt than fresh, and in most instances the water is practically the strength of sea water. The lowest proportion of saline matter in the water of the Firth of Inverness is nearly eight hundred times the quantity found in the water of the River Ness.

The relative amount of chloride of sodium, as indicated by the proportion of chlorine in the waters from the Rivers Ness and Beauly, is so minute that it only amounts to about half a grain of chloride of sodium in the imperial gallon; whilst the lowest proportion of chloride of sodium (calculated from the chlorine) which is present in the water of the Firth of Inverness is equal to 1574 grains in the imperial gallon.

The water, therefore, obtained from any part of the Firth of Inverness, contains more than two thousand times the quantity of chloride of sodium, in a given volume or weight, than that which is present in the waters of the Ness and Beauly. In this vast increase in the proportional amount of common salt, there is the strongest corroboration of the greater prevalence of salt water in the Firth of Inverness; and, judging alike from the specific gravity, the total amount of saline matter dissolved in the water, and the large proportion of common salt, there can be no doubt that the Firth of Inverness is sea, and that it will be found by naturalists to afford to marine flora and fauna all the required strength and chemical properties so essential for the unimpaired growth, development, and sustained life of marine vegetable and animal organisms.

3. On Hemiopsy, or Half Vision. By Sir David Brewster, K.H., F.R.S.

After describing the phenomena of hemiopsy, as observed by Dr Wollaston, M. Arago, and Mr Tyrrell, the author remarked that no attempt was made by these writers to ascertain the optical condition of the eye when it is said to be half blind, or to determine the locality and immediate cause of the complaint. Having experienced several attacks of hemiopsy, unaccompanied with any affections of the head or stomach, the author found that there was no insensibility to light, but merely an insensibility to the lines and shades of the object which disappeared. This insensibility commenced in both eyes, a little to the left of the *foramen centrale*, and extended itself irregularly to the margin of the retina on the left side. The parts of an object, or the letters of a word which disappear, are as bright as the ground around them, and are *white* if the ground is *white*, and always of the colour of the ground, so that the light of the ground has irradiated into the dark lines or shades of the picture on the retina, a phenomenon which can be produced in a sound eye by oblique vision.* This species of irradiation, however, is merely a local and temporary paralysis of the retina by the continued action of light upon the same part of it; but in hemiopsy, the irradiation is produced by the pressure of the blood-vessels, which may arise from various causes,—from the mere fatigue of the eye after long reading or exposure to bright light, or from affections of the head or stomach. That this pressure of the blood-vessels was the cause of the hemiopsy studied by the author, was proved by his going accidentally into a dark room while under its influence, when he was surprised to observe that all the parts of the retina which were affected were slightly luminous—an effect invariably produced by pressure upon that membrane.

* Letters on Natural Magic. Letter II. p. 13.

4. On the Tertiary Coals of New Zealand. By W. Lauder Lindsay, M.D., F.L.S., Honorary Fellow of the Philosophical Institute of Canterbury, New Zealand.

In 1861–62 the author visited and examined several of the Tertiary coal-measures of New Zealand; and the paper, of which this is an abstract, contains, or consists of, an epitome of his observations thereon. The collections of specimens made during his excursions, with relative maps and other illustrations, were exhibited to the Society at their Conversazione of 25th February 1863. A suite of coal specimens was submitted to chemical analysis by Professor Murray Thomson, the results of which are included in the paper.

The Tertiary coals of *Otago* are described : as being typical or representative of those of the other New Zealand provinces. Their characters or qualities are contrasted with those of the

1. *Tertiary Coals* of Auckland and Nelson, New Zealand.
2. *Tertiary Coals* of Europe.
   Glanzkohle of Germany.
   Brown Coals, or *Lignites*, of
      a. The Danube, Hungary, and Transylvania.
      b. Bohemia and the Rhine.
      c. Bovey-Tracey, Devonshire.
   Surturbrand of Iceland.
3. *Mesozoic and Palæozoic Coals* of Canterbury and Nelson, New Zealand.
4. *Palæozoic Coals* of New South Wales and Britain.

I. *Topography and Extent.*—Tertiary coal deposits occur more or less abundantly in most of the New Zealand provinces; especially, however, in Otago, Nelson, Canterbury, and Auckland. Occasionally they form belts extending for great distances, sometimes as much as fifty to one hundred miles, along sea-coasts or river banks. More generally, they are localised in isolated or circumscribed inland basins. Usually they occupy plains or valleys at low elevations. Sometimes, however, they are to be found at heights of several hundred, or even thousand, feet on the flanks of hills.

II. *Origin of the Coal.*—In different localities, and under different circumstances, it has at one time, apparently, consisted of *drift* wood and leaves; of *peat* bog, marsh, littoral or *forest* vegetation submerged *in situ* and subsequently re-elevated; or of *marine* vegetation (kelp) subsequently elevated. It has been found mainly in ancient lakes, estuaries, bays, fjords, coasts, or seas. Its associated strata present frequently, if not usually, alternations of *marine* (shell and kelp beds) with *terrestrial* deposits (dicotyledonous leaf or fern beds); indicating the occurrence of repeated and irregular oscillations of the relative levels of land and water during their deposition.

III. *Stratigraphical Relations.*—The best class of coals is referable to the *Lower* or *older* group of the Tertiary system; belonging, however, to different ages in this group.

Lignites, *jet*, and *fossilised wood* occur also in all the newer or superjacent Tertiaries, as well as the post-tertiary strata; while *drift wood* and *submerged forests* may be seen in process of fossilisation at the present day.

Not unfrequently the coal-beds rest immediately on the fundamental rock of the country, which is usually metamorphic slate, (probably of Silurian age), though sometimes granite.

The coal strata are frequently disturbed by eruptive or intrusive *Trappean* rocks of Newer Tertiary age, which sometimes tilt them up vertically, or throw them completely over. They are pierced likewise by *Trap-dykes*, and characterised by faults or dislocations resembling—save, perhaps, as to the scale on which they occur,—those of our own Palæozoic coal-measures. These Traps sometimes coke or cinder the immediately adjacent coal; more frequently, perhaps, the lithological character of the latter is unaffected.

IV. *Associated Strata*—

a. Conglomerates (locally known as "gravels" or "cements"), usually coarse and quartzose; frequently of a plum-pudding stone character; generally ferruginous; passing into

b. Grits, which again graduate into *sandstones*. Some of the latter are sufficiently hard and pure to be useful *building stones.* Occasionally they are *carbonaceous;* or they are impregnated, or intermixed, with *magnetic iron.*

c. *Clays*, frequently arenaceous or carbonaceous, or both; sometimes ferruginous; occasionally white and pure. They include every variety of *kaolin*, plastic or *potter's*, *pipe*, *fire*, and *brick* clays; and *ochres* or ferruginous earths; many of which are suitable for utilisation in the industrial arts.

d. *Shales*, also generally arenaceous or carbonaceous, or both; sometimes richly fossiliferous, containing especially *leaves* (of exogenous trees and ferns) beautifully preserved.

The coal-beds are frequently directly overlaid or roofed by Newer or upper Tertiary strata; consisting usually of various conglomerates or gravels, sands and clays.

V. *Contained Minerals*—

a. Various *Fossil Resins*, similar to those which occur in the brown coals of Germany. To the settlers they are generically known as *Kauri gum*, and are considered identical with the fossil resin so called in the North Island —which is generally regarded as the produce of the existing *Dammara australis* Lambert (N. O. *Coniferæ*). They include *Retinite* and *Ozokerite.*

b. *Iron Pyrites* (including *Marcasite*); *Sulphate of Iron; Clay Ironstone* nodules.

c. *Sulphur*, generally impregnating sands or sandstones; clays or mudstones.

d. *Quartz*, as an impurity.

e. *Jet;* and vegetable débris in the form of *Mineral Charcoal.*

VI. *Lithological or Physical Characters.*—Hand-specimens exhibit all gradations between *Lignite*, *Brown Coal*, *Pitch Coal*, *Cannel* or *Parrot*, and *Common British Domestic*, *Coal.* Their texture, fracture, and lustre consequently vary extremely. Generally they are earthy and massive; occasionally laminated; splinter readily on exposure; do not cake in burning; *colour* and *streak*, brown to black; *specific* *gravity*, 1250 to 1300 ; *ash* generally light like that of wood ; colour various shades of white, gray or buff ; *coke* dull to iridescent.

VII. *Chemical Constitution.*—The following, which is the mean (in round numbers) of numerous analyses, by various chemists, of the Tertiary coals of different parts of the New Zealand Islands, may be held to represent their average composition :—

a. Proximate Constituents—

Coke, ...	45	per cent.
Carbon in coke (or fixed carbon), .	40	,,
Volatile matter (hydro-carbons), . .	45	,,
Ash, ...	6	,,
(Components—Silica, alumina, iron, magnesia, and lime.)		
Water of constitution, . . .	15	,,
Gas, cubic feet per ton, . . .	4000	
Oil, gallons per ton, . . .	15	

b. Ultimate Elements—

Carbon, ...	60	per cent.
Hydrogen, ...	5	,,
Nitrogen, ...	1	,,
Oxygen, ...	20	,,
Sulphur, ...	2	,,

VIII. *Commercial Value.*—The following are defects in most, if not all, of the Tertiary coals of New Zealand :—

a. Proportion of *water* or moisture they contain : frequently 20 to 30 per cent.

b. Comparatively large amount of *ash.*

c. Comparatively large amount of *sulphur* (in pyrites), giving rise to a disagreeable odour during combustion.

d. Occasional presence of *lime*, which gives the quality of *fusibility.*

e. Tendency to fall to dust or "small" on exposure or desiccation.

f. Burn well only when associated with some more inflammable fuel, such as wood, peat, or Palæozoic coal.

Nevertheless, *in the absence, or with a mixture, of fuel of a superior kind*, this class of coal is, or may be, used as a domestic fuel, as well as in various branches of local manufacture, such as brick and pottery making, and metallurgic processes. Its use is, and is likely to continue, strictly *local.* At present it is employed as a domestic fuel, mostly on the gold-fields, where it abounds, and where fuel of a better class is scarce, if at all to be had; or, intermixed with better fuel, by the poorer classes in large towns. It cannot compete, either as a domestic, steam, or other fuel, with New South Wales or British coals (Palæozoic), which uniformly command a higher price, and occupy a superior position, in all the New Zealand markets.

In all the large towns of New Zealand, especially in Dunedin, Christchurch, Nelson, and Auckland, there is now a comparatively good supply of both local and foreign coals. The market prices of the former vary according as they are delivered at the pit-mouth or in the towns; and those of the latter as they are delivered in the towns, or from the ships' sides in harbours or roadsteads.

The market prices of New Zealand Tertiary coals vary from 7s. 6d. to 35s.—average, 10s. to 15s.—per ton, delivered at the pit; and 40s. to 50s.—average, 45s.—delivered in towns. Those of Newcastle (New South Wales), or Newcastle (English) coal, range from 40s. to 80s. per ton, according as they are delivered from the ship or in town.

IX. *Produce of the Collieries.*—As yet *labour* is limited and dear, and *machinery* defective; so that the highest yield at present is 100 to 150 tons per week (Fairfield Colliery, about six miles southward of Dunedin, Otago); the average elsewhere being 50 to 100 tons.

X. *Flora of the Coal Measures.*—Consists chiefly of the *wood* and *leaves* of *exogenous trees*, probably in great measure *coniferous;* and of *ferns.* The leaves include those of species of the following genera:—

Fagus,	*Myrtifolium,*
Loranthophyllum,	*Phyllitis.*

The general Tertiary flora comprises—

a. The *wood* of various *conifers*, perhaps including the *Kauri pine*, which still exists, though within a limited area, in the North Island; and of other *exogenous* trees:—frequently *silicified* like the fossil wood of Antigua.

b. The *leaves* of various exogenous trees of the orders apparently of *Lauraceæ* and *Cycadaceæ* (genera allied to *Laurus* and *Zamia*)—frequently, like the wood, beautifully silicified and preserved; of *endogenous* trees, chiefly of the family *Palmaceæ;* and of arborescent or large-fronded *ferns*.

Most of the fossil plants of the New Zealand Tertiaries are apparently *extinct* species; but, as in the parallel case of the *fauna*, a few may be referable to *living forms*.

XI. *Fauna of the Coal Measures.*—Mostly *marine*, including—

a. Cetaceæ; bones.

b. Fish of the *shark* family (teeth): genera *Lamna*, *Carcharias*, *Oxyrhina*.

c. Echinoderms: Brissus, *Schizaster*, *Hemipatagus*.

d. Mollusca: species of the following genera:—

Ostrea,	*Turbo*,
Pecten,	*Crassatella*,
Terebratula,	*Dentalium*,
Natica,	*Struthiolaria*,
Voluta,	*Scalaria*,
Purpura,	*Waldheimia*.
Trochita,	

The general Tertiary Fauna includes in addition:—

Cardium,	*Cyrena* } fresh-water.
Cucullæa,	*Melania* }
Mytilus,	

While the major portion are *extinct* species, some are identical with *existing forms*.

XII. *Fossilisation of Vegetation at the present day.*—Instances are given of *Tree Beds* at various depths below the soil, and at various elevations on the mountains: of the fossilisation of *drift-wood*, leaves and seeds in swamp clays: of the *submergence* of Kauri or other *orests*—that are being, or have been, converted into Lignite on the *western* coasts (which are undergoing a process of *subsidence*):

and of the overwhelming of existing forests by sea-sand on the *eastern* coasts (which exhibit phenomena of *elevation*).

Within an area of a few hundred yards on the Greenisland coast of Otago, the sand-dunes may be seen encroaching on the forest, which consists mainly of gigantic *conifers*: of other *exogenous* trees of the natural orders—

Myrtaceæ,	*Violarieæ*,
Araliaceæ,	*Pittosporeæ*,
Leguminosæ,	*Malvaceæ*,
Onagrariæ,	*Tiliaceæ*,
Magnoliaceæ,	*Corneæ* :

of palm-like and shrubby *Liliaceæ;* and of arborescent *Ferns:* while they are also covering in marshes and lagoons, whose vegetation consists chiefly of littoral *Grasses* and *Cyperaceæ : fresh-water aquatics ; salt-marsh plants :* and *marine Algæ.*

The following Donations were laid on the table :—

Bulletin de L'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique, No. 12. Bruxelles, 1864. 8vo.—*From the Academy.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. XIX[e] Deel, XXI[e] Deel, 1[e] Stuk. 4to. Haarlem, 1864.—*From the Society.*

Sitzungsberichte der Konigl. Bayer. Akademie der Wissenschaften zu Munchen, 1864. II., Heft 2. Munchen, 1864. 8vo.—*From the Academy.*

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire for 1863–64. 8vo. Leeds, 1864.—*From the Society.*

On the Early History of Leeds. By Thomas Wright, Esq., M.A. 8vo. Leeds, 1864.—*From the same.*

Forty-fourth Report of the Leeds Philosophical and Literary Society. 8vo. Leeds, 1864.—*From the Society.*

Thoughts on the Influence of Ether in the Solar System, its relations to the Zodiacal Light, Comets, the Seasons, and periodical Shooting Stars. By Alexander Wilcocks, M.D. 4to. Philadelphia, 1864.—*From the Author.*

Die Fossilen Mollusken des Tertiær-Beckens von Wien. Von Dr M. Hörnes. Band II. 5, 6. 4to. Wien, 1865.—*From the Author.*

Monthly Notices of the Royal Astronomical Society, Vol. XXV. No. 3. 8vo. London, 1865.—*From the Society.*

Letter from John Davy, M.D., F.R.S., addressed to the editors of the Philosophical Magazine, in reply to a certain charge made by Charles Babbage, Esq., F.R.S., against the late Sir Humphry Davy, when President of the Royal Society. 8vo. —*From Dr Davy.*

Proceedings of the Natural History Society of Dublin for 1863–64. Vol. IV. Part II. 8vo. Dublin, 1865.—*From the Society.*

The American Journal of Science and Arts, Vol. XXXIX. No. 115. 8vo. New Haven, 1865.—*From the Editors.*

The Quarterly Journal of the Geological Society, Vol. XXI. Part I. 8vo. London, 1865.—*From the Society.*

The Journal of the Linnean Society, Vol. VIII. No. 32, Botany. 8vo. London, 1865.—*From the Society.*

Reale Istituto Lombardo di Scienze e Lettere—Rendiconti—Classe di Scienze Matematiche e Naturali. Vol. I. Fasc. 7, 8. Classe di Lettere e Scienze Morale e Politiche. Vol. I. Fasc. 7. 8vo. Milano, 1864.—*From the Institute.*

Solenni Adunanze del Reale Istituto Lombardo di Scienze e Lettere, Adunanza del 7 Agosto 1864. 8vo. Milano, 1864. —*From the Institute.*

Journal of the Chemical Society, January 1865. 8vo. London, 1865.—*From the Society.*

Monday, 6th March 1865.

Sir DAVID BREWSTER, President, in the Chair.

1. On the World as a Dynamical and Immaterial World. By Robert S. Wyld, Edinburgh.

What is matter? has been the question of philosophy from the earliest times. The author of this paper referred to the speculations of Thales and other philosophers of the Ionic school six hundred years before Christ, and to the more profound views of the Eleatic school, which had its origin about fifty years later, and the questioning which then arose regarding the reality of the knowledge given us by the senses.

Hume, by ingenious arguments, endeavoured to throw distrust on all human knowledge, and to show that we could neither prove the existence of power, the connection of cause and effect, nor the existence of an external world. Kant, roused by this, undertook to prove that the mind had certain judgments and beliefs, irrespective of those derived from our connection with the world. This set the German thinkers upon an exhaustive examination of mental phenomena, and led to the idealism so prevalent in German philosophy.

Disregarding, however, the extreme views of a numerous class of idealists, the question still remains open before us, What is matter?

The phenomena met with in prosecuting chemical science are frequently so marvellous and unexpected as to raise in the mind of an abstract thinker doubts as to the theory that the atoms with which he is dealing are material atoms. The idea of *matter* or *substance* implies to every man who considers it abstractly the possession of *certain qualities inherent in each substance.* This idea is found, however, to be the reverse of a true one. The most trifling difference in the proportions in which *substances* are combined frequently creates the most entire change of property. Witness the results of the various combinations of oxygen with carbon, with hydrogen, or with nitrogen, and witness the still more surprising animal and vegetable productions which result from the united combination of these four elements—the oils, the gums, the dies, the flesh, the vegetables, the medicines, the poisons,—in fact, nearly the entire catalogue of animal and vegetable products and principles with which we are acquainted. Quinine is composed of seventy atoms of these four elements, and so is strychnine, the only difference being that the poison has two atoms more of carbon, and two less of hydrogen, than the tonic. All such facts indicate that the ultimate elements and their combinations act dynamically, for they do not act according to the way we would expect *substances* to act.

Consider the atoms as matter, and all seems contradiction ; consider them as forces, and the phenomena, we observe, become comparatively easy to understand or to conceive.

For example, the tissues of the animal frame are a nicely-balanced combination of elementary atoms. All animal and vegetable tissues are composed of clusters or groups of these atoms, and the nature of the grouping implies, as the organic chemist well knows, that these forces are held in comparatively feeble combination. What is flesh to-day is corruption to-morrow, resolving itself into new combinations. This is an essential condition, and without it nutrition, assimilation, and renovation would not be possible ; for it is only where all is feebly held together that a ready transfer of the parts can be effected. If, then, we regard our bodies, and the substances we take into the stomach, as nicely balanced collocations of forces, we can understand how one group may nourish us, or become incorporated with our bodies, while another slightly different combination may dissolve or break up the forces binding the substance of the animal tissues together, or may stifle or may stimulate the movements of the nervous energy, or may completely paralyse the organ where this vital agent is generated.

The following seven considerations and facts, derived from physical science, lead us to the conclusion that matter does not exist :—

1*st*, All matter (if such an entity exists) acts external to itself. The sun acts on the earth, and the earth acts on the moon. The power of attraction between these large bodies, considered as a mechanical force, is enormous ; and as we know of no material link between them which can explain so strange a fact, we are compelled to believe in the existence of this tremendous mechanical or physical force without a mechanical agent to produce it.

2*d*, It is evident, in like manner, that when chemical atoms act on each other, they act external to themselves. It is therefore here not matter which acts on matter, but force on force.

3*d*, It can be proved that no one portion of matter ever touches another. The elasticity of all substances proves this ; and when it is objected to this argument that the ultimate parts of matter may be compressible, this objection is merely equivalent to saying that *their* parts may *come closer*, and that they are not absolutely close.

In gases the intervals between the atoms must be enormous, and yet, if the old theory of repulsion holds, the atoms still repel one another, even under the nearly fully exhausted receiver of an air-pump.

4th, A ray of light falling on a polished surface of coloured glass, or on a mahogany table, &c., is reflected without acquiring any of the colour of the body reflecting it. This proves that the action in reflection is external to the substance of the glass, and that the ray never touches the reflecting surface.

The fact with regard to light, that the angle of reflection is equal to the angle of incidence, and that there is no dispersion of the ray, owing to the necessary roughness of all artificially polished surfaces, is, as Sir John Herschel observes, in his article on light (Ency. Metr.), a proof that the ray never touches the surface, but is reflected at a certain distance from it.

5th, The passage of the *refracted ray* after it has passed through the band of force (where it is bent down towards the glass), and comes upon the partially rough substance of the glass, affords a strong proof that it does not encounter matter there to obstruct or scatter it, for it meets the surface at every conceivable angle, and yet the different parts of the ray pass through all the inequalities, preserving their direction parallel with one another. We must therefore regard the surface of the glass as merely the first line of centres of the atomic forces which constitute the substance of the glass, and which centres terminate again in the line of the lower surface of the glass.

6th, The free vibration of the ether in the densest bodies, such as the diamond, ruby, glass, water, and crystals, and the parallel direction of the luminiferous ray, is not reconcilable with the theory of transparent bodies being solid and natural bodies.

7th, Our inability to interrupt the attracting action of the magnet by the intervention of numerous plates of non-magnetic dense bodies, such as glass, copper, lead, pasteboard, &c., either singly or in combination, affords a strong presumption that all these substances interposed are composed not of solid matter, but of combinations of immaterial forces.

It is evident from the above facts and considerations that we never touch matter (even if it exists). And that we never see it is admitted alike by physiologists and metaphysicians, for vision is merely a mental affection, called up by an impulse on the optic nerve made by the movements of the luminiferous ether, which, not the chair or table, but the forces existing and acting external to the chair or table, or other object, radiates off. Moreover, it is universally admitted that vision is only a mental affection, not corresponding to anything external to the mind.

Chemical atoms may therefore be regarded as circles of force without any nucleus or core of matter in them; for if the forces are the efficient parts, there is evidently no necessity to assume that an inert and useless part will exist within them. The law of Parsimony entirely justifies us in assuming this, and in discharging matter from the atom.

The universe in this light becomes a vast and glorious exhibition of *power*, acting and displayed according to those laws which have been impressed, and which laws and system we designate *the laws of nature.*

Sir John Leslie, in his Dissertation prefixed to the "Encyclopædia Britannica," seems to have no disfavour to Boscowich's "Theory of Dynamics," except that the material points are made mathematical points, and suggests that, in order to get over this prejudice, we may conceive the material centres "to have real dimensions, though *far smaller than any assigned measure.*"

Professor Forbes, in his Dissertation, expresses a difficulty in reconciling this theory to the law of *inertia.* This is probably a chief difficulty felt by most men, to conceive of inertia being possessed by immaterial bodies. But the difficulty is entirely imaginary, and arises from our habit of considering that *matter has inertia*, and conceiving that therefore nothing but matter can have it. It is evident we cannot declare what properties are incompatible with immaterial forces. Our proof that we must admit them to have *inertia* is this. Let us suppose a molecule of forces at rest; it evidently will not move *unless force is applied;* a *certain amount* of *force* is required *to give it a certain velocity.* If this be admitted, then it follows that if the molecule be increased 10, 100, or 1000 times *in mass*, it must necessarily require 10, 100, or 1000 times that force to produce the like velocity. So far, then, as we have analogy and argument to guide us, these immaterial bodies must have *inertia*, at least the mouth is shut against declaring that they cannot have it.

If a difficulty still remains in conceiving immaterial masses to possess *inertia* or the feeling of ponderosity or immobility, the difficulty should vanish when it is kept in mind that all our perceptions of force are only *relative*, not *absolute.* If our living bodies, then, and the substance of all external objects, are of the same immaterial nature, we should not be surprised, but should rather expect, that the *inertia* of external objects should appear in proportion to their masses, and that it should also have a relation to the strength as well as the mass of our percipient bodies, all being composed of the same immaterial substance.

The great difficulty felt by those metaphysicians who believe in matter has always been regarding this *inert thing, matter.* Take away, say they, the qualities of colour, heat and cold, resistance or solidity, from any object, and an inert something remains to puzzle us. The author, on the contrary, holds that resistance or solidity constitutes matter. The difficulty felt by metaphysicians is thus avoided—namely, the necessity of conceiving a thing to exist without qualities.

There is another difficulty which besets the believer in matter. The human mind has always felt a difficulty—an apparent incongruity, almost approaching to a feeling of impossibility—when it conceives of a Being, whose essence is spiritual, creating a thing of a different essence from Himself, which matter is conceived to be. The ancient philosophers of Greece, feeling this, declared that matter was uncreated, and eternal. Spinosa, one of the acutest minds, felt also the same difficulty, and in his *Ethics* he lays it down as an axiom of reason that "the knowledge of an effect (the world, for instance) depends on the knowledge of the cause, and things that have nothing in common with each other (matter and spirit) cannot be understood by means of each other." Hence the one cannot be the cause of the other. We state this principally to show how extensively the difficulty has been felt of conceiving the existence of two different essences in nature.

Recent discoveries have established that heat is mechanical force, the two being mutually convertible without loss. The attraction of gravity and chemical attractions and repulsions are all the same physical force, and the entire external world is nothing but a manifestation of it,—a simple and grand conception, and one which enters the domain alike of physics, of speculative philosophy, and of theology, and which in all of these sciences is equally important. It represents the external world and its Creator as possessed of one immaterial and *spiritual* essence—*power* and *intelligence* being the attributes of the Creator, and *power subordinate and sustained the characteristic of the creation.*

The objection to a system of pure dynamics will probably be this. It will be said forces cannot exist except as the *properties of matter.* The belief in the necessity of matter is all but universal. This arises, we think, from a law of the mind, which when it reflects on *any thing as existing* immediately, and of necessity, assigns a cause for its existence. The generality are satisfied to regard the *properties perceived as constituting the thing or object.* The object is thus a hard or soft, a black or white, or coloured thing. The man of science applies his mind to the consideration of the *properties*, and afterwards to the consideration of the thing itself, as if they were different entities, and he thus assigns matter as the *cause* of the properties he observes. The author also believes in a cause for the forces of which he has spoken; but as he has not matter to fall back on, he is compelled to assign as the *cause* that Being who is the centre of all power and wisdom, and who manifests these attributes to his creatures in the vast and complex arrangements of a dynamical universe.

The tendency of speculative philosophy has been to run into idealism. This has been its fate in Germany, and it is to be feared it may come to the same conclusion in Scotland. The author would deeply deplore such an end to our boasted Scottish philosophy. The ultimate foundation of all reality has been admitted by nearly every philosopher to be the Supreme Being. If, then, the theory propounded should assist abler hands in establishing realism directly on this foundation, the author would feel in no ordinary degree gratified and rewarded.

2. On the *Nudibranchiate Mollusca* of St Andrews; *Edwardsia;* and the Polyps of *Alcyonium digitatum.* By W. C. M'Intosh, M.D., F.L.S. Communicated by Professor Allman. (Accompanied by various Drawings.)

The Nudibranchs owe their prominence in British zoology to the late Dr Johnston of Berwick, and to the splendid monograph of Messrs Alder and Hancock.

Inhabitants for the most part of the laminarian and littoral zones, the rocks and rock-pools, by minute and continued search, produced the greater number of those met with at St Andrews, the few others being procured from fishing-boats and débris of storms. Almost all require to be sought for with care, and generally escape superficial notice altogether. Most have been kept for a longer or shorter period in confinement, and some are living even now, though with greatly diminished bodies, and less brilliant tints, the results of insufficient food and other unfavourable circumstances.

Their favourite haunts are under stones in pools, and the more undisturbed these look, the better chance is there of securing fine specimens. The upturned surface of the stone, however, should be immersed an inch or two under the clear water, so as to float out the branches of the zoophytes and the branchiæ of the Eolids. The fondness of the smaller forms for surfaces covered with Sertularidæ is also seen in the case of storms, where the richest fields are the broad blades of the Laminariæ that are covered with *Laomedea geniculata* and *gelatinosa*.

The species met with at St Andrews will be given in the order in which they occur in the "Monograph" above-mentioned, with such remarks appended to each as may seem necessary or new.

The most plentiful Nudibranch here, as elsewhere, is *Doris tuberculata*, which occurs in all sorts of places amongst the rocks at low water. In storms, many are found on the west sands in the intricate hollows of large masses of *Halichondria panicea*, a situation affording them both food and shelter. Some, found under large stones in pools, were unusually flattened and rounded, like gigantic Lamellariæ : such are not gaily tinted. Most of the specimens, especially those of large size, had some of the parasites described by Alder and Hancock under the name of Ergasilus, which sported over their branchiæ and other organs with wonderful agility. Messrs Alder and Hancock state that they are colourless, but in most cases these had a pure white cross on the back, and some were pinkish. The largest Doris measured fully $4\frac{3}{4}$ inches. Their food, as usual, is *Halichondria panicea*.

Doris Johnstoni is somewhat scarce, and generally in company with the former under stones between tide-marks. This species does not sport in tint. It is an active animal in confinement. The same species of Ergasilus occurs on this Doris as on the former. Largest specimen, 2½ inches.

Doris repanda is one very commonly found at all seasons amongst the rocks. The largest specimens are often of a dusky yellow tint. Many had the border of the cloak injured, as if a portion had been eaten out. It is very tenacious of life in captivity. Two kept for some time in a vessel along with a little *Corallina officinalis* deposited their ova; and this being one of the few species that Messrs Alder and Hancock had not observed at the breeding season, nor yet succeeded in obtaining its spawn, a more detailed account will be given.

On the 10th of November, the two were observed *in coitu*, and apparently in a state of excitement, elevating the cloak all round the margin in a curiously frilled manner. They lie head to tail, but not very closely, and the intromittent organ is capable of great extension and distension, so that the animals are enabled to effect their purpose, even when one is lying at right angles to the head of the other. On the 12th they were both in process of depositing their spawn on the side of the glass. The coil is a simple one, attached by the edge, and sloped upwards and inwards. The eggs are very large and conspicuous.

In spawning, the body is shortened; the posterior edge of the cloak being doubled inwards, so as to press on the outer edge of the coil of ova. The upper (left) edge of the cloak is raised from the surface and arched in a graceful manner. The anterior border is spread out and flattened on the surface of the glass, and the fore part of the foot is likewise similarly fixed. In the centre of the coil of spawn, the foot was bent upon itself, causing a deep dimple, and this hollow remained although the animal changed its position. As the act of deposition proceeded, it glided the anterior (attached) extremity upwards, while the posterior (free) turned downwards, thus favouring the gradual exit of the coil. The anterior part of both foot and mantle constituted a broad pivot on which the animal revolved from right to left. The posterior border of the mantle did not always remain alone at the outer part of the coil, for by and by the posterior part of the foot likewise projected, and the dimple in the centre became less marked, though still present.

Next day it had nearly completed two coils, and then, having diverged at an angle, left an interrupted row of ova in single file.

So far as observed, their stomachs contained only cells and granules.

Doris aspera.—Under stones in pools near low-water mark; not uncommon.

Doris bilamellata.—Abundant all the year round; occurring in swarms in March, and, according to Dr John Reid, in February also. They manifest a tendency to congregate together in a vessel, and often crawl out of the water. Their stomachs contain a greyish-brown mass of granules.

Doris pilosa.—Common; of all hues, and occasionally party-coloured. The same peculiar granular matter existed in the stomachs of this species, but with the addition of a greater number of larger granules and cell-like bodies; there was also a tendency to form bolus masses.

Of *Doris subquadrata,* only a single specimen occurred.

Goniodoris nodosa is a very common species, first found here by the late Rev. Dr Fleming, and afterwards by Dr John Reid. There is little to be met with at St Andrews in support of the statement of the able authors of the "Monograph"—in regard to the disappearance of the adult animal and the growth of the young; for the varying sizes occur throughout the entire year, fine full-grown specimens ($1\frac{1}{4}$ inch) being found in December as well as in March, April, and May. They are hardy in confinement.

Triopa claviger occurs now and then under stones, in situations seldom invaded by aught but the waves. The most striking fact in connection with this animal is the occurrence, in two out of three specimens, of crustacean parasites (Ergasili) similar in all respects to those found on the two first-mentioned species of Doris.

One of the most remarkable amongst the Nudibranchs, and at the same time comparatively rare, is met with in considerable abundance, viz., *Ægirus punctilucens.* Belying its generic name, it frequents the under surfaces of stones in pools, from low water to above half tide mark, apparently delighting in dark surfaces whose tints closely resemble its own. They were met with several times in groups. *Æ. punctilucens* lives well in captivity, and it spawns in July.

Polycera quadrilineata was first found at St Andrews by Dr John Reid in the month of September. It is occasionally got after October storms, and at low-water mark during the same season. They also spawn at that time.

Polycera ocellata is gregarious amongst these rocks; very active in confinement; apparently phytivorous. Spawns in September, and sometimes the ova are deposited on the surface of the water in an incomplete coil.

One young specimen of *Polycera Lessonii* occurred after an October storm on a laminarian blade covered with *L. geniculata*.

Ancula cristata is rather a common Nudibranch, living under stones in quiet pools between tide marks, sometimes in groups of three. The majority of the specimens are pale. They spawned in August.

Tritonia Hombergii comes occasionally from the deep-sea fishing. In the stomach of one, about 3½ inches long, were fragments of the usual food (*Alcyonium digitatum*), mixed with darker débris, possibly from Amphitrite tubes.

Tritonia plebeia, very abundant on *Alcyonium digitatum* (on which it probably feeds), cast on shore by storms, on corallines from deep-sea fishing, and procured by the dredge off the laminarian zone. Twice were full-grown specimens got in autumn, having a remarkable process on the left side, about the last branchial appendage; indeed, the tail seemed bifid.

Dendronotus arborescens generally comes from deep water in the fishing-boats, or from débris of storms. Dr John Reid first procured it at St Andrews. None were ever heard to emit the sounds mentioned by him and Dr Grant.

Doto fragilis.—Specimens occur on corallines from deep-sea fishing. They are rarer than the succeeding species, and generally larger.

Doto coronata.—Abundant in the same regions as the former and also under stones in rock pools. One showed a curious abnormality in the left dorsal tentacle.

Eolis papillosa occurs very plentifully during some years amongst the rocks, but is absent from its accustomed haunts during others, without apparent cause.

Supplying the place of the large *E. Drummondi* of the west coast, is the more beautiful and graceful *Eolis coronata*, which is occasionally met with near low-water mark. They sometimes devour portions of their own tails.

Eolis rufibranchialis appears amongst the rocks, and in débris of storms. The white granular streak down the tail is interrupted by pale papillæ. They are agile and restless in confinement, and do not scruple to devour a dead companion of any species.

Eolis olivacea is met with sparingly under large stones in rock pools, between tide marks. It is hardy.

One of the most plentiful species is *E. viridis*, a group of six or seven occasionally occurring under a stone, and smaller numbers more frequently. Of all the Eolides observed, this has the most prehensile tail. It is easily kept for many months, though it loses its tints.

Eolis Andreapolis, n. s.—*Body* half an inch long, ovate-oblong, of a pale-yellow or dull purplish hue, the latter chiefly marked at the sides; with the dorsum faintly granular, and brilliantly blotched over with large, elongated, bright orange-pink spots, which were quite absent from the tail. Some of these spots were in front of the dorsal tentacles—one at the anterior and outer aspect of each, and a very distinct mass at their junction. There are a few smaller orange spots at the sides below the branchiæ. *Dorsal tentacles* about twice as long as the oral, not much tapered, approximating at the base; tips pale amber, then a broad belt of reddish orange; a few white grains at either end of the orange. *Oral tentacles* short and blunt, capable of a spoon-like flattening; similarly tinted. *Branchiæ* elliptical or club-shaped, purple, pale at the base, and densest in colour next the reddish-orange cap at the tip. In one pale specimen, a waved central vessel was apparent. There appeared to be more than a dozen transverse rows. The structure of the tongue approached most nearly to *E. tricolor*. Found after storms, and at low water amongst the rocks.

Eolis Farrani.—At low water amongst the rocks, and on the beach after storms. Not uncommon.

Eolis exigua.—A number were found on *Laomedea geniculata* upon Laminarian blades, cast on shore by an October storm.

Eolis Robertianæ, n. s.—*Body* three-tenths of an inch long, rather stout, and of a prevailing orange-red hue; granular, with a few paler spots. *Dorsal tentacles* extremely attenuated, long, linear, smooth, orange-red. Eyes very distinct, set in a pale yellow space at the base of the tentacle posteriorly. *Oral tentacles* shorter, linear, similarly attenuated, orange red, and proceeding from the angles of the lip. *Branchiæ* thick, rather swollen, elongated, tipped with deep orange-red, which likewise passes down the sides; the base paler orange. They were incomplete in the specimen, but appeared to be set in nine or ten transverse rows, leaving a considerable space in the centre. The first row comes nearly as far forward as the dorsal tentacles. *Foot* orange yellow, rather suddenly tapering to a short tail. *Jaws* of a pale straw colour; lingual plates somewhat like those of *E. tricolor*, and stouter than in *E. Farrani.* From the border of the laminarian zone during a spring tide.

Note on the Polyps of Alcyonium digitatum.

The varied descriptions and figures of these common polyps probably arise from the changes which so readily ensue on removing them from their native sites in the usual manner. The figure given by Ellis,* though not accurate, shows a closer approach to the natural aspect of the tentacles than Dr Johnston's,† and the same may be said of Müller's.‡ Dr Johnston is correct enough in his description, so far as it relates to faded and sickly specimens brought from deep water by the fishermen. Sir J. G. Dalyell§ is somewhat more exact in his description of the tentacula and general appearance, but his figure does not represent the polyps in perfection.

The most perfect specimens are got amongst the rocks at low water, under stones in pools. Small patches can be chipped off, adhering to a fragment of stone, without injury ; and taking one of these, three-fourths of an inch in diameter, it is found that the

* The Nat. Hist. of many Curious and Uncommon Zoophytes.

† British Zoophytes, p. 177. Plates xxxiv. and xxxiv*.

‡ Zool. Danica. Tab. lxxxi.

§ Rare and Remarkable Animals, &c., vol. ii. p. 176. Plate xlvii.

thickness of the film in contraction is not more than one-tenth of an inch. As the polyp contracts into its stellate aperture, its mouth gapes, apparently the more readily to give exit to the water in its interior. It presents the aspect of an octagon with hollow sides when about the level of its cell. Rows of spicula project from the corners towards the centre.

If further extended, the tentacula, their pinnæ, and the rows of spicula become more apparent; oral aperture dilated; outline of oral disc similarly octagonal, though much larger.

When still further extended, a coiling of the arms is frequently seen, like the circinate vernation of the ferns.

In a state of full expansion, the polyp is elongated and narrowed towards the head, measuring more than half an inch from the tips of the tentacula to the base. The tentacles can be stretched to more than twice the diameter of the oral disc, are narrow and tapering, and have the elongated pinnæ at each side; the tips are slightly opaque, probably from minute suckers. The tentacles are also roughened by minute spicula, which do not, however, go further than the base, where a pale, unspiculated portion occurs; below this the neck of the polyp is supplied with long spicula with tuberculated edges, arranged in an arrow-shaped manner. In those polyps which are best expanded, the diameter of the oral disc is smallest. Sometimes, from the position of the parts, the tentaculum with its pinnæ presents a spindle-shaped appearance.

Note on two New Species of the Genus Edwardsia.

Edwardsia Allmanni, n. s.—Found on the beach at St Andrews after an October storm. This actinia inhabits a very apparent free tube. The tentacles can be retracted, and the external border of the disc pouted over them. The disc is marked by eight alcyonian divisions or radii, and has always a ragged border of the investing sac. The colour of the disc is pale brown or dark flesh tint.

Tentacles simple, rather blunt, pale and translucent, with a white streak in the centre. The rim of the mouth occasionally protruded as a conical process.

Case composed of a vast number of diatomaceæ, entangled in a basis of tough cells and granules, developing algæ and débris of various kinds; and it gradually increased in density from the growth of its constituent structures, and probably from the shedding of mucus.

The presence of the case distinguishes it from Peachia and Halcampa; from the former it is also separated by the fact of the tentacles being wholly retractile within the swollen disc. It seems most nearly allied to Edwardsia, though the case was much larger than any previously mentioned, and its tentacles were also blunter and shorter.

Edwardsia Goodsiri, n. s.—Found with the foregoing; sheath less perfect. It constantly protruded a pale bladdery portion with minute suckers posteriorly, and was more lively and sensitive than the former. When fully contracted, it assumed the shape of a Roman jar, and measured less than $\frac{1}{8}$th of an inch in length.

Tentacles fifteen, translucent, longer than the diameter of the oral disc, and not tapering much. At the tip of each, under a low power is seen a slightly opaque whitish ring; then the tentacle is perfectly transparent for a short distance. From the base, a white spear-head reaches more than half-way up, its centre, however, showing the transparent texture.

Oral disc streaked with white and light brown; mouth not observed to project. Column behind the tentacles pale.

When fully extended, it measures about half an inch, the posterior pellucid portion forming nearly the half of this. The anterior part of the latter, however, is tinged of a light fawn colour from the viscera.

3. Miscellaneous Observations on the Blood. By John Davy, M.D., F.R.SS. Lond. & Edin. &c.

These observations are given in six sections.

In the first, "On the Action of Water on the Red Corpuscles of the Blood," the results are stated of trials of different proportions of water on these corpuscles; from which it would appear, that two of water to one of cruor of the blood of the common fowl, sufficed to change the form of the corpuscles, and to render them globular. Other changes are described, which were witnessed when water in great excess was used,—changes referred by the author to endosmosis and exosmosis, and rupture of the corpuscles, and the exclusion of their nuclei.

In the second, "On the Changes which take place in the Blood when excluded from air," it is shown that these changes are much the same as when blood is exposed to the air, the difference being chiefly in degree as to time, the accordance, it is inferred, owing to the presence of oxygen in the blood itself, the retained oxygen being sufficient to originate putrefactive decomposition.

In the third, "On the Action of the Air-pump on the Blood," it is stated by the author that the results obtained were more various than he could have expected. Some of them were the following:—Of the several animals of which the blood was tried (the common fowl, the duck, sheep, bullock, pig), least air was procured from that of the common fowl; more from the blood of animals killed after feeding than after fasting; more from venous than arterial blood; none from serum of the blood; this last result confirmatory of the inference that the air—the extricable air—is chiefly derived from the red corpuscles, &c.

In the fourth, "On the Effects of a Low Temperature on the Blood," results are described showing that the freezing of the blood does not preserve it from change of composition, ammonia having been found evolved from it when frozen; and that evolution of the volatile alkali takes place from stable dung when frozen, and from some other manures; but that muscle (meat) in its frozen state does not appear to be liable to the same change.

In the fifth, "On the Action of Ammonia on the Blood," an account is given of the effects of different proportions of aqua ammoniæ on the entire blood, and on its fibrin, its serum, and red corpuscle. The results obtained were such as to confirm the inference that the coagulation of the blood is nowise owing to escape of the volatile alkali, a very large proportion of ammonia not preventing coagulation.

In the sixth, "On the Coagulation of the Blood," some remarks are offered on one of the latest hypotheses brought forward to account for the phenomenon, the hypothesis of Professor Lister tending to show that that hypothesis is not sufficiently founded on fact, and concluding with the expression of belief, that the *vera causa* of the change is still to be discovered.

The following Gentleman was elected an Ordinary Fellow:

John Moir, M.D., F.R.C.P.E.

The following donations were laid on the table:—

Journal of the Asiatic Society of Bengal. No. 4 (with Supplement), 1864. Calcutta, 1864. 8vo.—*From the Society.*

Annales des Mines, ou recueil de Memoires, sur l'Exploitation des Mines et sur les Sciences et les Arts qui s'y rattachent, rediges, par les Ingenieurs des Mines. Tom. V. VI. VII. 1864. Paris 1864. 8vo.—*From the Ecole des Mines.*

Journal of the Royal Dublin Society. Nos. 32 and 33. Dublin, 1865. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 88. Edinburgh, 1865. 8vo. *From the Highland Society.*

Proceedings of the British Meteorological Society. Vol. II., No. 16. London, 1865. 8vo.—*From the Society.*

A General Description of Sir John Soane's Museum. New Edition. London. 12mo.—*From the Trustees.*

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland, for Quarter ending 31st December 1864 (with Supplement.) Edinburgh, 1865. 8vo—*From the Registrar-General.*

Monthly Return of Births, Deaths, and Marriages, registered in the Eight Principal Towns in Scotland, for January 1865, with Supplement to the Monthly Returns for 1864. 8vo.—*From the Registrar-General.*

Proceedings of the Royal Horticultural Society. Vol. V. No. 2. London, 1865. 8vo.—*From the Society.*

Report on the Formation of the Canterbury Plains, with a Geological Sketch Map, and Five Geological Sections. By Julius Haast, Ph.D., &c., Provincial Geologist. Christ Church, 1864. Folio.—*From the Author.*

Report on the Geological Survey of the Province of Canterbury. By Julius Haast, Ph.D., &c. Christ Church, 1864. Folio.—*From the Author.*

Récherches Astronomiques de l'Observatoire d'Utrecht. Par M. Hoek. La Haye, 1864. 4to.—*From the Author.*

Récherches sur la quantité d'Ether, continue dans les Liquides. Par M. Hoek, et A. C. Oudemans. La Haye, 1864. 4to.—*From the Authors.*

Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Germanieæ, Naturæ Curiosorum. Dresden, 1864. 4to.—*From the Academy.*

Monday, 20th March 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. On the Pronunciation of Greek. By Professor Blackie.

I. On the revival of learning at the middle of the fifteenth century, the Hellenists of Europe took the pronunciation of Greek from their teachers, the learned Greek refugees who fled from Constantinople when that city was taken by the Turks in 1453, and who carried with them the Greek language, both as the living people who used it, and as the inheritors of the rich store of philological learning accumulated by an unbroken succession of Alexandrian, Roman, and Byzantine scholars.

II. This Greek pronunciation of Greek remained undisturbed among European scholars till Erasmus, in the year 1528, published an essay on Greek pronunciation, at Basle, to prove that the Byzantine Greeks had in this matter departed in many points from the practice of their ancestors. The effect of this essay was not to reconstruct the lost pronunciation of classical Greek upon any scientific basis, but merely to unsettle the minds of men, and to set every European people upon the task of inventing a pronunciation of Greek according to their own conceit, and after the model generally of their own national peculiarities. The consequence of this unreasoning procedure has been that Babel of confusion which now reigns with regard to the pronunciation of that noble language, of which the living Greeks with so much reason complain, and which, in my opinion, it is the duty of philologers, as it now is to a large extent in their power, to remove.

III. In this haphazard creation of a modern pronunciation of Greek according to individual conceit all nations fared ill, but the English by far the worst; for they flung the whole basketful of their phonic anomalies into the Greek grammar, and produced a jargon as like Greek as French would be spoken by a Cockney who had never shown himself beyond the sound of the Bow Bells in Cheapside. The Scotch, partly by following the analogy of their own musical Doric dialect—partly from old habits of familiar intercourse with Continental scholars not under English influence—contrived to preserve a pronunciation of Greek as far as possible removed from the barbarous innovations of their English neighbours, and conformable in some most important respects to the acknowledged practice of the Greeks in the classical periods.

IV. Specially it can be proved by a very distinct passage in Dionysius of Halicarnassus—a rhetorician by profession in the age of Augustus Cæsar (*περὶ συνθέσεως ὀνομάτων*, ch. XIV.)—that the whole series of the vowels *α ε ι ο υ* is pronounced by the Scotch, as by all the Continental nations, correctly, with the single exception of *υ*, which in some parts of Scotland is confounded with *oo*, and not according to the perfect analogy supplied by the native words *guid*, *bluid*, as these words are pronounced by the best speakers of the Scottish dialect, corresponding to the sound of *ü* in German, as in *Bühne*, *Brüder*, &c. It is also certain that the pronunciation of the diphthong *ου* practised by the English is contrary alike to the whole traditions of philology and to the most marked characteristic of the Greek language. All scholars recognise *oo* as the only legitimate pronunciation of that most musical of the diphthongs.

V. About the pronunciation of the other diphthongs in the strictly classical—that is, the Athenian—period, great doubt prevails; but there is good evidence to show that *αι* was pronounced like the same diphthong in the English word *vain*, and *ει* like this diphthong in the English word *receive*, at Alexandria in the time of Callimachus, about two hundred years before Christ. Any attempt to reconstruct the Attic orthoepy of the diphthongs on the principle suggested by Erasmus, of showing how they *ought* to be pronounced by the most obvious and easy interflow of their vocal elements, can, according to the experience of all languages, issue in no reliable result. Pronunciation is a matter of usage, not of argument.

VI. What is called the modern Greek pronunciation, or that used by the Greeks speaking their own language at the present day, is not modern in our sense of that word—it is Byzantine and Alexandrian; and in its most characteristic elements as old as the oldest Greek manuscripts now existing—as old, we may say more correctly, as the general body of the ante-Nicene theology. That it is a corruption from the oldest classical pronunciation is self-evident, from the fact of its giving the slender sound of ι to half a dozen different vowels and diphthongs. But this is only what may be said with equal truth of French, English, and other languages, which have passed through various stages of culture during successive centuries. Their present pronunciation is, in many important points, a corruption of that which was originally the rule.

VII. In these circumstances, the practical question is not without difficulty how far the Byzantine Greek pronunciation should be acknowledged by those nations who, like the Scotch, have the happiness to use a pronunciation of the vowels and diphthongs, on the whole exhibiting a pretty fair approximation to what can be certainly known about the true pronunciation of Greek in the palmy days of Attic eloquence. It is certain, for instance—or at least extremely likely, for the modern Greeks show sturdy fight on this point—that the Scottish pronunciation of η, as a prolonged *e*, like the long English *a* in *mate*, is classical, while the English and Byzantine pronunciation of that vowel as a long *i* is fundamentally false. Nevertheless, I lean to the opinion recently announced by the French Academy, that the Byzantine pronunciation, notwithstanding some obvious defects, should be accepted as a general basis for the pronunciation of the vowels and diphthongs by all European scholars; and that for these four reasons:—(1.) It is not a modern innovation, but a historical fact of nearly two thousand years' duration in its main points, and must be known to the student of early manuscripts, as the only true key to a whole class of blunders made by the early transcribers. (2.) Though a corruption in some points, it is a characteristic corruption, and, in fact, only the development of a marked national tendency—a tendency well known to Quintilian, as is evident from the contrast drawn by him between Latin and Greek in the words:—*Quamquam iis major est gracilitas, nos tamen sumus fortiores.* (3.) If adopted, it would form a uniform basis of mutual understanding between all persons, whether scholars or native Greeks, who may use the Greek language; and no other uniform basis is at present possible. (4.) It would tend to keep up a friendly feeling between professional scholars and the living Greek people—a feeling by no means a matter of indifference either to the peace of Europe, or to the growth of a scientific philology.

VIII. But though I willingly follow the French Academicians in assuming the Byzantine pronunciation as the only sure historical basis for the pronunciation of Greek among European scholars, I claim the liberty of making one or two deviations from that traditional norm in the special case of its application to ancient poetry. In this region the mere luxury of sound must always be a legislative element; and as, in reading Chaucer, an English scholar of the present day, if he would enjoy the poetical rhythm, necessarily departs in some points from the pronunciation suitable for the recitation of Tennyson or even Shakspeare, so, in reading Homer, if I depart so far from the Byzantine basis as to pronounce *οι* with the full vocalism heard in our English word *joy*, rather than with the attenuated sound of the modern Greek itacism, I am only using what every intelligent Greek will consider a most legitimate liberty in the circumstances. For though I may have no means of knowing how Homer enunciated his well-known *πολύφλοίσβοιο*, I am sure that in the early stage of a language used by such a hardy and vigorous people as the Greeks the extreme *gracilitas* of the modern itacism could not have been a dominating characteristic: rather it seems impossible that the pronunciation of any human language should have remained absolutely without change for a period of nearly 3000 years.

IX. But the sound of the vowels and diphthongs, however important, is only one element in the proper pronunciation. Accent and quantity—that is, pitch, emphasis, and duration of syllabic sound—are matters of no less consequence, and form a no less significant feature in the physiognomy, so to speak, of each particular form of human speech. With regard to quantity, I remark simply that the practice so common among classical teachers, both in England and Scotland, of allowing short syllables to be pronounced long and long short, except in penultimate syllables, is worthy of all reprobation; nor is there the slightest scientific foundation for the practice recently introduced into some English academies of pronouncing the long vowel, as in māter, with a decidedly different quality from the same vowel when short, as in păter. The long vowel is merely a prolongation of the identical sound heard in the short vowel, as in *jŏb*, *Jōb*, and many familiar English examples. With regard to accent, it is quite certain that both the English and Scottish scholars are altogether wrong; and that the living practice of the Greeks in this matter is the only one that harmonises at once with historical tradition, and with the conclusions of philological science. That the classical Greeks pronounced their language with an exact observance of the accent is a point on which the ancient grammarians are quite decided: they all assume that certain determinate accents are as much the law of living Greek utterance generally as certain quantities are the law of rhythmical composition. Neither do they leave us in the slightest doubt as to what the nature of accent really is. The name *acute* ὀξύς given to the ruling accent plainly marks an elevation of the pitch of the voice on a certain syllable, and the words ἐπίτασις and ἄνεσις technically applied to the acute and grave accents, meaning *tension*, *stress*, or *strain*, and *relaxation* or *remission*, plainly point out the element of emphasis, which gives one syllable of a word a marked preponderance to the ear above the rest. The whole doctrine of enclitics also marks emphasis or stress as an essential element of the Greek accent; and the accented verses of the Byzantine popular poetry and the pronunciation of the modern Greeks all drive us to the same conclusion, which only obstinate prejudice, ignorant conceit, or stolid stupidity can resist. This conclusion is that when Olympian Pericles thundered against Spartan insolence, and Demosthenes against Macedonian aggression, they emphasised the thunderbolts of their speech in the same manner that Greek words are now emphasised by an orator in the modern Greek Parliament, or a muleteer on the ridge of the modern Greek Parnassus.

X. The practice by which the British school of Greek scholars has hitherto been distinguished, of pronouncing Greek by the laws of Latin accentuation, transmitted to us through the Roman Catholic Church, while at the same time the real Greek accents are carefully marked on every printed page, and taught minutely as a matter of learned indoctrination, is one of the most curious instances of combined carelessness and perversity in the whole history of learning. Had the Greek accents not been marked so curiously on every Greek word in every page of printed Greek for the last four centuries, some excuse might have been found for a practice, for which the *vis inertiæ* of human nature and the Latinised habitude of academic ears so powerfully plead; but as the matter now stands, the persistence in a perverse practice, refuted by every fact in historical tradition, and every argument in philological science, stands as a staring absurdity alone in the annals of scholastic life. The aversion which the English scholars generally have to acknowledging the truth in this matter appears to me to have its origin partly in a gross habit of ear, which renders them unable to appreciate certain musical and elocutional distinctions which underlie the subject, partly in a sort of unreasoning conservatism, which is the backbone of their whole scholastic and academic system, partly also, and principally, perhaps, from a vague imagination they entertain that the spoken accent of Greek prose has something to do with the rhythmical recitation of Greek verse. Now, it is quite certain that, however distinct the accented syllable was in Greek oratory, in the composition of Greek verse the duration of the vowel sounds was the only element necessarily taken into account, while the spoken accent was either silent altogether or heard with a marked subordination to the accent of the rhythm. And, as a matter of educational practice, nothing is more easy for a boy who has an ear—and he who has none need never read verse—to pass from the accented pronunciation of prose to the quantitative mensuration of poetry without confusion. Even the daily practice of our schools teaches that a boy cannot read a single distich of Ovid rhythmically without putting a stress on the last syllable of the final dissyllable, which is quite contrary to the natural accent of the same word when pronounced in prose.

XI. In conclusion, I have to observe that the pronunciation of all Greek words indiscriminately according to the monotonous Latin accentuation, is merely a part of an entirely false method of teaching prevalent in the great English schools, according to which dead rules are substituted for living functions, and doctrines about sounds for the sounds themselves. Whosoever as a teacher of languages has seized on the great principle that the ear is the special organ used by nature in acquiring a knowledge of articulate sounds, will never commit the mistake of pronouncing ἔλεος, the divine attribute of mercy, with the same intonation that marks ἐλεός, a *wooden block for washing mince-collops.* The Greek language contains whole columns of such words, which the man who pronounces Greek according to Latin accents must pervert and turn into nonsense. To teach any language with false accents and false quantities, and yet to inculcate rules about true accents and true quantities, is to declare the schoolmaster wiser than the Creator, and to insist on doing by a forced and painful process of memory what nature is willing to do for us by the pleasant habituation of the ear.

2. Note on Action. By Professor Tait.

The quantity represented by $\int vds$, or its equivalent $\int v^2dt$, in any case of the motion of a particle, is known to possess important dynamical relations. The accidental discovery of a singularly simple geometrical representation of this quantity in the case of planetary motion led me to inquire whether the method involved might not be easily generalized. This note contains a sketch of some of the results of a hurried investigation of the point.

Graphical representations of the action in some common cases of motion readily suggest themselves.

Thus, in the case of the parabolic trajectory of an unresisted projectile, the action through any arc of the path is proportional to the area included between that arc, the directrix, and two ordinates parallel to the axis; while the time is, of course, represented by the intercept on the directrix.

Again, in the case of the ordinary brachistochrone (the cycloid with its vertex downwards), the action and the time, corresponding to any arc from the cusp, are respectively proportional to the area and the arc of the corresponding segment of the generating circle.

Numerous other simple cases might be given, but these are sufficient to show that such representations depend mainly upon the particular nature of the path, and therefore cannot be included in any general formula. But the example which follows appeared to point out some such general method; applicable at least to central orbits.

In an elliptic orbit described about the focus, the time is proportional to the sectorial area described about one focus, and the action to that about the other.—The proof of this theorem is obvious, if we remember that the product of the perpendiculars, from the foci, upon the tangent to an ellipse, is constant.

This appeared to me to indicate, as a mode of representing the action in a central orbit, the seeking for a curve allied to the orbit, and in its plane; such that, if two tangents be drawn to it, the area intercepted between them, the curve, and the orbit, shall be proportional to the action. In the case of the elliptic orbit, above referred to, this curve would evidently become a point, viz., the second focus. The following investigation, however, does not give a very encouraging result:—

Taking the centre of force as origin, let x, y, be the co-ordinates of a point in the orbit, ξ, η, those of the corresponding point in the allied curve. The equation of the tangent at x, y, is

$$(x-x')\frac{dy}{ds}-(y-y')\frac{dx}{ds}=0;$$

and, consequently, the lengths of the perpendiculars drawn to it from the origin, and from the point ξ, η, are

$$p=x\frac{dy}{ds}-y\frac{dx}{ds},$$

and
$$p'=(x-\xi)\frac{dy}{ds}-(y-\eta)\frac{dx}{ds},$$

respectively. That the elementary triangle, whose vertex is ξ, η, and whose base is δs, may be proportional to the element of the action, we must evidently (as we see by referring to the case of the ellipse above) have

$$pp'=\text{constant}.$$

Hence our first condition is

$$\left(x\frac{dy}{ds}-y\frac{dx}{ds}\right)\left((x-\xi)\frac{dy}{ds}-(y-\eta)\frac{dx}{ds}\right)=a^2,$$

or, in a somewhat more convenient form,

$$\eta \frac{dx}{ds} - \xi \frac{dy}{ds} = -p + \frac{a^2}{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

Also, by the nature of the construction we are attempting, it is obvious that the line joining the points x, y, and ξ, η, must be a tangent to the locus of ξ, η. This gives us at once the second condition

$$\frac{d\eta}{d\xi} = \frac{\eta - y}{\xi - x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

Since, by the equation of the central orbit, which is supposed to be known, we have x and y in terms of s, we may take s as independent variable, and we have the equations (1) and (2) necessary and sufficient for the determination of ξ and η in terms of s.

Eliminating η by differentiation and substitution, we find for ξ the equation

$$\frac{a^2}{p}\frac{dx}{ds}\frac{d\xi}{ds} = (\xi - x)\left\{ (\xi - x)\left(\frac{dx}{ds}\frac{d^2y}{ds^2} - \frac{dy}{ds}\frac{d^2x}{ds^2}\right) - \frac{a^2}{p^2}\left[x\left(\frac{dx}{ds}\frac{d^2y}{ds^2} + \frac{dy}{ds}\frac{d^2x}{ds^2}\right) - 2y\frac{dx}{ds}\frac{d^2x}{ds^2}\right]\right\}$$

with, of course, a similar equation for η.

If we take x as the independent variable, and put

$$Y = \frac{a^2\left(1 + \left(\frac{dy}{dx}\right)^2\right)}{x\frac{dy}{dx} - y}, \text{ a } \textit{given} \text{ function of } x,$$

it is easy to reduce this equation to

$$\frac{d}{dx}\left(\frac{Y}{x - \xi}\right) + \frac{Y}{(x - \xi)^2} = \frac{d^2y}{dx^2},$$

which seems to be the simplest form to which it can be brought, unless special relations between x and y are introduced, and without such it seems to be quite intractable.

The remainder of the paper refers to a subject which, though allied to action, is so distinct from the investigation above that I give the following abstract of it under a distinct title.

3. On the Application of Hamilton's Characteristic Function to Special Cases of Constraint. By Professor Tait.

Hamilton's beautiful theory of Varying Action reduces to the discovery of a single function any problem connected with motion under the action of a conservative system of forces, and with constraint by any system of smooth fixed surfaces.

It does not appear to have been applied to cases (such as the brachistochrone) in which the requisite constraint is the thing to be determined.

Taking $\tau = \int \frac{ds}{v}$, the *time* in the brachistochrone, it is shown that we have, τ being regarded as a function of x, y, z,

$$\left(\frac{d\tau}{dx}\right)^2 + \left(\frac{d\tau}{dy}\right)^2 + \left(\frac{d\tau}{dz}\right)^2 = \frac{1}{v^2} = \frac{1}{2(H - V)},$$

where H is the whole energy, and V the potential of the given system of forces. If a complete integral of this equation can be found, we have

$$\frac{dx}{dt} = 2(H - V)\frac{d\tau}{dx}, \text{ \&c.}$$

Also, if α, β, be constants in the expression for τ,

$$\frac{d\tau}{d\alpha} = \mathfrak{A}, \frac{d\tau}{d\beta} = \mathfrak{B},$$

where $\mathfrak{A}$ and $\mathfrak{B}$ are two new constants, are the equations of the brachistochrone.

Various properties of brachistochrones, and the corresponding free paths, are deduced from these equations; the connection between this process and that of Hamilton is illustrated by the solution of problems in optics, based on the corpuscular and on the undulatory theories; and the paper concludes with an application of the principle to cases in which the characteristic function is of such forms as

$$\int f(v)\, ds \qquad \text{or} \qquad \int F(x,y,z) f(v)\, ds$$

where f and F are given functions.

4. On Transversals. By the Rev. Hugh Martin, Free Greyfriars.

This paper contains upwards of seventy theorems, in great part new, with reference to the intersection of systems of lines. The demonstrations are based upon determinants.

5 On the Motion of a Heavy Body along the circumference of a Circle. By Edward Sang.

This paper contains a demonstration of the theorem given in the fourth volume of the proceedings at p. 419.

The theorem in question was arrived at by the comparison of the well-known formula for the time of descent in a circular arc, with another formula given in the "Edinburgh Philosophical Magazine" for November 1828, by a writer under the signature T. W. L. Each of these series is reached by a long train of transformations, developments, and integrations, which require great familiarity with the most advanced branches of the higher calculus. Yet the theorem which results from their comparison has an aspect of extreme simplicity, and seems as if it could be reached by an easier road. A search for this easier road has led to the discovery of a few simple propositions, which contain the whole theory of motion in a circle, and which only require for their examination a knowledge of the fundamental law of dynamics, and an acquaintance with trigonometry.

There are two distinct cases of motion in a circle, viz., one in which the heavy body describes with a varying velocity the whole circumference; the other in which the motion is oscillatory, as in the example of a pendulum. The first step of the investigation is to establish a relation between a continuous and an oscillatory motion, such that their periodic times bear a certain ratio to each other. To these two motions the name *conjugate* is given. By means of this relation the problem, "to compute the time of revolution" in the case of continuous motion, can be converted into another problem, "to find the descent in a circular arc," and contrariwise.

The second step is to deduce from this pair of conjugate motions a second pair of motions also conjugate to each other, and having their periodic times in simple ratios to those of the preceding pair.

The third step is to form a progression of pairs of conjugate motions deduced successively one from another. In this progression, carried in the direction inverse to that just mentioned, the motions approach with extreme rapidity, on the one hand to a uniform circular motion, on the other hand to the oscillation in an exceedingly minute arc.

As a practical result of the whole, it is shown that, for all cases of clock motions, and for experiments to determine the length of the seconds pendulum, the time of oscillation may be held to be proportional to the square of the secant of the eighth part of the whole arc described; the number of oscillations per day to be proportional to the square of the cosine of the same eighth part; and the daily retardation to the square of the sine.

6. On the Action of Hydriodic Acid on Mandelic Acid. By Alex. Crum Brown, M.D., D.Sc.

The relation of mandelic acid to benzoic aldehyd is so precisely the same as that of lactic acid to acetic aldehyd, that whatever constitution we assume for the latter acid, a similar one must be ascribed to the former.

The researches of Kolbe and Lautemann, and of Wislicenus, prove that lactic acid is oxypropionic acid. Mandelic acid must therefore be oxytoluic acid, and, indeed, it has been so formulated by Kolbe in his work on Organic Chemistry.

While agreeing with Kolbe and Wislicenus, I prefer, for some purposes, to employ formulæ slightly different from those of either of these chemists.

Thus, using Ξ as a contraction for $\left.\begin{matrix} \\ H\dot{O}\end{matrix}\right\} CO$, the relation of aldehyd, chloride of ethyliden, ethylidenic chlorhydrine, and common lactic acid, may be expressed by the formulæ

$$\left.\begin{matrix}CH_3\\H\end{matrix}\right\}CO, \qquad \left.\begin{matrix}CH_3\\H\end{matrix}\right\}CCl_2, \qquad \left.\begin{matrix}CH_3\\H\end{matrix}\right\}C\left\{\begin{matrix}Cl\\(HO),\end{matrix}\right. \quad \text{and}$$

$$\left.\begin{matrix}CH_3\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\(HO).\end{matrix}\right.$$

It is thus shown *which* of the atoms of hydrogen in propionic acid $\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\} C \left\{\begin{matrix} \Xi \\ H \end{matrix}\right.$ is replaced by the water residue HO to form common lactic acid, and the latter is distinguished from sarcolactic acid

$$\left.\begin{matrix} CH_2(HO) \\ H \end{matrix}\right\} C \left\{\begin{matrix} \Xi \\ H. \end{matrix}\right.$$

Replacing CH_3 in these formulæ by C_6H_5 we get the formulæ of the corresponding substances in the aromatic series.

The complete analogy between lactic and mandelic acids as to the mode of their formation naturally suggests the idea that their decompositions should also be analogous; and yet, considering that no oxyacid of the aromatic series had as yet been directly reduced to the corresponding normal acid, it seemed to me to be of interest to examine the reaction of hydriodic acid on mandelic acid, in order to see whether it follows the analogy of salicylic or of lactic acid, and if the latter, to compare the toluic acid thus produced with the two isomeric acids at present known.

For this purpose, mandelic acid was boiled with concentrated aqueous hydriodic acid and phosphorus in a flask fitted to an ascending Liebig's condenser, so that the vapours of hydriodic acid condensed, and ran back into the flask. Notwithstanding the presence of excess of phosphorus, the liquid immediately became opaque from the separation of a large quantity of free iodine, and the drops of condensed hydriodic acid became milky. After boiling for about half an hour, the reaction was complete, and the iodine was removed by the phosphorus. The clear liquid, while still hot, was decanted from the excess of phosphorus, and on cooling solidified to a crystalline magma. The crystals, when drained and recrystallised once or twice from boiling water, presented the following properties:—

Large extremely thin iridescent plates, closely resembling those of benzoic acid, but without the serrated character of the latter; readily soluble in hot, sparingly in cold water; readily soluble in alcohol, ether, and solutions of the hydrates and carbonates of the alkalies. When treated with boiling water, they at first fuse to a colourless oil denser than water, and subsequently dissolve, and when a hot saturated solution is cooled, the substance is at first deposited in the liquid state.

Both the solution and the crystals have a strong and persistent smell of honey.

When heated, the crystals fuse, and at a higher temperature boil, readily volatilising far below the boiling point.

The fusing point was found to be 76° C., and the boiling point (corrected) 264° C.

Combustion with oxide of copper and oxygen gave the following results :—

I. 0·2422 grm. gave 0·1344 water.

II. 0·2212 grm. gave 0·1297 water and 0·5803 carbonic acid.

Indicating the formula $C_8H_8O_2$.

	Calculated.		Observed. I.	Observed. II.
C_8	96	70·6	...	71·5
H_8	8	5·9	6·2	6·5
O_2	32	23·5	...	...
	136	100·0		

Hydriodic acid, therefore, acts in the same way on mandelic acid as on lactic acid. The reaction probably takes place in two stages, and may be expressed thus :—

$$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\HO\end{matrix}\right.+HI=\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\I\end{matrix}\right.+H_2O$$

$$\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\I\end{matrix}\right.+HI=\left.\begin{matrix}C_6H_5\\H\end{matrix}\right\}C\left\{\begin{matrix}\Xi\\H\end{matrix}\right.+I_2.$$

A lime salt prepared by boiling the acid with powdered Iceland spar crystallised in radiated needles, readily soluble in water. Analysis of the salt dried in *vacuo* over sulphuric acid gave the following results :—

I. 0·0977 grm. lost 0·0101 at 130° C.

II. 0·2459 grm. gave 0·0386 quicklime.

III. 0·2674 grm. gave 0·0419 quicklime.

These results agree with the formula $C_{16}H_{14}CaO_4 + 2H_2O$.

	Calculated.		Observed. I.
$C_{16}H_{14}CaO_4$	310	89·6	89·7
$2H_2O$	36	10·4	10·3
	346	100·0	100·0

	Calculated.		Observed. II.	Observed. III.
C_{16}	192	55·5	...	...
H_{18}	18	5·2	...	...
Ca	40	11·3	10·9	11·18
O_6	96	28·0	...	...
	346	100·0		

The silver salt forms small, indistinct, white scales, soluble in boiling water. The copper salt is a bright green amorphous precipitate. The ferric salt, a pale brown precipitate, exactly like the ferric benzoate.

The acid resists the action of dilute sulphuric acid and bichromate of potash, even when boiled; when heated with strong sulphuric acid and bichromate it is oxidised, and gives off the smell of oil of bitter almonds. Fuming nitric acid readily dissolves the acid when heated, the solution becoming at first red, then colourless, and on cooling, a nitro-acid crystallises out. This nitro-acid forms colourless crystals, which dissolve in solutions of the alkalies with a yellow colour. I am at present engaged in its examination, and hope to obtain from it the corresponding amido- and oxy-acids.

A comparison of the properties of the toluic acid thus prepared from mandelic acid with those of Möller and Strecker's alpha-toluic acid from vulpic acid,* leaves no doubt of their identity. The fusing point of alpha-toluic acid is 76·5, that of the acid from mandelic acid is 76°·0; the former boils at 265°5, the latter at 264°. All the characters of alpha-toluic acid, with the exception of the smell, are so exactly the same as those of the acid from mandelic acid, that there is not a word in Möller and Strecker's description of the former which does not perfectly apply to the latter.

The reduction of mandelic acid to alpha-toluic acid appears to prove, 1*st*, that, notwithstanding its lower fusing point, the latter acid is the true homologue of benzoic acid.†

2*d*, That the reduction of the oxy-acids to the normal acids by the action of hydriodic acid is not peculiar to the fatty series, and

* Ann. Ch. Pharm. cxiii. 56.

† The irregularity in the fusing point is not surprising, considering that benzoic acid is probably the first term in the series, and that a similar irregularity is observed in the case of the lower terms of the series of fatty acids.

probably depends on the "chemical position" of the alcoholic water residue in the molecule.

Recollecting that benzoic aldehyd has been prepared from benzoic acid by Piria and by Chiozza, we see that by three processes, 1*st*, the subtraction of oxygen; 2*d*, the addition of the elements of formic acid; and, 3*d*, the subtraction of oxygen, we have advanced one step in the homologous series of the aromatic acids; and, as far as we can see, there is nothing to prevent the repetition of this step, and the gradual ascent of the series.

With a view to ascertain whether this is possible, I have treated cuminol with hydrocyanic and hydrochloric acids, and the results obtained are sufficient to encourage me to continue the investigation.

7. On the Nature of Antozone. By Alfred R. Catton, B.A., F.R.S.E., Fellow of St John's College, Cambridge, and Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

Many of the properties of ozone are very similar to those of peroxide of hydrogen. Thus ozone, like peroxide of hydrogen, is in many cases a powerful oxidising agent. In other cases, however, it acts as a deoxidiser. Thus ozone deoxidises peroxide of hydrogen and peroxide of barium with the production of water and oxide of barium. Peroxide of hydrogen also deoxidises oxide of silver, the peroxides of manganese and lead, permanganic and chromic acids, &c. Again, ozone is decomposed catalytically by dry silver leaf and by several oxides, such as the peroxides of manganese and lead, &c. Peroxide of hydrogen is also decomposed catalytically by several metals—gold, silver, platinum, and metallic oxides. Ozone liberates iodine from a solution of iodide of potassium. Peroxide of hydrogen does the same by the mere addition of a few drops of protosulphate of iron, the latter undergoing no change during the reaction.

We see then that the general properties of ozone are very similar to those of peroxide of hydrogen. If, however, we examine the properties of these compounds in detail, we find that their particular properties are complementary to each other. In other words, for the particular compounds for which ozone acts as an oxidising agent, peroxide of hydrogen does not act as an oxidising, but in general as a reducing agent. Thus mercury and silver are converted by ozone into oxides. These oxides are reduced to the metallic state by peroxide of hydrogen.

A piece of paper moistened with sulphate of manganese is turned brown by ozone, owing to the formation of peroxide of manganese. The peroxide of manganese thus formed is reduced by peroxide of hydrogen to the state of protoxide. Similarly, by the action of ozone on subacetate of lead paper, peroxide of lead is formed, which is again reduced to protoxide of lead by peroxide of hydrogen.

Peroxide of barium is produced by the action of peroxide of hydrogen on hydrated protoxide of barium. Peroxide of barium is on the contrary reduced by ozone to oxide of barium; the ferrocyanide of potassium is converted by ozone into ferricyanide, which latter is again reduced by peroxide of hydrogen.

This opposition in the characters of ozone and peroxide of hydrogen, indicated by their action on other compounds, is maintained in their action on each other. Though peroxide of hydrogen and ozone are both powerful oxidising agents, by their action on each other two neutral substances are produced, water and ordinary oxygen. These characters naturally suggest the idea that ozone and peroxide of hydrogen are related to each other, much in the same way as acids and bases, which, though both possessed of decided characters, mutually neutralise each other. In other words, that the characters of ozone and peroxide of hydrogen bear to each other that relation which is indicated by the words electro-negative and electro-positive; a conclusion remarkably confirmed by the production of ozone during the electrolysis of an acid liquid at the positive pole, and of peroxide of hydrogen at the negative pole, as shown by Meidinger, thus showing that ozone is to be regarded as an electro-negative compound, and peroxide of hydrogen as an electro-positive compound. And as ozone and peroxide of hydrogen neutralise each other, so to speak, we are led to suppose that they are each formed by the combination of the same number of molecules. We are thus led to assign to ozone the formula OOO (O = 16) as suggested by the equation

$$\overbrace{H_2OO}^{+} + \overbrace{OOO}^{-} = H_2O + 2\,(OO)$$

The signs placed over the bracket merely denoting that H_2OO as a whole is to be considered as an electro-positive compound, and OOO as electro-negative.

This view of the constitution of ozone is due to Professor Odling (Manual of Chemistry, 1861), and the most important argument in its favour is the non-diminution in volume of ozonised oxygen when the ozone is decomposed by iodide of potassium or mercury (*loc. cit.* p. 94).

The existence of antozone has been fully established by the experiments of Schönbein and Meissner.

The latter has shown that when electric discharges are passed through dry oxygen, another substance, antozone, is produced besides ozone. If the latter be destroyed by passing the electrised oxygen through a strong solution of iodide of potassium, antozone remains mixed with ordinary oxygen.

The properties of antozone can thus be observed. One of the most characteristic of these is the formation of a thick white mist when passed into water. This same white mist is also formed when the gas produced by the action of concentrated sulphuric acid on peroxide of barium is passed into water. In the latter case, therefore, antozone is produced, and not ozone (as stated by Houzeau).

Now, on examining the characters of antozone as far as they have hitherto been observed, we find that, instead of being complementary to those of peroxide of hydrogen, as in the case of ozone, they correspond with them very closely. In other words, where peroxide of hydrogen acts as a reducing agent, antozone does so also.

Thus a paper moistened with sulphate of manganese, and coloured brown by ozone, is again decolorised by antozone, owing to the reduction of the peroxide of manganese at first formed to the state of protoxide. Peroxide of manganese is also reduced by peroxide of hydrogen.

Similarly, a paper moistened with subacetate of lead, and discoloured by ozone, is again whitened by antozone, owing to the reduction by the latter of the peroxide of lead first formed to protoxide of lead. Peroxide of lead is also reduced by peroxide of hydrogen.

Similarly, dilute acidulated solutions of bichromate and permanganate of potassium are reduced by antozone. Peroxide of hydrogen also reduces chromic and permanganic acids and their salts.

We are thus led to regard antozone as a compound analogous in constitution to peroxide of hydrogen; in other words, to regard antozone as peroxide of hydrogen, in which the hydrogen is replaced by oxygen, or representing, as before, peroxide of hydrogen by $+(H_2OO)$, antozone is $+(OOO)$, and ozone $-(OOO)$. The $+$ and $-$ signs being merely used to denote the idea that one compound acts as electro-positive and the other as electro-negative.

If we adopt the hypothesis that free oxygen is formed by the combinations of two atoms of oxygen $(0=16)$, one of which acts as an electro-positive and the other as an electro-negative atom, free oxygen is $\overset{+}{O}\,\overset{-}{O}$.

Hence, since free oxygen is produced when ozone is decomposed by mercury, ozone must be either $\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}$ or $\overset{-}{O}\,\overset{-}{O}\,\overset{+}{O}$, in accordance with the equations

$$\overset{+}{Hg_2} + \overset{-}{O}\,\overset{+}{O}\,\overset{-}{O} = \overset{+}{Hg_2}\overset{-}{O} + \overset{+}{O}\,\overset{-}{O}, \text{ or}$$

$$\overset{+}{Hg_2} + \overset{-}{O}\,\overset{-}{O}\,\overset{+}{O} = \overset{+}{Hg_2}\overset{-}{O} + \overset{-}{O}\,\overset{+}{O}.$$

The latter formula is inadmissible, because, as we have shown, ozone acts as an electro-negative compound, which therefore requires that the two outside atoms should both be electro-negative. For $\overset{-}{O}\,\overset{-}{O}\,\overset{+}{O}$ would neither be decidedly electro-negative nor decidedly electro-positive. Hence ozone is $\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}$, which is the view of Professor Odling.

Sir Benjamin Brodie has shown (Phil. Trans. 1850) that the reducing properties of peroxide of hydrogen require us to assign to it the formula $\overset{+}{H_2}\,\overset{-}{O}\,\overset{+}{O}$. Hence antozone is $\overset{+}{O}\,\overset{-}{O}\,\overset{+}{O}$, a formula which indicates that antozone acts as an electro-positive compound. The production of ozone and antozone by the passage of electric sparks, or the silent discharge through dry oxygen, is thus represented by the following equation:—

$$\underbrace{\overset{-}{O}\,\overset{+}{O} + \overset{-}{O}\,\overset{+}{O} + \overset{-}{O}\,\overset{+}{O}}_{\text{Ordinary Oxygen.}} = \underbrace{\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}}_{\text{Ozone.}} + \underbrace{\overset{+}{O}\,\overset{-}{O}\,\overset{+}{O}}_{\text{Antozone.}}.$$

These formulæ indicate hypothetically why antozone combines with water to form peroxide of hydrogen, but not ozone. For, in accordance with the electrical theory of chemical action, the following reaction is perfectly possible :—

Water.		Antozone.		Peroxide of Hydrogen.		Oxygen.
$\overset{+}{H}_2\overset{-}{O}$	$+$	$\overset{+}{O}\overset{-}{O}\overset{+}{O}$	$=$	$\overset{+}{H}_2\overset{-}{O}\overset{+}{O}$	$+$	$\overset{-}{O}\overset{+}{O}$.

Peroxide of hydrogen cannot, however, be formed by the combination of $\overset{+}{H}_2\overset{-}{O}$ and $\overset{-}{O}\overset{+}{O}\overset{-}{O}$.

Again, it gives an explanation of the formation of antozone by the action of oil of vitriol on peroxide of barium. For we may suppose the peroxide of barium to decompose in the following manner :—

$$\overset{+}{Ba}_2\overset{-}{O}\overset{+}{O} = \overset{+}{Ba}_2\overset{-}{O} + \overset{+}{O}.$$

The oxide of barium being formed as sulphate of barium. $\overset{+}{O}$ then combines with some of the ordinary oxygen also given off at the same time with the formation of antozone :—

$$\overset{+}{O}\overset{-}{O} + \overset{+}{O} = \overset{+}{O}\overset{-}{O}\overset{+}{O}.$$

It must not be supposed that by the algebraic signs here used it is intended to denote that the atoms of oxygen preserve any absolute electric state. Although in a compound oxygen may act as $\overset{+}{O}$, we must guard against imagining that in any chemical action $\overset{+}{O}$ cannot be transformed even with the greatest facility into $\overset{-}{O}$. The fact of the production of free oxygen in the action just referred to shows that such is the case. Sulphuric acid is a highly electro-negative compound, and we can easily understand how the positive electricity of $\overset{+}{O}$ is neutralised by the sulphuric acid, and how $\overset{+}{O}$ is even changed into $\overset{-}{O}$.

Again, by the action of heat on peroxide of hydrogen, it is decomposed into water and ordinary oxygen. We must here suppose that the peroxide decomposes thus—

$$\overset{+}{H}_2\overset{-}{O}\overset{+}{O} = \overset{+}{H}_2\overset{-}{O} + \overset{+}{O},$$

and that half of the $\overset{+}{O}$ is changed by heat into $\overset{-}{O}$ in order to form inactive oxygen $\overset{+}{O}\,\overset{-}{O}$. This supposition is also necessary in order to explain the conversion of ozone and antozone by heat into ordinary oxygen.

It is probable that the protosulphate of iron in the method of testing for peroxide of hydrogen exerts a similar action. Having a strong affinity for oxygen, it decomposes the peroxide into $\overset{+}{H}_2\,\overset{-}{O}$ and $\overset{+}{O}$, and at the same time converts the latter into $\overset{-}{O}$, which then decomposes the iodide of potassium thus:—

$$\overset{+}{K}_2\,\overset{-}{I}_2 \;+\; \overset{-}{O} \;=\; \overset{+}{K}_2\,\overset{-}{O} \;+\; I_2.$$

This last reaction being similar to that of the decomposition of iodide of potassium by ozone:—

$$\overset{+}{K}_2\,\overset{-}{I}_2 \;+\; \overset{-}{O}\,\overset{+}{O}\,\overset{-}{O} \;=\; \overset{+}{K}_2\,\overset{-}{O} \;+\; \overset{+}{O}\,\overset{-}{O} \;+\; I_2.$$

The production of antozone by the action of sulphuric acid on peroxide of barium is perfectly analogous to the formation of peroxide of hydrogen by the action of carbonic dioxide on peroxide of barium, thus—

$$\overset{+}{Ba}_2\,\overset{-}{O}\,\overset{+}{O} \;+\; C\,O_2 \;=\; \underset{\text{Carbonate of Barium.}}{Ba_2\,O\,C.O_2} \;+\; \overset{+}{O}$$

$$\overset{+}{H}_2\,\overset{-}{O} \;+\; \overset{+}{O} \;=\; \underset{\text{Peroxide of Hydrogen.}}{\overset{+}{H}_2\,\overset{-}{O}\,\overset{+}{O}}.$$

It might be supposed, from these views of the constitution of ozone and antozone, that when in contact they ought to combine with each other to produce ordinary oxygen. There is, however, no more reason that this should be the case than that an electro-positive element like hydrogen should combine with oxygen, which is electro-negative, when mixed with each other. As in the case of hydrogen and oxygen, however, it is possible that ozone and antozone may combine to form ordinary oxygen by the passage of the electric spark. The increase in volume of electrised oxygen by the passage of the spark from a Rühmkorff's coil, may possibly be partially due to this cause, although no doubt owing in great measure to the decomposition of some of the ozone and antozone by heat.

On the contrary, antozone appears, from the experiments of Meissner, to be more stable in the presence of ozone than when mixed with ordinary oxygen.

The following fact may possibly be considered analogous. An aqueous solution of peroxide of hydrogen (an electro-positive compound) is rendered more stable by the addition of an acid, an electro-negative compound, but less stable by the addition of alkalies.

Also, since oxygen is essentially an electro-negative element, we can easily understand why antozone, which we may look upon as containing electro-positive oxygen, gradually decomposes, and is changed into ordinary oxygen, as observed by Meissner. And we can, on the contrary, understand why ozone is a comparatively stable compound.

Schönbein has shown that peroxide of hydrogen is produced in many cases of slow oxidation occurring in the presence of moisture. This is commonly attributed to the formation of antozone, which subsequently combines with water to form peroxide of hydrogen. In the author's view, however, the peroxide of hydrogen is the immediate product of the reaction.

In the oxidation of zinc, for instance,

$$\overset{+}{Zn_2} + \overset{-}{O}\overset{+}{O} + \overset{-}{O}\overset{+}{H_2} = \overset{+}{Zn_2}\overset{-}{O} + \overset{+}{O}\overset{-}{O}\overset{+}{H_2}.$$

Supposing that this view of the constitution of antozone is confirmed by further investigation, it will afford a strong support to the theory that the elements in the free state are formed by the combination of two atoms in opposite electrical states, as well as of the electrical theory of chemical affinity.

Some persons find great difficulty in the supposition that oxygen can combine with itself to form compounds differing entirely in properties from ordinary oxygen. There is, however, in reality no greater difficulty in this supposition than in other admitted cases where a compound combines with itself to form other compounds. Methylene, for instance, when liberated from iodide of methylene by the action of copper and water, combines with itself to form ethylene and tritylene, as shown by M. Boutlerow. Tritylene, in fact, bears to ethylene a somewhat similar relation to that which ozone and antozone bear to oxygen. Again, oxygen, in the language of modern chemistry, is a polyatomic element; and it is a well-known fact that polyatomic compounds have a great tendency to combine with themselves to produce others of greater complexity.

There is, therefore, *à priori*, nothing improbable in the supposition that oxygen may, under proper conditions, combine with itself; but, on the contrary, the analogies of science are in favour of such a supposition.

It may be well here to repeat, that the author's view of the constitution of antozone freed from all hypothesis as to the electric states of molecules is, that antozone is peroxide of hydrogen, in which the hydrogen is replaced by oxygen.

The following Donations to the Library were announced:—

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland. February 1865. 8vo.—*From the Registrar-General.*

The Canadian Journal of Industry, Science, and Art. January 1865. Toronto. 8vo.—*From the Editors.*

Die Fortschritte der Physik im Jahre 1862 Dargestillt von der physikalischen Gesellschaft zu Berlin. XVIII. Jahrgang. I. and II. Abtheilung. Berlin, 1864. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, London. Vol. XXV. No. 4. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XIV. No. 72. 8vo.—*From the Society.*

On the Laurentian Rocks of Britain, Bavaria, and Bohemia. By Sir Roderick I. Murchison, K.C.B., F.R.S. 8vo.—*From the Author.*

On the Origin of the Alpine Lakes and Valleys : A Letter addressed to Sir R. I. Murchison. By M. Alphonse Favre. 8vo.—*From Sir R. I. Murchison.*

Proceedings of the Royal Horticultural Society, London. Vol. V. No. 3. 8vo.—*From the Society.*

On the Utilisation of Sewage, with a Description of the Plan of Messrs Napier and Hope for the Utilisation of the Sewage of London. By George Robertson, C.E., F.R.S.E., &c. 8vo.—*From the Author.*

Annuaire de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique, 1865. Brussels. 8vo.—*From the Academy.*

Bulletin de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique. No. 1, 1865. Brussels. 8vo.—*From the Academy.*

Nyt Magazin for Naturvidenskaberne—udgives af den Physiographiske Forening i Christiania. Hefte 1, 2, 3. Christiania, 1864. 8vo.—*From the University of Christiania.*

Meteorologische Beobachtungen—Aufgezeichnet auf Christiania's Observatorium. III. and IV. Leiferung, 1848—1855. Christiania, 1864. 4to.—*From the same.*

Om de Gologiske Forbold paa Kyststrækningen af Norde Bergenhus Amt, af M. Irgens og Th. Hiortdahl. Christiania, 1864. 4to. —*From the Authors.*

Om Sneebræen Folgefon, af S. A. Sexe. Christiania, 1864. 4to. —*From the Author.*

Forhandlinger i Videnskabs—Selskabet i Christiania, Aar 1863. Christiania, 1864. 8vo.—*From the University of Christiania.*

Chemisk Udersogelse af Mergeller og deri indeholdte Boleer af Th. Hiortdahl. Christiania. 8vo.—*From the Author.*

Om det Syphilitiske Virus, af L. Bidenkap. Christiania, 1863. 8vo. —*From the Author.*

Biblical Natural Science, being the Explanation of all References in Holy Scripture, in Geology, Botany, Zoology, and Physical Geography. By the Rev. John Duns, D.D., F.R.S.E. Two vols. large 8vo.—*From the Author.*

Monday, 3d April 1865.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Food of the Royal Engineers stationed at Chatham. By Dr Lyon Playfair.

The value of the food of soldiers is an important subject, because it presents us with the results of a long experience in feeding adult men, so as to preserve them in health and strength.

In this country fixed rations of $\frac{3}{4}$ lb. meat and 1 lb. of bread are issued to the soldiers, and the rest of their food is furnished from their own pay. The average diet of soldiers in peace and war is as follows, in ounces and tenths of an ounce :—

		In Peace.	In War.
Flesh formers,		4·2	5·4
Heat givers,	Fat,	1·8	2·4
	Starch, &c.	18·7	17·9
Starch equivalent of heat givers,		22·1	23·5
Total carbon,		12·0	12·7

The peace diet has been obtained by discussions of the food given to the English, French, Prussian, and Austrian armies; while the war diet, in addition to these, includes the Russian, Dutch, Federal States, and Confederates States' armies. Our own country is the only one which does not possess a special war diet, and the want of it told in the frightful mortality of the Crimea. During the latter part of the Russian war, the rations to the English soldiers were increased; but the diet of the English army when engaged in the arduous work of war is, according to the author of the paper, unworthy of the country—twenty years behind the state of science, and a hundred years behind the experience of other nations. To ascertain what well-paid soldiers, engaged in occupations which would represent moderate war work, found it necessary to eat, Dr Playfair obtained returns from the garrison at Chatham. As is well known, the Sappers and Miners are men versed in trades with which they are occupied when not working at fortifications, or in the field. With the permission of Col. Harness, Col. Collinson undertook this inquiry, and obtained the exact food consumed by 495 men for twelve consecutive days. The reduction of these carefully prepared returns is as follows, in ounces and tenths of an ounce :—

Flesh formers,	5·1	Starch equivalent of heat givers,	29·4
Fat,	2·9		
Starch, &c.,	22·2	Total carbon,	14·8

It will be seen that this dietary resembles much the war dietary, except that as potatoes are largely used in garrison, the starch, and consequently the carbon, is increased. The author concludes that a war diet should have as a *minimum* a supply of 5½ ounces of flesh formers in the food. This quantity is necessary to enable them to march fourteen miles daily, with 60 lbs. weight of accoutrements, without living upon their own tissues to obtain the necessary force.

2. Notice of a large Calcareous Stalagmite brought from the Island of Bermuda in the year 1819, and now in the College of Edinburgh. By David Milne Home, Esq., of Wedderburn.

The author stated that this stalagmite was a calcareous deposit of a columnar shape, which had been brought to Edinburgh, about forty-six years ago, by his father, the late Admiral Sir David Milne.

Whilst commander-in-chief on the North American and West Indian Station during the three years ending 1819, Sir David had passed a part of every winter in the genial climate of Bermuda. He took much interest in the various objects of natural history abounding in the island, and particularly in its remarkable caves.

Possessing some knowledge of geology, and being a personal friend of the late Professor Jameson of the University of Edinburgh, who was then collecting specimens from all quarters for a Museum, Sir David resolved, on the expiry of his command, to bring home with him, besides madrepores and other marine productions, some of the beautiful calcareous deposits from the caves, and present them to the Museum.

These calcareous deposits consist—1*st*, Of crusts of crystallised matter coating the floor, sides, and roof of the caves; 2*d*, Of icicle-shaped formations attached to and pendant from the roof; 3*d*, Of columnar-looking deposits resting on the floor, with broad rounded tops.

These various deposits are formed in the usual way, by water highly charged with lime;—the lime being held in solution by carbonic acid gas contained in the water, and on the escape of that gas, as the water evaporates, the lime is precipitated.

All the requisites for these deposits abound in Bermuda. The rocks of the island (of which a specimen was exhibited) are entirely calcareous, being composed of comminuted fragments of sea-shells and zoophytes. The amount of rain which falls annually on the island, and which percolates through the rocks, is very considerable,—whilst the heat of the climate is great; and there are frequently strong parching winds, which promote evaporation.

The different forms of the stalactite deposits are believed to be formed in the following manner:—When the water, after percolating the limestone rock, reaches the roof of the cave, and in such quantity as to drop copiously and rapidly, the evaporation takes place, both during the falling of the water to the floor of the cave and after it reaches the floor. In that case the calcareous matter accumulates on the floor, and if the water continues to drop long enough from the same part of the roof, the deposit gradually rises up in a columnar form. These are the *Stalagmites.*

If, however, the water is less abundant, and the drops less frequent, evaporation takes place whilst they are adhering to the roof. In that case the drops of water thicken on the roof itself into a calcareous paste, and icicle-looking deposits are formed. These are the *Stalactites.*

The two forms of deposit were indicated on a sketch exhibited, and were illustrated by specimens on the table, which Professor Allman had allowed to be brought over from the College Museum.

Much larger specimens, however, of both kinds, had been brought to the Museum,—one of these, a stalagmite, about 6 feet high, now at the door of the Museum. Another, to be more particularly described, was too ponderous to be placed there; it had always lain in the vestibule of the Mathematical Class-Room.

Its length is, ...	11	feet	3	inches.
,, average diameter at the base, .	2	,,	1	,,
,, girth half-way between base and top,	7	,,	4	,,

Supposing that there are 44 cubic feet of stone in this stalagmite, and that each cubic foot weighs 170 lbs., the weight would be nearly $3\frac{1}{2}$ tons.

The cave from which this stalagmite was taken is situated at Walsingham, in the parish of Hamilton, and upon the side of a hill, about 40 or 50 feet above the sea, and a quarter of a mile distant from it. The author remembered the cave well, having, with his brother, been in Bermuda with Sir David Milne during his command.

The cave inside might be about 25 or 30 feet high at the greatest height of the roof, about 50 or 60 yards in length, and 20 to 30 yards in breadth. But it is quite irregular in shape. It contains an immense number of both stalactites and stalagmites of all sizes. Some of the latter had grown up so high as to have reached the roof and become supports to it, and were from 30 to 40 feet in girth.

At the bottom or lowest part of the cave there is a large and deep pool of salt water, rising and falling with the tides,—proving a connection with the sea.

The entrance of this cave is narrow, and about 8 feet high. The floor descends rapidly and irregularly. At the distance of 25 or 30 yards from the mouth stood the stalagmite which forms the subject of the present notice. At this place the floor slopes downwards, and the roof is about 15 feet above the floor, so that the stalagmite had grown up high enough to nearly reach the roof.

This stalagmite, the author's father caused to be sawn across near its point of attachment to the floor. It was first sawn half across, and a nick made with the saw on the opposite side; it was then pulled over, so as to cause fracture, the column having been previously secured by strong tackling and shears to prevent it falling over altogether.

The author's brother, Rear-Admiral Sir Alexander Milne, having been commander-in-chief for the last four years on the North American Station, he also, as their father had done, spent the winter at Bermuda, and when there, paid one or two visits to the cave from which the stalagmite had been taken. He had no difficulty in recognising the trunk, by the evident appearance of its having been sawn across; and he was at once struck by observing that it was again growing, by the accumulation of fresh calcareous matter. It occurred to him that it might be interesting to measure, as exactly as possible, the quantity deposited during the forty-four years which had elapsed since the stalagmite had been removed. With that view he made the following observations:—

He noticed five drops of water falling on the trunk,—two at the rate, each of them, of three or four drops in the minute. The other three dropped much less frequently.

On the part of the trunk where the two first-mentioned drops were falling, two small knobs of calcareous matter had been formed.

On the part of the trunk where the three last-mentioned drops were falling, the deposit consisted of only a thin crust.

One of the knobs measured in height above the fractured surface five-eighths of an inch, and had at its base an area of about $3\frac{3}{4}$ inches in diameter. The other knob measured in height four-tenths of an inch, and had at its base an area of about $2\frac{1}{4}$ inches.

Supposing these knobs to be exact cones, there would be 2·3 cubic inches in the former, and ·53 cubic inches in the latter,—making altogether 2·83 cubic inches. But as the tops were rounded, one-third should be added to this result,—making altogether 3·77 cubic inches. With regard to the amount of matter deposited by the three remaining drops, it was scarcely appreciable, so that the cubic contents of the whole deposit may be very safely assumed as not having exceeded five cubic inches.

Such having been the amount of growth of the stalagmite during forty-four years, it occurred to inquire how long, at the same rate of growth, it had taken for the whole stalagmite to be formed. In the part of it now at the College, to say nothing of the contents of the trunk still in the cave, there are 44 cubic feet, or above 76,000 cubic inches. If this amount of calcareous matter had been deposited at the same rate as the 5 cubic inches during the last forty-four years, the whole stalagmite would have required the astounding and incredible period of more than 600,000 years for its formation.

There are several circumstances, however, deserving of notice, which show how little such a calculation is to be relied on,—though at first sight it is perhaps quite as plausible as many other calculations of a similar kind.

It assumes that during the whole time of the formation of the stalagmite, the calcareous matter had been deposited at exactly the same rate as during the last half-century; in other words, that the supply of calcareous water to this part of the roof had been always exactly the same. There is, however, nothing to prove that this was the case;—it is, moreover, not in the least likely to be true. Indeed, the great probability is, that the supply of water to any one spot in the roof would be much greater at first than afterwards. The porous limestone rock of Bermuda becomes hardened and encrusted by the rain-water percolating through or over it, and the rapidity of this process was marvellous. Lieut. Nelson of the Engineers,* when he was superintending the excavations in Bermuda for the dockyard, found the eggs and bones of a sea-fowl, one of the existing species which lays its eggs in crevices of the rocks, entombed in the coarse limestone rock. The poor bird, whilst sitting on its nest, had been caught by some storm of sand which filled up the crevice, and the prisoner, with its eggs, became petrified and encased in the rock. Many examples of the same kind had come to Lieut. Nelson's knowledge. He found a canister-shot and a gold knee-buckle similarly fossilised. Wherever the limestone rock has been exposed to the weather, it gets encrusted with crystallised stalagtitic matter, so that in any place where a hollow or trough occurs on the surface of the rock, water falling or flowing into it, stands. In these circumstances it is not difficult to see how water, filtering at first through to the roof of a cave, might, in the course of time, have its course diverted from the spot where it used to drop abundantly, or at all events, how it should diminish in quantity. It is therefore reasonable to infer, that in the early history of the caves, the water flowed through the roofs much more copiously than afterwards. The cracks and interstices in the porous rock would become gradually filled up, so as to cut off or curtail the flow of water, and consequently lessen the supply of calcareous precipitate.

On these grounds the author entirely repudiated the notion that this stalagmite had taken the enormous period to grow, indicated by the foregoing calculation,—though what period it actually did take, there were no data to determine.

In concluding, the author referred to the probable origin of these caves. He considered that they had originally consisted of great masses of loose sand which had become enveloped in compact limestone. Lieut. Nelson, in his paper describing the excavations for the dockyard, mentioned that "the irregular density of the rock is exhibited on all scales, from minute flaws and patches, to *large masses of dry sand*, which more than once occurred during the progress of our excavations in the heart of otherwise hard, sound rock." He says that these beds of dry sand lay just above the level of high water, and were "covered by cliffs of good rock sometimes

* Geological Society Transactions for 1837, vol. v.

50 *feet high.*" The extent to which shelly sand was thrown up by the waves on the shores of the island, and then blown by the S.W. winds, so as actually to form hills of 180 feet in height, had been described by Lieut. Nelson, and the author himself distinctly remembers them, along the south side of the island. It seemed probable that the rain-water, containing as it does a certain amount of carbonic acid gas, had, by percolating through the sand-dunes in ancient times, hardened and consolidated the calcareous sand, down to a certain depth, into solid rock; and this result would be all the more likely if, at a former period of the earth's history, as many geologists supposed, the earth's atmosphere then contained a larger proportion of carbonic acid gas. The compact limestone rock having been formed in this way, enclosing and lying above huge masses of sand, it was suggested that in the course of time the sand had been undermined and washed out by the action of the sea. It was understood that every one of the Bermuda caves are at or near the sea-level, and have pools of salt-water in them.

3. Meteorological Observations on Storms of Wind in October, November, and December of 1863. By Alexander Buchan, M.A., Secretary to the Scottish Meteorological Society.

The author had traced eleven distinct storms of wind passing over parts of Europe, between the 26th October and 18th December. With the view of ascertaining the state of the atmosphere during the progress of these storms, in respect of pressure, temperature, wind, cloud, and rain, he had collected observations from all parts of Great Britain and Ireland, as well as from many places on the Continent. He found that each storm was marked by concentric circles of equal atmospheric pressure. Generally, the point of greatest barometric depression was 28·5 inches, round which, as a centre, the isobarometric lines could be traced up to 30 inches.

These isobarometric lines, especially when near the central area of minimum pressure, were often circular, or nearly so;—when they were elliptic, the longer axis generally coincided with the direction in which the storm moved.

In the great majority of the cases investigated, the storm moved towards some point of the quadrant between north-east and south-east. In one case the movement had been from the north-east; but this had soon receded or disappeared, apparently absorbed by a new storm from the south-west.

The observations on temperature indicated that before a storm from south-westward reached a place, the temperature rose, and after it had passed, the temperature fell at that place.

The direction of the wind in the storm was ascertained to be pretty nearly coincident with tangents to the isobarometric curves, though with a tendency to turn inwards towards the centre. The author considered that he had established that all storms marked by a low barometer, and moving north-easterly, rotated from right to left, looking northwards.

With regard to the violence of the winds, he found that it was greatest where the isobarometric curves (having each a difference of two-tenths of an inch) were closest to each other;—when these lines, whether of high or of low pressure, were far apart, the wind was moderate.

4. On the Use of Graphic Representations of Chemical Formulæ. By Dr A. Crum Brown.

The idea of atomicity, or the definite equivalence of chemical atoms, is the necessary consequence of the theory of replacement. It was employed by Frankland to explain the nature of the organo-metallic bodies, and its application was further extended by Kolbe to a large number of organic substances.

It is, however, to Kekulé that we owe the complete generalisation of this idea and its systematic application to all classes of compounds. This first rendered it possible to represent, as it is often advantageous to do, the constitution of compounds by completely dissected formulæ. The most convenient way of doing this is to employ some suitable system of graphic notation.

Kekulé himself, in his "Lehrbuch," made use of a system which has the advantage of compactness and clearness, but is limited in its application to those compounds in which the poly-atomic atoms form a single chain. In order to obviate this inconvenience, I proposed, in my thesis presented to the Medical Faculty of the University in 1861, a form of graphic notation which, while inferior in compactness to that of Kekulé, appears to me preferable, as being at least equally clear and applicable to every formula in accordance with the theory of atomicity.

In an able and suggestive paper published in the "Bulletin de la Société Chimique de Paris" for February 1865, Kekulé uses a modification of his original notation, which to a great extent removes my first objection to it, but at the same time lays it open to another and more serious one—that of obscurity and ambiguity. That this is not an imaginary or trivial defect is made evident by the circumstance that Kekulé has himself, in the paper referred to, been led into an error by his notation. In a foot note, pp. 103 and 104, he says:—"On conçoit cependant au point de vue de la théorie de l'atomicité l'existence d'une categorie d'alcools, dont la constitution devra être exprimée par les noms que je viens de citer. [Alcool méthylo-éthylique, éthylo-méthylique et diméthylo-méthylique.] C'est cette categorie d'alcools dont la sagacité de M. Kolbe a prévu l'existence. La différence entre ces alcools et l'alcool propylique normal est assez clairement rendue par les figures 27 et 28.

Il ne faut cependant pas confondre avec ce genre d'alcools isomériques les pseudo-alcools que résultent de la réduction des acétones et que se rattachent évidemment aux acétones mêmes (figs. 29 et 30).

Il ne faut pas confondre non plus les pseudo-alcools additionnels que M. Wurtz a dérivés des hydrocarbures; c'est une isomérie d'un ordre tout à fait différent," &c. The figures referred to are—

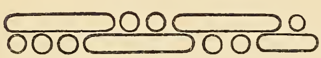


Fig. 27. Alcool Propylique.

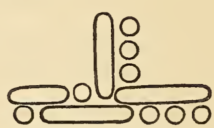


Fig. 28. Alcool Méthyle-éthylique.

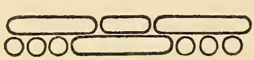


Fig. 29. Acétone.

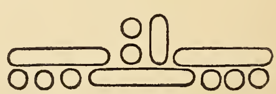
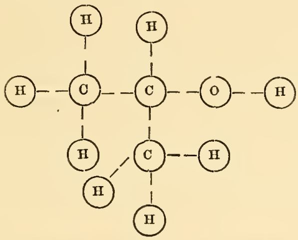


Fig. 30. Alcool Acétonique.

Now if we translate those formulæ into any other system capable of indicating the chemical position of each atom, we find that figs. 28 and 30 are identical. In Butlerow's formulæ, we have

$$\left.\begin{matrix} CH_3 \\ CH\,(HO) \\ CH_3 \end{matrix}\right\} \text{ or typically } C\left\{\begin{matrix} CH^3 \\ CH_3 \\ H \\ (HO) \end{matrix}\right.$$

or, on the graphic system which I use,



In fact, a little consideration will show that the theory of atomicity does not admit of more than two substances having the formula C_3H_7 (HO). In reference to the last sentence quoted from Kekulé, I shall only remark that his view is not borne out by fact in the case of hydrate of propylene, as Berthelot has shown that it is identical with the alcohol derived from acetone.

The following Gentlemen were elected Ordinary Fellows of the Society:—

1. James Powrie, Esq., F.G.S.
2. Charles Jenner, Esq.

The following Donations to the Library were announced:—

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique, Nos. 1, 2. Bruxelles, 1865. 8vo.—*From the Academy.*

Proceedings of the Royal Geographical Society. Vol. IX., No. 2. London, 1865. 8vo.—*From the Society.*

Proceedings of the British Meteorological Society. Vol. II., No. 17. London, 1865. 8vo.—*From the Society.*

The Journal of the Chemical Society, February 1865. London, 1865. 8vo.—*From the Society.*

Visible Speech: A new Fact demonstrated. By Alexander Melville Bell, F.E.I.S., &c. Edinburgh, 1865. 12mo.—*From the Author.*

Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin, 1863. Berlin, 1864. 4to.—*From the Academy.*

Verzeichniss der Abhandlungen Gelehrter Gesellschaften und der Wissenschaftlichen Königl. Preussischen Akademie der Wissenschaften zu Berlin. Berlin, 1864. 8vo.—*From the Academy.*

Lawson's Pinetum Britannicum. Part VIII. Elephant Folio.—*From the Right Hon. The Lord Provost.*

Monday, 17th April 1864.

LORD NEAVES, V.P., in the Chair.

The following Communications were read :—

1. On Confocal Conics. By H. Fox Talbot, Esq.

2. On the Celtic Topography of Scotland. By W. F. Skene, Esq.

The author commenced by distinguishing between an etymology of names of places founded upon mere resemblance of sounds, and one where the names are analysed according to fixed laws, based upon sound philological principles and a comprehensive observation of facts. The former is the ordinary process to which they are subjected, and has characterised all systematic attempts hitherto made to analyse the topography of Scotland. It can lead only to fanciful renderings, and is incapable of yielding any certain results, while the latter becomes an important element in fixing the ethnology of the inhabitants of a country. Names of places undergo a process of change and corruption. The language from which they were derived has likewise gone through a process of change and decay, and an interpretation based upon mere resemblance of sounds, in the present form of the names of places, to words in an existing language, ignores this fact and can only mislead. In order to obtain a sound etymology it is necessary to ascertain the old form of the name, and to analyse it in conformity with the phonetic laws of the language from which it sprung.

The author then showed the fallacy of the system of phonetic etymology, on which the conclusions of Pinkerton, Chalmers, and others were based, and that the attempts hitherto made to discriminate between that part of the population speaking a Kymric, from that speaking a Gaelic dialect, from the topography of the districts, was founded upon an inaccurate conception of the facts and a false view of the dialectic differences. In especial, he showed that the attempt to draw a line of demarcation between them from the respective prevalence of the terms Aber and Inver, was founded upon an incomplete and inaccurate apprehension of the real facts of the case, and was not borne out by the actual topography of the country.

The author then explained a table he had prepared, showing the geographical distribution of a complete list of the terms which enter into the Celtic topography of Scotland. This table showed the number of times that each term occurred in Ireland or in Wales, and likewise in every county of Scotland, and to a great extent disproved the assumed facts upon which the deductions usually made from the topography, are based.

This table likewise showed that there were four terms peculiar to the districts inhabited by the Picts, and these words belonged to the Gaelic and not to the Kymric branch of the Celtic.

The author then showed that some of the terms belonged to an older form of the language than others, and after giving examples of this, he concluded by stating the following as the results of his investigation:—

1. In order to draw a correct inference from the names of places as to the ethnologic character of the people who imposed them, it is necessary to obtain the old form of the name before it became corrupted, and to analyse it according to the phonetic laws of the language to which it belongs.

2. A comparison of the generic terms affords the best test for discriminating between the different dialects to which they belong, and for this comparison it is necessary to have a correct table of their geographical distribution.

3. Difference between the generic terms in different parts of the country may arise from their belonging to a different stage of the same language, or from a capricious selection of different

synonyms by different tribes, as well as from a real dialectic difference between the languages from which they were derived.

4. In order to afford a test for discriminating between dialects, the generic terms must contain within them those sounds which are differently affected by the phonetic laws of each dialect.

5. Applying this test, the generic terms in Scotch topography do not show the existence of a Kymric language north of the Firths of Forth and Clyde.

6. We find in the topography of the north-east of Scotland traces of an older and of a more recent form of Gaelic. The one preferring labials and dentals, and the other gutturals. The one hardening the consonants into *tenues*, the other softening them by aspiration. The one depositing Abers and Invers simultaneously, the other Invers alone. The one a low Gaelic dialect, the other a high Gaelic dialect, the one probably the language of the Picts, the other that of the Scots.

3. On the Bands produced by the Superposition of Paragenic Spectra formed by the Grooved Surfaces of Glass and Steel. Part II. By Sir David Brewster, K.H., F.R.S.

4. Remarks on the Flora of Otago, New Zealand. By W. Lauder Lindsay, M.D., F.L.S., Hon. Member of the Philosophical Institute of Canterbury, New Zealand.

The North Island flora has hitherto been regarded (in the absence of a knowledge of the South Island flora) as representing the general vegetation of our New Zealand possessions. But the New Zealand Islands extend through thirteen degrees of latitude, and the floras of their northern and southern extremes necessarily present various marked differences. The former flora is more subtropical, and the latter more antarctic in its affinities. The former, morever, is richer in natural orders, genera, and species.

Until very recently, however, comparatively little or nothing was known of the Otago flora, all collections previous to 1861 having been made on its coast, and with a single limited exception on its western coast. In 1861 the author botanically examined the vicinity of Dunedin, and the settled districts between that capital and the Clutha River,—all on the eastern sea-board of the province. The immediate fruit of this examination included, in the department of phænogams and ferns alone, a total of 235 species.

Five species were new to science, viz., *Viscum Lindsayi* (Oliv.), parasitic on *Metrosideros hypericifolia*, *Celmisia Lindsayi* (Hook. fil.), *Poa Lindsayi* (Hook. fil.), *Aciphylla Colensoi* (Hook. fil.), and *Crepis Novæ Zelandiæ* (Hook. fil.) (Drawings of these plants were exhibited.)

Five species had not been previously found in New Zealand; twenty-two had not been previously found in Otago thirty were rare in Otago; and twenty-five species indigenous in Otago were British.

In addition to these and to the total of 235 species, there were twenty-seven species of British plants naturalised in Otago, making a total of 262.

Between 1862 and 1864, the interior of Otago has been explored by the Government Geological Survey, and the collections made by the botanist attached thereto have largely added to our knowledge of the flora, more especially of its western alps and great central lake basins.

The author in his paper (which refers only to Phænogams, Ferns, and their allies) endeavours to give the great characteristics of the flora of Otago, as a type more especially of the southern flora of New Zealand, and he draws a comparison between the flora of the south and of the north. The subject is treated mainly in a tabular and statistical manner.

The following table shows the numerical strength of the Phænogamic Flora of Otago :—

I. PHÆNOGAMS.

†Dicotyledons.

	No. of Orders.	No. of Genera.	No. of Species.
A. *Angiospermæ*—			
1. Thalamifloræ, ...	12	27	53
2. Discifloræ, ...	5	5	7
3. Calycifloræ, ...	13	38	98

	No. of Orders.	No. of Genera.	No. of Species.
4. Corollifloræ, ...	17	53	178
5. Incompletæ, ...	7	14	30
	54	137	366
B. *Gymnospermæ*, ...	1	4	10
Total Dicotyledons, . .	55	141	376

††Monocotyledons.

1. Petaloideæ, ...	6	26	49
2. Glumaceæ, ...	3	31	70
Total Monocotyledons, .	9	57	119
Total Phænogams, . .	64	198	495

II. CRYPTOGAMS.

1. Filices, ...	1	24	88
2. Lycopodiaceæ and Marsileaceæ, .	2	3	8
	3	27	96
Total Phænogams and Ferns in Otago,	67	225	591

Proportion of species to a genus, 2·61 to 1.
Do. do. natural order, 8·82 to 1.
Do. Dicotyledons to Monocotyledons, 3·15 to 1.
Number of natural orders containing only *one* genus, 26.
Number of genera containing only *one* species, 104.

The author then enumerates the prominent orders and genera, mentions the proportion of ligneous species, and gives a sketch of the geographical distribution of the plants of Otago under the groups Endemic, Australian, Antarctic, South American, Polynesian, and Cosmopolite (including British plants and widely distributed species).

5. On the Composition of some Old Wines. By Douglas Maclagan, M.D., Curator Roy. Soc. Edin.

The samples of wine were furnished to Dr Maclagan by the Earl of Dalhousie; they had been found in a recess in a wall in Panmure House, which was known to have been built up in 1715; the samples were consequently at least 150 years old.

The wines submitted to examination were three in number, and were contained in quart bottles, resembling those ordinarily in use at the present day. They were, when sent to Dr Maclagan, securely corked; evaporation had, however, gone on to a sensible extent in two of the bottles, the third being nearly full.

No. 1.—Bottle No. 1 contained 21 fluid ounces of wine, its capacity being 25 fluid ounces. The fluid was carefully decanted, and thus separated from a considerable quantity of dark red apothema.

The fluid separated by decantation was slightly turbid, the turbidity not disappearing on filtration. Its colour was a pale tawny brown. It possessed a distinct vinous aroma, which when the bottle was first opened, resembled very closely that of claret. In addition to the vinous, there was a distinctly acetous odour. Its density at 60° Fahr. was 995·42.

The acids of the wine were separated by precipitating first with ordinary, and then with basic acetate of lead, and decomposing the separate precipitates by sulphuretted hydrogen, and testing. The wine was found to contain tartaric and tannic acids, besides sulphuric and phosphoric acids and chlorine in a state of combination. It contained no racemic acid.

The results of a quantitative analysis were the following :—

Water in 1000 parts,	918·414
Alcohol,	70·000
Acetic acid,	3·906
Tartaric acid,	3·187
Sugar,	·654
Soluble salts,	1·672
Insoluble salts,	1·330

In the above analysis the total acidity of the wine was determined by means of a standard alkaline solution; the fluid having then been acidified with sulphuric acid, was distilled. The acidity of the distillate was then determined by means of the standard alkaline solution; from the amount of alkali used in the second determination, the acetic acid was determined, it being assumed that this was the only volatile acid present. By subtracting the amount of alkali required to neutralise the volatile acid, from the total amount required to neutralise the wine, was found the amount of alkali required to neutralise the fixed acid. The calculation was made on the assumption that the only fixed acid present in the wine was tartaric acid. The assumption is an erroneous one, but was adopted, so that the analysis might compare with other wine analyses, which are usually conducted on this plan.

The sugar was determined in the wine which had been treated with acetate of lead, and subsequently with sulphuretted hydrogen, by boiling with Fehling's solution, and determining by the balance the amount of copper reduced.

The sediment (apothema) of the wine was examined, and found to contain much tannic acid, in combination with the red colouring matter of the wine, besides tartrate of potash.

No. 2.—The bottle was full to the neck of a wine having the unmistakable flavour, and average colour, of Madeira. Though it was very acid, it was by no means undrinkable. Its density at 60° Fahr. was 989·7.

It contained a trace of tannin, but no tartaric acid. The amount of sulphuric acid and chlorine which it contained appeared to be unusually large.

Its complete examination has been prevented by other, and more important, work. The following particulars have been, however, ascertained:—

Total solids in 1000 parts, ...	27·625
Salts, ...	2·446
Alcohol, ...	100·000
Acetic acid, ...	1·290

Fixed acid, equivalent to 2·152 parts of caustic soda.

The amount of sugar which the wine contained was not determined.

No. 3.—The bottle was full to the shoulder of a turbid, deed brown wine, of very sour taste, and having the flavour of port. It contained an abundant red deposit.

Its density at 60° Fahr. was	994·06
Total solids in 1000 parts, ...	19·66
Salts, ...	2·79
Alcohol, ...	50·00

The total amount of free acid in 1000 parts was determined by means of a standard solution of soda, and found to be equal to 5·37 parts of caustic soda. The amount of acetic acid was not separately determined. This wine contained a very large quantity of tannic acid still in solution, besides the large amount which had been precipitated in combination with red colouring matter. It contained no tartaric acid in solution. The exact amount of sugar was not determined; it was, however, decidedly small.

6. Preliminary Note on the Colouring Matter of *Peziza æruginosa*. By Dr A. Crum Brown.

The *Peziza æruginosa* is a fungus belonging to the family Ascomycetes, and order Elvellaceæ. Although the fructification is not often met with, the plant itself is by no means rare, growing on dead wood, chiefly of the oak, birch, and ash. It has an intense green colour, and tinges the wood on which it grows to a considerable depth.

The raw material upon which my investigations were made was derived partly from the plant itself, but to a much larger extent from the wood upon which it had grown, or was growing.* I am indebted for the wood and the plants to Dr Alexander Dickson, at whose suggestion I undertook this research.

As Dr Dickson had observed that the colouring matter dissolves without apparent change in the strong mineral acids, but is sparingly soluble in dilute acids, I employed the following method for its isolation:—

The wood, broken into small pieces, was placed in a large funnel,

* In order to determine with certainty the connection between the green wood and the Peziza, Mr M'Nab of the Botanic Garden exposed pieces of the wood, which showed no trace of the fructification, to heat and moisture, when large crops of the fungus were obtained.

containing a small asbestos filter, and the funnel was filled with strong commercial nitric acid. The acid was completely saturated, after passing two or three times through the wood. The solution had a dark-green colour by reflected, and a deep-purple red by transmitted, light. When poured into water, a copious but extremely light flocculent precipitate, of a bright-green colour, was produced, which slowly subsided, leaving the supernatant liquid nearly colourless. As this precipitate was found to possess the same properties, whatever acid was used in its preparation, I had no hesitation in using nitric acid, which is by far the best solvent. On attempting to wash the precipitate with distilled water, either by decantation or on a filter, I found that, while nearly insoluble in moderately dilute acid, it dissolves to a considerable extent in water, even when the latter contains distinct traces of acid. I therefore had recourse to the method of dialysis to get rid of the acid.

The acid liquid containing the green matter in suspension was placed on a dialysor, consisting of a sheet of parchment paper, stretched over a double ring of gutta-percha, and floating in a vessel containing distilled water. After two or three days (the water being frequently renewed) the nitric acid was found to be entirely removed, and the contents of the dialysor consisted of a green liquid, and a dark-green precipitate. The latter left a small white ash on ignition; and as the quantity of ash bore no constant relation to the quantity of green matter, it was obvious that the substance was still impure. In order to purify it further, I took advantage of its solubility in alkalies, and dissolved it in the smallest possible quantity of very dilute ammonia. The brown solution thus obtained was filtered, allowed to stand several days in the dialysor, and precipitated by means of hydrochloric acid. The acid was as removed by dialysis, and a green liquid and precipitate obtained before. This was dried *in vacuo* over sulphuric acid.

The substance thus obtained is a very light powder, almost black when viewed in mass, dark bluish-green when finely divided, and is probably nearly pure. I have, however, not yet analysed it, as it still leaves a decided trace of ash; and I am unwilling to expend the small quantity at my disposal until I have made further efforts to obtain it in a state of purity.

As before stated, the substance dissolves readily in the strong mineral acids, and to a considerable extent in glacial acetic acid. These solutions are precipitated by water. It also dissolves in water and chloroform. All these solutions are green. It is insoluble in alcohol and ether. It is soluble with a brown colour in alkaline solutions. When no excess of alkali has been used, these solutions are precipitated green by dilute acids; but when allowed to stand, even for a few minutes, with excess of alkali, they undergo a change, and acids then produce a slimy-brown precipitate. The same change takes place when the aqueous or alkaline solution is heated to 100° Cent.

The neutral ammonia solution gives precipitates of a dirty green or brown colour with most metallic solutions.

When the substance is fused with dry caustic potash, a powerful ammoniacal odour is given off: It therefore contains nitrogen.

These observations lead to the conclusion that the substance is a weak acid, and that it forms compounds of slight stability with the stronger acids. Any speculations as to its nature are, however, premature, until we obtain analyses of the body itself, and of some of its compounds.

Since writing this note, I have observed in the "Comptes Rendus," vol. lvii. p. 50, a paper by M. Fordos, apparently on the same subject. M. Fordos was not aware of the origin of the green colour, and seems to have obtained only a very small quantity of it. He has anticipated me in the observations as to its solubility in strong acids and chloroform, and has proposed for it the name of "Acide xylochloerique."

7. On the Motion of Interpenetrating Media. By Alfred R. Catton, B.A., Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

The following Gentlemen were balloted for, and elected Fellows of the Society:—

1. Charles Lawson, junior, Esq.
2. Alex. Keiller, M.D., F.R.C.P.E.

The following Donations to the Library were announced:—

Journal of the Statistical Society of London. Vol. XXVIII., Part 1. 8vo.—*From the Society.*

Journal of the Chemical Society. Vol. III., No. 27. London. 8vo.—*From the Society.*

Proceedings of the Royal Society, London. Vol. XIV., No. 73. 8vo.—*From the Society.*

American Journal of Science and Arts. No. 116. New-Haven. 8vo.—*From the Editors.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, March 1865. 8vo.—*From the Registrar-General.*

Seventh Detailed Annual Report of the Registrar-General of Births, Deaths, and Marriages in Scotland. Edinburgh, 1865. 8vo.—*From the Registrar-General.*

On the Malacostraca of Aristotle. By J. Young, M.D., F.R.S.E. 8vo —*From the Author.*

On some of the more Important Diseases of the Army; with Contributions to Pathology. By John Davy, M.D., F.R.S. London, 1862. 8vo.—*From the Author.*

Physiological Researches. By John Davy, M.D., F.R.S. London, 1863. 8vo.—*From the Author.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XVII., Pt. 2. Genève, 1864. 8vo.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-naturwissenschaftliche Classe, Band XXIII. Philosophisch-historische Classe, Band XIII. Wien, 1864. 4to.—*From the Academy.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Philosophisch-historische Classe, Band. XLV., Hefte ii., iii.; Band XLVI., Hefte i.–iii. Mathematisch-naturwissenschaftliche Classe (Meteorologie), Band XLIX., Hefte ii.–v. (Mineralogie), Band XLIX., Hefte ii.–v.; Band L., Heft i. Wien. 4to.—*From the Academy.*

Almanach der Kaiserlichen Akademie der Wissenschaften. Wien, 1864. 8vo.—*From the Academy.*

Abstracts of the Proceedings of the Geological Society of London, Nos. 130, 131. 8vo.—*From the Society.*

Journal of the Society of Arts, Weekly, for 1864–65. London. 8vo.—*From the Society.*

Comptes Rendus Hebdomadaires des Seances de l'Académie des Sciences. Paris, 1864–65. 4to.—*From the Academy.*

Monday, 1st May 1865.

Professor CHRISTISON, V.P., in the Chair.

The following Communications were read:—

1. Some Observations on the Cuticle in relation to Evaporation. By John Davy, M.D., F.R.S. Lond. & Edin.

In this paper the author gives an account of many experiments made on the loss of weights of different animals in their fresh state, when suspended, exposed to the air, from evaporation; from the results of which he infers, that it is comparatively greatest from the batrachians, not quite so great from fishes, less from mammalia, and least from birds.

Physiologically considered, he infers that the function, in all but the fishes, is connected with the regulation of animal heat, tending to keep the cool-blooded batrachians cool, and birds of a high temperature warm.

Viewed pathologically, he shows how it tends to prevent inspissation and drying, and to preserve the blood in a healthy, and the tissues in a flexible, moist state.

In addition, he gives an account of some similar trials on vegetables, in which the cuticular covering performs a part in relation to the retarding of evaporation and the preservation of life, similar to that which it exercises on animals.

He concludes with calling attention to the drying of meats and vegetables in an economical point of view, and with the expression of regret that these in their dried state—so much used in the United States of America, and on the Continent, and so easily obtained, considering the simplicity of the process, are not more used in Great Britain, especially by the labouring class.

2. On Water, Hydrogen, Oxygen, and Ozone. By John Macvicar, D.D. Communicated by Dr E. Ronalds.

3. Note on the Behaviour of Iron Filings, strewn on a vibrating plate, and exposed to the action of a magnetic pole. By Professor Tait.

While a horizontal plate is in a state of rapid vibration (as in Chladni's experiments), iron filings strewed on the surface, near a point of maximum vibration, are prevented from being scattered to the nodal lines by a magnetic pole held *above* the plate, but, if the pole be held *below*, they are speedily dissipated. If too powerful a pole be used, or if the magnet be held too near the plate, the filings nearest to the pole are not dispersed in the latter case. I mention this curious fact (which was observed recently by Mr Talbot and myself), on account of its explanation, which is very simple.

The filings tend to place their greatest length in the direction of lines of magnetic force; and thus, when the pole is above the plate, their upper ends incline inwards to it, so that the agitation of the plate, combined with the magnetic attraction, brings them nearer to the point immediately below the pole. When the pole is below the plate, the upper ends of the filings diverge *from* the pole, and the agitation sends them outwards, unless the magnetic attraction be considerable.

4. On some Congenital Deformities of the Human Skull. By Wm. Turner, M.B., F.R.S.E.

1*st*, *Scaphocephalus.*—After making reference to his previous papers,* more especially to that in which he had described several specimens of the scaphocephalic skull, in which he had discussed the influence exercised on the production of deformities of the cranium, by a premature closure or obliteration of the sutures, and to the recent memoirs of Professor von Düben of Stockholm,†

* Natural History Review. January 1864, and January 1865.

† Medicinskt Archiv. Stockholm. Vol. ii. Part i. p. 1. 1864.

and Dr John Thurnam,* the author proceeded to relate two additional cases of scaphocephalus to those he had already recorded. He had met with one of these in the head of a living person, the other in a skull in the Natural History Museum of the University of Edinburgh.

The first case occurred in a young man, a native of Scotland, and was a very characteristic specimen. The great elongation and lateral compression of the skull in the parietal region were well exhibited, the sagittal ridge was strongly pronounced, and the flattening of the skull on each side of the ridge was considerable. The head was 9 inches long; and this great elongation was chiefly displayed in the bulging backward of the occipital region, for there was no marked projection of the forehead. The characteristic shape of this youth's head was congenital, for it had been observed from his earliest infancy, and his birth was attended with considerable difficulty. He was of studious habits, and very intelligent. For in these cases of scaphocephalism there is not necessarily any intellectual deficiency, as the impeded growth of the skull in the transverse direction from early obliteration of the sagittal suture is compensated for by the increased growth in the antero-posterior, and the growth of the brain though restricted in one direction is permitted in another. Hence, the cubic capacity of these crania does not seem to be below the mean of the race or races in which they have been found; one of the skulls the author had formerly described—117 *a*, Edinburgh University Anatomical Museum—having a capacity as high as 108 cubic inches.

The skull in the Natural History Museum is that of an Egyptian mummy, and was described and figured as such by the late Mr Andrew Fyfe, in his "Illustrations of the Anatomy of the Human Body." † He states, that "it is remarkable, not only for its length and narrowness, but for the strong impression made by the temporal muscle, and for the sharpness of the arches of the forehead and occiput;" but he says nothing of the condition of the sagittal suture, and apparently regards the skull as a characteristic specimen of the ancient Egyptian cranium. Conjoined, however, with this

* Natural History Review. April 1865.

† Third Edition. Plates vii. A. and vii. B. Edinburgh, 1814. And in Table viii. page 8, of the edition published in 1830.

length and narrowness are an absence of parietal eminences, a complete obliteration of the sagittal suture, a keel or ridge along the sagittal line, and such a complete blending of the two parietal bones, that it must be pronounced to be a typical specimen of the scaphocephalic skull. Hence it cannot be regarded as expressing the normal form of head of the ancient Egyptian, but simply as an individual peculiarity due to premature closure of the sagittal suture, and possessing no ethnological value. For skulls of this form may apparently occur in any race, and in any clime, as well in the old Egyptian as in the Scotchman of the present day.*

As minor characters in this cranium, may be noticed, that the lateral, longitudinal, and vertical transverse lines of sutures are marked externally, but probably obliterated internally. The forehead is rounded and projecting in the region of the frontal eminences, but behind these tubera the frontal bone has a roof-like form. The biparietal bone has no beak jutting forward into the frontal, and there are indications of the former presence of parietal foramina. A narrow beak runs forward from the superior angle of the occipital bone into the biparietal bone. The facial bones are broken away, and the cavity of the skull is full of a black bituminous-like material. The skull is apparently that of a person past the middle period of life, but whether male or female is somewhat uncertain, though it is probably the latter.

The following are some of the principal measurements, expressed in inches and tenths :—

Extreme length, 8·1; breadth, 4·8; height, 5·3.
Greatest frontal breadth, 3·9; parietal, 4·3; occipital, 3·6.
Frontal radius, 4·8; parietal, 4·7; occipital, 4·3.
Frontal arc, 5·4; parietal, 6·2; occipital, 4·9; longitudinal, 16·5.

* Upwards of forty cases of scaphocephalism have now been recorded by the following anatomists :—Sandifort, Blumenbach, and Von Baer, each one; Virchow and Lucae, each two; Minchin, three; Welcker, four; Von Düben, seven; Thurnam, nine, and the author, including the two cases described in the text, eleven; and they have been found in English, Scotch, Irish, French, German, Danish, Swedish, Croatian, Illyrian, Tartar, Gentoo, Esquimaux, Ancient Egyptian, Negro, and Australian heads.

Frontal transverse arc, 12·6; parietal, 12·0; occipital, 10·6. Circumference, 21·3.

2*d*, *Congenital Deficiencies in the Cranium.*—For the opportunity of examining the very remarkable skull-cap next described, the author was indebted to Professor Maclagan, who, on account of some circumstances connected with the death of the person to whom it belonged, possessing a medico-legal interest, had had it sent him by Dr T. J. Maclagan of Dundee.* The skull-cap was from a woman æt. 25. In the inter-parietal part of the occipital bone an oval opening, with a smooth rounded margin, existed in the middle line. Its long axis was vertical, and measured one inch; its transverse diameter was a little more than half an inch at the widest part. A suture extended upwards from the upper end of this opening in the middle line, as far as the superior angle of the bone. This hole was, in the recent state, filled up by a membrane. In the posterior slope of each parietal bone an oval opening, with a rounded margin, was situated. The long axis of each was transverse; that on the right side $\frac{8}{10}$ths, that on the left $\frac{6}{10}$ths of an inch long; whilst the antero-posterior diameter on the widest part, on the right side, was $\frac{6}{10}$ths, on the left $\frac{4}{10}$ths of an inch. These openings were filled up in the recent state with a cribriform membrane. A suture passed from the inner end of the left parietal opening almost transversely inwards for about half an inch, when it reached the middle line, and then extended downwards and backwards for $1\frac{1}{4}$ inch, as far as the lambdoidal suture, occupying the position of the posterior part of the sagittal suture. The right parietal opening had no suture proceeding from it, though there were appearances as if one had formerly existed. The parietal openings by their outer ends were close to elevations in the bones, which evidently corresponded to the parietal tubera.

The inner surface of the skull-cap, in front of the parietal openings, was marked by the groove for the superior longitudinal sinus along the middle line; opposite these apertures it was deflected, and ran close to the inner end of the right parietal opening; and preserving this direction it ran along the right side of the occipital opening as far as the internal occipital protuberance; from the

* Proc. Med. Chir. Soc. Edin. in Edinburgh Medical Journal, May 1865.

inner end of the left parietal opening a shallow groove proceeded, which ended in the groove for the superior longitudinal sinus, and had apparently, at one time, lodged a small venous sinus. Anteriorly, the right parietal bone sent forward into the frontal a beak similar to those the author had described in some of the scaphocephalic crania recorded in his former paper. Traces of a suture, visible only externally, might be seen commencing at the coronal suture, immediately to the left of the base of the beak. It extended in an interrupted manner backward for about an inch and a half, and then disappeared, so that from this spot, to a point midway between the two parietal openings, the sagittal suture was entirely obliterated, and the two parietal bones were completely blended together. The other sutures of the skull-cap were well marked, both internally and externally.

The author then discussed the probable modes of production of these malformations. He argued that the opening in the occipital bone was due to want of union in the middle line of the ossific spicula proceeding from the two centres of ossification from which the inter-parietal, or cerebral, part of the occipital bone is developed. The malformation might be compared, therefore, with the deficiency in the neural arches of the spinal column, occasioning a spina bifida. The two large openings in the parietal bones were of a different nature: they were not congenital deficiencies in the middle line; they did not occur along the line of junction of spicula—proceeding from ossific centres orginally distinct, but were placed laterally, and each was situated between the eminence which seemed to be the centre of ossification for the parietal bone in which it occurred, and the middle line. The openings, indeed, occupied the position of the parietal foramina, but were many times larger than those apertures are in a normal skull. The possibility of these being greatly exaggerated vascular foramina was then discussed, the cribriform condition of the membrane closing them over, and the relations of the grooves for the venous sinuses internally, seemed to favour such a conclusion. Abnormalities in the construction of the bones of the skull-cap, *i.e.* of the bones developed in membrane, are apparently more frequent than those of the basis cranii, which are developed in cartilage. This is probably due to the circumstance, that the areas of the different bones are less precisely defined, and that the process of ossification is more liable to disturbance in the former than the latter. The modifications in arrangement are especially apt to occur along the lines of apposition of adjacent osseous areas, *i.e.*, along sutural lines, or along the margins of junction of the subdivisions of a bone proceeding from distinct centres; and in these localities it is that the anatomist so frequently meets with Wormian or triquetral bones, or occasionally with a beak projecting from one bone into an adjacent one, or with the not unfrequent blending of one bone with another along the sutural lines.

5. On Saturated Vapours. By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS. Lond. and Edin., &c.

As this paper consists almost wholly of formulæ, calculations, and tables, it is not suited for being read to a meeting; and therefore the following short abstract of its contents is alone offered for the purpose of being read aloud:—

In the "Edinburgh Philosophical Journal" for July 1849, the author proposed the following formula for the pressure of saturated vapour corresponding to a given boiling point:—

$$\log p = A - \frac{B}{t} - \frac{C}{t^2};$$

where t is the *absolute temperature*, reckoned from the *absolute zero;* and A, B, and C are three specific constants, to be determined from at least three experiments on each substance; and he showed that the results of that formula agreed better with experiment than those of any other formula containing three constants only. In a series of papers on the Mechanical Action of Heat, read to the Royal Society of Edinburgh in 1850, and subsequent years, and in other publications also, the same formula is explained, and its use exemplified in various ways. The first division of the present paper gives the results of the computation of the values of the constants A, B, and C for several fluids for which they had not been previously computed, the data being taken from the second volume of M. Regnault's "Rélation des Expériences, &c.," published in

1862; and it is also shown that by the formula a conclusion was anticipated, which M. Regnault has deduced from his experiments, viz., that "*the elastic force of a vapour does not increase indefinitely with the temperature, but converges towards a limit which it cannot exceed.*" ("Rélation des Expériences," vol. ii. page 647.)

The second division of the paper is occupied chiefly with a comparison between the actual values of the pressures of saturation of the vapours of various fluids, and the values which those pressures would have if the vapours were perfectly gaseous. In the first of the papers already referred to, read to the Royal Society of Edinburgh, and published in their Transactions in 1850, the author proved from the principles of thermodynamics that the "*total heat*" of evaporation of a perfectly gaseous vapour must be represented in dynamical units by the expression

$$\mathrm{J}b + \mathrm{J}c't,$$

where b is a constant to be found by experiment, c' the specific heat of the vapour at constant pressure, and J the dynamical equivalent of an unit of heat, t being the absolute temperature as before. In a paper read to the Royal Society of Edinburgh in 1855, but not published, the same formula was shown to express, in dynamical units, the *total heat of gasefication* of any substance under any constant pressure, when the final absolute temperature is t. In the present paper the author equates that expression to another expression for the total heat of evaporation, from the absolute zero, at a given absolute temperature t, as follows:—

$$\mathrm{J}b + \mathrm{J}c't = \mathrm{J}\int_0 c''dt + t\frac{dp}{dt}(v - v'');$$

in which v and v'' are the volumes of unity of weight of the substance in the gaseous and liquid states respectively, under the pressure p, and at the absolute temperature t. Then putting for v its value in the perfectly gaseous state—namely,

$$v = \frac{\mathrm{J}(c' - c)t}{p},$$

where c is the specific heat of the gas at constant volume, and neglecting v'' as very small in comparison with v, there is found, by integration, the following value of the hyperbolic logarithm of the pressure of saturation (a being a constant to be deduced from one experiment for each fluid):—

$$\text{hyp. log}\, p = a - \frac{b}{(c' - c)} + \frac{c'}{c' - c}\,\text{hyp. log}\, t$$

$$- \frac{1}{c' - c} \int_0^t \frac{d}{t^2} \int_0^t c'' dt \quad \ldots \ldots \quad \text{(A)}$$

When c'' is constant (as is approximately the case in some instances) the preceding equation becomes

$$\text{hyp. log}\, p = a - \frac{b}{(c' - c)\, t} - \frac{c'' - c'}{c' - c}\,\text{hyp. log}\, t \quad . \quad \text{(B.)}$$

The pressures of various vapours, as calculated on the supposition of their being perfectly gaseous by means of the preceding equations, are compared with their actual pressures; the general result being, that when the vapours are rare, the differences are small, and that when the densities increase, the differences increase. For example, in the case of steam, the pressures calculated by equation B agree very closely with the actual pressures from 0° to 160° Cent.; but above the latter temperature the difference gradually becomes considerable, and at 220° Cent. is about one-fiftieth part of the whole pressure. At 0° Cent. 1 pound of saturated steam occupies 3400 cubic feet; at 160° Cent. about 5 cubic feet; and at 228° Cent. about 1·4 cubic foot.

The author also makes some comparisons between the actual volumes of saturated vapours at given boiling-points, and the calculated volumes which they would fill if they were perfectly gaseous; and also between the actual latent heat of evaporation, and the calculated latent heat of perfect gasefication. The general results are in accordance with what is already known,—viz., that the actual volumes of vapours are less than those corresponding to the perfectly gaseous state, and the actual latent heat of evaporation less than the latent heat of gasefication; and the author further points out that the differences in the case of steam increase nearly as the absolute temperature.

6. On the Ganglia and Nerves of the Heart, and their connection with the Cerebro-Spinal and Sympathetic Systems in Mammalia. By James Bell Pettigrew, M.D., Edinburgh, Assistant in the Museum of the Royal College of Surgeons of England.

The Memoir, of which the subjoined is an abstract, is based upon seventy dissections, and is intended as a contribution to our knowledge of the arrangement of the cardiac nerves in the mammalia.

It has the five following objects in view :—

1*st*. To describe the parts of the sympathetic and vagus, which furnish branches to the heart.

2*d*. To trace the branches given off by the sympathetic and vagus, till they disappear in the great cardiac plexuses.

3*d*. To unravel the plexuses, so as to show the manner in which they are formed, and how they resolve themselves.

4*th*. To point out the arrangement of the nerves on the pulmonary artery and aorta, and on the surface and in the substance of the auricles and ventricles.

5*th*. To demonstrate the existence of certain nervous enlargements on the surface and in the substance of the heart generally, and to show that these enlargements are true ganglia, and contain innumerable unipolar and bipolar nerve-cells.

In the first part of the investigation, the cardiac branches furnished by the sympathetic and vagus have been examined in the cat, calf, and rabbit, and also in man; but the author is indebted for his results chiefly to the three former, the nervous system of the domestic animals being, in his opinion, especially interesting, as the animals themselves are admirably adapted for the purposes of vivisection.

The chief points of difference to be noted in the cardiac nerves of the animals referred to, occur in the sympathetic, and are as follows :—

In the cat, the cardiac nerves furnished by the sympathetic proceed from two large solitary ganglia, one of which is situated at the root of the neck on the right side, the other on the left.

In the rabbit, they proceed from four smaller ganglia, two of which are situated on the right side of the root of the neck, the remaining two on the left.

In the calf, the number of ganglia furnishing cardiac branches increase to six, these being similarly divided and situated.

The cat, therefore, seems best adapted for physiological pursuits, and a series of carefully performed experiments on that animal may probably be the means of determining the nature and the extent of the influence exerted by the nerves on the movements of the heart, if indeed these movements, as the author remarks, are not referable to the ganglia situated in the heart itself, which, from various considerations, he thinks not unlikely. The heart, *e. g.*, is known to contract and dilate for a considerable period after the blood, which is regarded as its natural stimulus, is abstracted from it. It further acts regularly when removed from the body and placed under a bell jar from which the air has been subsequently exhausted by the action of an air-pump. In the frog, moreover, as not unfrequently happens, the heart suddenly ceases to contract, if the base, where the ganglia are most numerous, be removed by the stroke of a scissors.*

In the second part of the investigation, the great cardiac plexuses are shown to resolve themselves into four minor ones.

Of these, one occurs on the pulmonary artery, and supplies branches to that surface of the auricles which is directed towards the great vessels. It also supplies branches to the right ventricle. A second occurs between the pulmonary artery and aorta, and furnishes branches to the anterior coronary vessels, and to the right and left ventricles, particularly the latter. A third occurs on the posterior coronary sinus, and gives branches to the left auricle and ventricle, especially the latter. The fourth occupies that surface of the auricles which is directed towards and is in contact with the pericardium, and supplies branches to the inferior cava, to the auricles, and to the posterior surface of the right ventricle. The

* Brachet declares that if the cardiac plexus in mammals be destroyed the movements of the heart are suddenly and permanently arrested.—*Du Système Nerveuse Ganglionaire*, p. 120.

four minor plexuses referred to supply branches which pursue a definite direction. Thus the branches from the plexus, situated between the pulmonary artery and aorta, and between the former and the right auricle, proceed in a spiral direction from right to left downwards, so that they cross the muscular fibres composing the ventricles. The same may be said of the branches proceeding from the plexuses occurring on the posterior surface of the auricles and on the posterior coronary sinus. By this arrangement the nerves distributed to the heart are brought into intimate contact not only with the muscular fibres, but also with the blood-vessels; and this is important, as it is on the latter that the ganglia are most frequently detected.

In the third and concluding part of the investigation, the enlargements and fusiform swellings figured by Scarpa* and Lee† have been examined microscopically, and their precise nature ascertained. The hearts examined for this purpose were numerous, and consisted, among others, of those of man, the horse, ox, camel, heifer, dog, panther, deer, seal, and pig.

The ganglia occur as irregularly shaped enlargements, having three, four, five or more nerves connected with them. Sometimes they appear as simple dilatations occurring on the nerves as they cross the vessels. They are most numerous on the posterior coronary sinus, where they form a continuous network not hitherto described; but they are also to be found in large quantities on the vessels and throughout the substance of the heart generally.

When a ganglion, with several nerves proceeding from it, is detached and treated with carmine and glycerine, it is found, on microscopic examination, to be crowded with nerve-cells, the poles of which are directed towards the nerves themselves. When one of the swellings or dilatations which occur on the nerves, as they cross the vessels, is similarly treated, the nerve-cells are seen to form an oval patch corresponding in shape with the dilatation, and the poles of the cells are directed, as a rule, in the direction of the nerve trunk. In some instances the nerves terminate in bulbous expansions, and on such occasions the expansions in question are crowded with nerve-cells, the poles of which are directed towards the attached

* Tabulæ Neurologicæ, fol. 1794.

† Phil. Trans., 1849.

nerve. It is not uncommon to observe one of these terminal expansions, with a smaller one, apparently in process of formation, attached to it.

The nerves and nerve-plexuses, in their various combinations, and the ganglia and their contents, have been described at length, and the appearances presented by them carefully figured.

Note to Paper on the Action of Hydriodic Acid on Mandelic Acid, by Dr A. C. Brown. Read March 20, 1865.

June 6, 1865.

Since this paper was printed I have prepared the aldehyd of alpha-toluic acid. I shall only mention here that it possesses in a very high degree the smell of honey, which was observed in the case of the alpha-toluic acid described in the paper; and that it is probable that that acid contained traces of the aldehyd to which it owed not only its smell, but also the excess of carbon and hydrogen indicated by the analyses.

The following Donations to the Library were laid on the table :—

Der Zoologische Carten. Zeitschrift fur Beobachtung Pflege und Zucht der Thiere. Herausgegeben von Prof. Dr C. Bruch. Jahrg. V. Nos. 2–12. Frankfurt, 1864. 8vo.—*From Prof. Bruch.*

Sitzungsberichte der Konigl. Bayer. Akademie der Wissenschaften zu Munchen. II., Heft 3–4. Munchen, 1864. 8vo.—*From the Academy.*

Monatsberichte der Koniglichen Preuss. Akademie der Wissenschaften zu Berlin. aus dem Jahre 1864. Berlin, 1865. 8vo.—*From the Academy.*

Haematologische Studien von Dr Alexander Schmidt. Dorpat, 1865. 8vo.—*From the Author.*

The Sewage of the Metropolis. A Letter to John Thwaites, Esq. London, 1865. 8vo.—*From G. Robertson, Esq., C.E.*

Proceedings of the British Meteorological Society. Vol. II., No. 18. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society. Vol. V., No. 4. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. V., No. I. 8vo.—*From the Society.*

The Power of Form applied to Geometric Tracery. By Robert William Billings, Esq. Edinburgh, 1851. 8vo.—*From the Author.*

Notes on the South Slavonic Countries in Austria and Turkey in Europe. Edited, with a Preface, by Humphry Sandwith, C.B., D.C.L. Edinburgh, 1865. 8vo.—*From the Editor.*

Monthly Notices of the Royal Astronomical Society. Vol. XXV., No. 5. London, 1865. 8vo.—*From the Society.*

Societá reale di Napoli, Rendiconto delle Tornate e dei Lavori dell' Accademia di Scienze Morali e Politiche. Anno quarto. Napoli, 1865. 8vo.—*From the Society.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1865–66. No. 68.

Eighty-Third Session.

Monday, 27th November 1865.

Professor KELLAND, V.P., in the Chair.

The following Council were elected:—

President.

Principal Sir DAVID BREWSTER, K.H., LL.D., D.C.L.

Honorary Vice-President, having filled the Office of President.

His Grace the DUKE of ARGYLL.

Vice-Presidents.

Professor Kelland.
Hon. Lord Neaves.
Principal Forbes.
Professor Innes.
Prof. Lyon Playfair, C.B.
D. Milne Home.

General Secretary—Dr John Hutton Balfour.

Secretaries to the Ordinary Meetings.

Dr George James Allman.
Professor P. Guthrie Tait.

Treasurer—David Smith, Esq.
Curator of Library and Museum—Dr Douglas Maclagan.

Councillors.

A. Keith Johnston, Esq.
Rev. Dr Stevenson.
Dr Stevenson Macadam.
Hon. Lord Jerviswoode.
James T. Gibson-Craig, Esq.
Edward Sang, Esq.
Sir James Coxe, M.D.
Rev. Dr Blaikie.
Dr Christison.
Dr A. Crum Brown.
Dr Burt.
Professor Macdougall.

Monday, 4th December 1865.

The President, Sir David Brewster, at the request of the Council, delivered the following Opening Address:—

Among the various functions which our scientific institutions are expected to discharge, not the least important is to foster the labours and protect the interests of discoverers and inventors,—of those who create new forms of matter and new processes of art,—who invent new instruments, and new machinery for controlling and rendering useful the forces of the material world.

The rights of property, in its material phase, whatever be its character, and by whatever means it has been acquired, have ever been held sacred, even in barbarous communities. The hoarded treasure, or the portion of the earth's crust which it may purchase, can be wrested from its owner but by the forfeiture of crime, or the grasp of conquest. As civilisation advances, new wants are developed, and new rights established. The historian, the philosopher, the antiquary, and the poet—the pioneers of intellectual life—strive to instruct and amuse us, and claim in return our sympathy and protection. Hence has arisen the law of copyright, in virtue of which the author of any work, however frivolous in its character, however immoral in its tendency, however subversive of order, and however hostile to religion, acquires a right of property which successive Acts of Parliament have enhanced in value, by lengthening its tenure and adding to its security. This just privilege, of which the humblest and the highest in the community avail themselves, is granted gratuitously by the State, and is enjoyed during the long period of forty-eight years, and by the youngest author during the whole of his life.

In the progress of civilisation, wants other than intellectual demand immediate gratification. The genius of invention in its youngest exercise, is summoned to feed and to clothe us, to conjure from the inner earth the elements of civilisation, to strengthen the human arm and aid the failing eye, to shield us from the elements, and to open to the missionary and the merchant the rough pathway of the ocean. In its manhood, it is summoned to more transcendental functions; to supply, for the higher civilisation, the luxuries and elegancies of life; to carry us swiftly and safely over earth and ocean; to navigate the fields of ether; to converse with the world, in accents of lightning, through the air and under the deep; to bring within our research the most distant star; and to reveal the minutest life which swarms beneath us and around us.

With such functions to discharge, and having discharged them nobly, the inventor might have looked for a generous patronage from the State, and for a monopoly as free and secure as the copyright of the author.

The right of property in inventions has been acknowledged by almost every community in the old and the new world,* and a patent law has been passed to define its character, to fix its limit, and to secure it against infringement.

In England, I grieve to say, her inventors are more cruelly taxed than in any other part of the world. Though her prosperity, more than that of any other nation, depends on the encouragement of the industrial arts, yet she levies from the poor inventor—nay, from her best benefactor, the enormous sum of L.175 for a patent-right of *fourteen* years. In France the same privilege, for *fifteen* years, is given for L.60, paid by instalments of L.4 for each year of its tenure; and in the United States a patent continues *seventeen* years, and costs only L.7, 6s. 10d. In Sweden and Norway a patent is given for *fifteen* years, for the mere expense of advertising the specification. In other countries the diversities in the expense and endurance of patent rights, measure the legislative wisdom which characterises the laws that pretend to encourage the useful arts; and show us how unblushingly the limited means of the poor inventor are transferred to the pockets of ignorant officials, and, in this country, accumulated in the coffers of an overflowing Exchequer.

The consequences of such ungenerous legislation it is not difficult to discover. The average number of patents granted annually in England is 2000, in France 4000, and in the United States 4000; and hence we are entitled to infer that upwards of 2000 patents are annually suppressed in England, and that many valuable inventions

* Switzerland, China, and Japan have no patent law.

and processes in the arts are either not perfected by their authors, or employed in secret and for ever lost to society.*

This is not the occasion to analyse the patent laws of England, and to criticise the principles which are supposed to regulate their enactments. It may be enough to have referred to the miserable tenure of *fourteen* years which they assign to the inventor; to the crushing tax of L.175 which they levy from him; to the illusory privilege which they give him; to the endless litigation into which they lead him; and to the bankruptcy and ruin in which he is so frequently involved. There are, doubtless, cases in which patent rights have led to fortune, but it is chiefly when the wealthy capitalist has come to the rescue of the humble inventor, or when the patent has been confirmed by the decision of a court of law.

The injustice of the patent law has been so fully admitted, that various acts of Parliament have been passed in favour of the patentee, adding slightly to the protection of his right, and reducing to the sum we have mentioned the expense of its attainment; but no addition has been made to the shortness of its tenure, and no increase of security against direct piracy, or partial infringement.

Whatever difficulty the statesman may experience in giving security to the rights of inventors, he can have none in giving them the same tenure as copyrights, and conferring them as gratuitously, or at no greater cost than is necessary to cover the expenses of the patent office.

Between the national claims of authors and inventors there can be no comparison. Value as you may, and value highly, the treasures of ancient and of modern thought, what are they when weighed against the inventions of art and science, predominating over our household arrangements, animating our cities with the sounds of industry, and covering with mechanical life the earth and the ocean? The eloquence of the orator, the lesson of the historian, the lay of the poet, are, as it were, but the fragrance of the plant whose fruit feeds us, and by whose leaves we are healed; or

* On this subject the Commissioners state, in their recent Report, that "They have been pressed with the opinion, that the cost of obtaining letters-patent is still so high as to be an insuperable bar to the poor inventor, in obtaining the protection to which he is fairly entitled."—*Report*, p. v. Lond 1865.

as the auroral tint which gives a temporary glory to a rising or a setting sun. But grant to the favoured genius of copyright its highest claims, and appreciate loyally its most fascinating stores, their value is shared, and largely shared, with that of the type, the paper, and the press, by which these stores have been multplied and preserved. The relative value of books and inventions may be presented under another phase. Withdraw from circulation the secular productions of the press that are hoarded in all the libraries of the world, and society will hardly suffer from the change. Withdraw the gifts with which art and science have enriched us—the substantial realities through which we live, and move, and enjoy our being—and society collapses into barbarism.

Under the influence of views like these, the friends of inventors have continued to watch over their interests, and to prosecute improvements on the Patent Laws. In this cause some of the leading members of the British Association, the Inventors' Institute, and the Social Science Congress, have been specially active, and through their exertions the subject was brought before the House of Commons in the last session of Parliament. In the discussions which took place in the House and in the Commission, the most startling opinions were advanced, and by some persons received with favour. The entire abolition of Patent Rights was gravely proposed, and the Report of the Commission was not submitted to the consideration of Parliament, on the ground that that fundamental question should be previously decided.

Had this proposal to rob the citizen of the most sacred of his rights been accompanied with any suggestion that Government should give equitable rewards for successful inventions, even patentees might have welcomed the change; but no such suggestions have been made, and, judging from the past history of British science and art, we cannot indulge the hope of any such act of national liberality. It is under despotic governments alone that national benefactors are rewarded and honoured. Where mammon is in the ascendant, and the demigods of trade and commerce influence legislation, intellectual eminence must look to other lands for its recognition and its patronage. The present raid against the patent laws is the direct and acknowledged result of the ungenerous influence of trade. The shortness of the tenure of patent rights, and the heavy tax levied from inventors, are expressly maintained, in order to diminish the number of patents; and the avowed reason for thus diminishing them is, that from their number and frivolity they interfere with the operations of tradesmen and manufacturers, by exposing them to actions for infringement.*

That there are many patents not remunerating, and not immediately beneficial, is painfully true, when we consider how much they have cost the sanguine inventor. That there are any patents really frivolous or useless, in the true sense of these terms, can be maintained only by ignorant or interested parties. There is no patent that does not contain a proposal to do something that is new, or to make some improvement upon what is old; and there are many examples of apparently useless patents containing the germs of future and valuable inventions. There are cases even in which the invention stigmatised as useless has proved to be an essential element in a future patent, where the new patentee has piratically used it, and dared to complain that he has been prosecuted for infringement. But there is a still more intelligible reason why no patent can be called useless. In bringing it into the market, workmen are employed, and materials purchased; and even if the process, instrument, or machine thus offered to the public has no sale and no useful application, the hapless patentee has

* On this subject the commissioners make the following statement:—

"The evil arising from the multiplicity of monoplies *is alleged* to be of a twofold nature. In the first place, that of the existence of a number of patents for *alleged inventions* of a *trivial character;* in the second place, that of the granting of patents for inventions which are *either old* or *practically useless*, and are *employed by the patentees* only to *embarrass rival manufacturers*."—*Report*, p. v. London, 1865.

These *allegations* submitted to the commissioners are not supported by specific facts, and are the mere opinions of interested parties. Before giving effect to such allegations, we may demand the following information:—

1*st*. A list of *alleged inventions* of a *trivial character.*

2*d*. A list of *old* patents that have embarrassed rival manufacturers.

3*d*. A list of *practically useless* patents that have embarrassed rival manufacturers.

4*th*. A list of the embarrassments occasioned to *rival* manufacturers by old, trivial, and useless patents; and,

5*th*. A list of actions for the infringement of patents, with the grounds upon which their validity was challenged.

given liberal fees to several functionaries of the State, and contributed nobly to the Patent Fund.

That any patent is frivolous and injurious, in the sense of interfering with the functions of honest traders, is simply untrue. If an invention which has been patented at the cost of L.175, and produced nothing in return, is a necessary part of an important invention subsequently patented, it is a positive proof that patents apparently frivolous may be truly valuable. The first invention is, therefore, neither an obstacle to improvements, nor a ground for litigation. It has, on the contrary, led to a greater invention; and whether the second patentee has used it ignorantly, or advisedly, he ought to pay for the use of it, instead of pleading in a court of law, as he generally and dishonestly does, that the original specification is defective.

But even if the cases of interfering patents were more numerous than they are, and more fertile in litigation, it is the lawgiver, and not the inventor that is to blame. If Parliament, in its wisdom, cannot reconcile the interests of patentees and honest tradesmen but by robbing the former, they overlook the fundamental law in social economy, that no great improvement can be made in the arts of life, and no true reform in our institutions, without interfering with a variety of interests.

To abolish intellectual rights inherent in man, and long recognised and enjoyed, and this, too, on the single ground of public convenience, would be a retrograde step in legislation, of which history affords no example. As well might the surgeon propose to heal a rheumatic limb by amputation, or the philanthropist reform a criminal by his execution.

In proposing to abolish patent rights, its promoters seem to have wholly overlooked the international interests that are at stake. If we have no patent law, we deprive every foreigner of his existing right to a British patent. Foreign governments may therefore adopt a policy of retaliation, and refuse to our countrymen the patent rights which they now so freely enjoy; or, what is more probable, they may hold out additional privileges to our ingenious artisans, and thus obtain the first fruits of their skill. Inventors will follow their inventions, and in the exodus to foreign countries,—to the United States, especially, with its cheap and judicious patent laws, we shall lose, more rapidly than we have yet done, the most ingenious of our inventors, and the most useful of our citizens.

A policy like this, so Bœotian in its character, and so injurious in its results, is as politically unsafe as it is socially unwise, and personally unjust. Rights that have been firmly established and long enjoyed are not readily abandoned. Illiberal and oppressive as the patent laws are, they are still the *Magna Charta* of the commonwealth of inventors, and in an age tending to democracy they will not be surrendered without a struggle. Rights hitherto unquestioned, and not more sacred, may be exposed to the same scrutiny, and social interests endangered which all classes have been accustomed to respect and defend.

If these views of patent rights be just, and if, as moveable property, they are as sacred as copyrights, there can be no just reason why they should not be granted equally cheap, given to every applicant, and enjoyed during at least the life of the patentee. When a philosopher or an artisan offers an invention to the State, and receives an exclusive privilege in exchange, we might expect some equality between the gift and its reward. In perfecting his invention the inventor has already spent much of his time, and in many cases exhausted his means. When a suppliant at the Patent Office a heavy payment is demanded, and he purchases a privilege which may ruin him. The theory of such a tax it would be difficult to discover. Its avowed object is to diminish the number of patents for the benefit of non-inventors; but the object which it really accomplishes is to paralyse inventions; to cause valuable processes to be wrought in secret, and in many cases to be lost; to give fees to clerks and officers of State, and to create a fund, the purpose of which has not yet been revealed. A tax sufficient to defray the expenses of a patent office* might be justly exacted, but to demand a sum twenty-fold that amount is a freak of finance, alien both to reason and justice. Will it be believed in an enlightened age, that the sum paid by inventors to the State during

* In the Report of the recent Commission, it is stated that the Commissioners "find a very general expression of opinion that the price to be paid by inventors in the aggregate, should not be more than sufficient to provide for the expenses of the Patent Office Library and Museum."—*Report*, p. x. Lond. 1865.

nine years and a-half, from October 1852 to December 1861, was L.772,778, which, at the same rate, will be L.1,001,764 at the end of the present year?

Of the sum of L.772,778 received in 1861, L.502,000 has been expended, viz., L.96,000 in fees to law officers and their clerks, who do nothing for the inventor, and L.406,000 for the expenses of the Patent Office.

After all this expenditure, the enormous sum of nearly a quarter of a million of money, wrenched from the inventive genius of England, slumbers, unapplied, in the Exchequer, while our schools and universities are left to starve, and the interests of science and art consigned to the munificence of our scientific institutions.

In discussing the policy of untaxing, extending, and securing patent rights, we may view them in relation to the doctrine of free trade, now developing itself in the legislation of every civilised community. In the present state of the law, patent rights may be said to be imported and exported as freely as the instruments and machines in which they are embodied; but in so far as they are more taxed in one country than another, the trade in their products and in their privileges cannot be considered free. A discovery in science, and a process or invention in art, are gifts offered to the families of mankind wherever they are made, and whatever be their character. To fetter their development in one country while they are fostered in another, is an act of international injustice, which free trade disclaims. To tax them anywhere, under any circumstances, and under any pretence, is a blot upon political wisdom, an act of cruelty to genius, and a wrong inflicted upon society at large.

In tracing the rise and progress of those great inventions and discoveries which have added to our physical enjoyments and consolidated our power over the material world, we cannot fail to recognise the grand object which, in the arrangements of Providence, they are meant to accomplish. Whatever man is fitted to understand he is destined to know. Whatever has been created for his use he is destined to enjoy. We have yet much to learn of the sidereal universe of which we form a part; of the system of planets to which our own belongs; of the physical history and construction of our terrestrial home; of the organic and inorganic substances which compose it; of the precious materials stored up for civilisation; and of those noble forms of life and beauty which everywhere appeal to the affections and intelligence of man.

But while we have thus much to learn we have also much to do, and whatever we have power to do must eventually be done. The great inventions which, in living memories, have so mysteriously altered the social condition of our race, measure to us, however feebly, what art and science have still to accomplish. Our gigantic steam-vessels—our telegraphs, aerial and submarine—our railways—our light-houses, are still in their infancy. We have yet to pass through the sea with a surer compass, a sharper prow, and a stronger impulse. We have yet to speak more articulately through the air and beneath the ocean. We have yet to guard our coasts with brighter beacons and safer lifeboats; and our railways have yet to convey us more swiftly and safely to our home. But, what is more important still, we have yet to discover and combat those subtle poisons which are everywhere assailing the seat of life, and hurrying thousands of their victims to the grave.

In the completion of these great inventions and discoveries, we shall then learn, what statesmen have been unable or unwilling to learn, that art and science are the means by which the blessings of religion and civilisation are to be sent to the distant isles of the sea,—the several families of the earth united in one, and the reign of peace and righteousness established on the earth.

But while art and science are thus adding to our social blessings, and are pre-eminently the instruments of peace, they have in our day been busily and successfully employed in forging the weapons of violence and destruction. Nor is this a retrograde step in civilisation. By increasing the dangers, we diminish the chances, of war. In perfecting the machinery of Death, we eventually add security to Life. War may become so disastrous in its consequences, so indiscriminate in its slaughter, and so appalling in its carnage, that it will cease to be the arena of the heroic virtues; and this bloody scourge of humanity—the master crime of nations—will be crushed by the genius of art, and perish by the weapons itself has used.

In calling your attention to the present state of our Society, I regret to say that during the year which is about to close, our losses have been unusually severe, not only when reckoned numerically, but when measured by the talent and reputation of the colleagues we have lost.

Of our foreign Honorary Fellows we have lost two, Frederick George William Struve of Pulkowa, and Professor Encke of Berlin. Of our Honorary Home Fellows we have lost three—Sir John Richardson, Sir William Jackson Hooker, and Sir William Rowan Hamilton. Of our Ordinary Fellows we have lost seven:—Mr James Skene of Rubislaw; Professor Aytoun; Sir John Maxwell of Pollock, Bart.; Sir William A. Maxwell of Calderwood, Bart.; Dr Maclagan; Sheriff Gordon; and Dr Thomas Herbert Barker, Bedford. Two Fellows of the Society have resigned—Mr G. R. Maitland, and the Rev. Dr Nisbet. The names of two Fellows have been cancelled—Mr A. Mackenzie Edwards, and Mr Alfred Wanklyn. Two of the Fellows in our last list should have been transferred to the list of British Honorary Fellows—Dr Thomas Graham, Master of the Mint; and Sir John F. W. Herschel.

The following seven new Fellows have been elected:—Messrs Alfred R. Catton, Charles Jenner, Charles Lawson, junr., Dr John Moir, James Powrie, Rev. Francis Redford, and James Stevenson.

Upon our roll for 1864 we had Ordinary Fellows, .	279
Of these 7 have died, 2 have resigned, 2 have been cancelled, and 2 have been placed on the honorary list, .	13
Leaving	266
New Ordinary Fellows elected, ...	7
Total Ordinary Fellows on our list, . . .	273

In proceeding to give a brief, but necessarily imperfect account of the colleagues we have lost, I must plead the difficulty of obtaining the requisite information so soon after their decease. On the present occasion, the duty is one of delicacy also, as I have been in personal communication with all of them but one, and with some in relations of a warmer kind. It is likewise one of some solemnity when discharged by one who, with a single exception, is senior to them all.

Frederick George William Struve, a distinguished astronomer, was born at Altona, on the 15th April 1793, and was the fourth son of Dr Jacob Struve, Director of the Gymnasium in that city. At the University of Dorpat, which he entered in 1808, and where his elder brother was classical lecturer, he took the degree of Doctor of Philosophy in 1813, and in the following year he was appointed Assistant at the Observatory, and Extraordinary Professor of Astronomy. In 1820, he was chosen Director of the Observatory, an office which he held till 1839, when he was called to the direction of the great observatory which the Emperor of Russia had established at Pulkowa, and furnished with the finest instruments.

Between 1816 and 1819, he executed the trigonometrical survey of Livonia. Between 1822 and 1827, he measured a part of the meridian in the Baltic provinces; and in 1831 he published an account of his operations. In 1828 he connected this survey with that of General Tenner; and in 1851 he completed the measure of the Russo-Scandinavian arc of the meridian between Ismael, at the mouth of the Danube, in 45° 20′ and Fuglenaes in 70° 40′ of north latitude,—an arc of 25° 20′, the largest that ever has been measured.

Among the other scientific expeditions undertaken by M. Struve, was the levelling of the country between the Black Sea and the Caspian Sea, the determination of the geographical position of several points in Siberia, in the Trans-Caucasian provinces and in Asiatic Turkey, and the observation of the great eclipses of 1842 and 1851. The results of these different expeditions have been published in the Memoirs of the Academy of Sciences of St Petersburg.

During the fifty years spent by M. Struve in the observatories of Dorpat and Pulkowa, he made many valuable observations on double and multiple stars; on the parallax of the stars, on their distribution in space; on the Milky Way; and on the motion of the solar system. His observations at Dorpat between 1837 and 1839 have been published in eight volumes. Those on Double Stars are contained in treatises published in 1820, 1827, 1830, 1837, and 1852; and those on the Parallax of the Fixed Stars, on the Milky Way, and on the Motion of the Solar System in Space, were published in 1847, in a very interesting volume, entitled "Etudes d'Astronomie Stellaire." Adopting 0″·209 as the parallax of stars of the first magnitude, he found that the annual velocity of the solar system round a point in the constellation Hercules is 33 millions of geographical miles, and that we may wager 400,000 to 1 that such a motion exists.

Frederick Struve was an ordinary Counsellor of State, a Commander of the Legion of Honour, and a Corresponding Member of the Imperial Institute of France. He died at St Petersburg, after a short illness, on the 23d November 1864, in the 72d year of his age, and was succeeded in the Direction of the Observatory of Pulkowa by his distinguished son, Otto William Struve, well known to the scientific world by his writings and his astronomical labours.

John Francis Encke, a distinguished astronomer, was born at Hamburg on the 23d September 1791. His father, who was minister of the church of St James', in that city, sent him to the University of Gottingen, where he studied under the celebrated Gauss, who was then Professor of Mathematics, and Director of the Observatory. In 1813 he was enrolled for active service in the military force raised by the Hanseatic towns, and afterwards rose to the rank of lieutenant of artillery in the Prussian service. In this capacity his acquirements became known to Baron Lindenau, the Director of the Observatory of Seeberg, near Gotha. Having become Minister of State in 1817, the Baron gave young Encke the entire charge of the Observatory, which he conducted so ably that he was made Joint-Director in 1829. Soon after this he was called to Berlin, where he was appointed Director of the Royal Observatory, and became Secretary to the Academy of Sciences.

During his occupation of these two observatories Encke made many valuable contributions to astronomy. Among the most important were his determination of the orbit of the famous comet of 1680, of the distance of the earth from the sun, and of the orbit of the comet discovered by Pons in 1818; for the first of which he obtained the prize of Cotta, adjudged to him by Gauss and Olbers. His solution of the problem of the Earth's Distance from the Sun, by the aid of the Transits of Venus in 1761 and 1769, was published in two memoirs, entitled *La Distance du Soleil.* In several papers in the Memoirs of the Academy of Berlin, between 1829 and 1851, he demonstrated the periodicity of Pons' comet, which he proved to be identical with the comets of 1786, 1795, and

1805. This interesting body, now known as Encke's Comet, moves in an elliptical orbit within that of Jupiter, and completes its revolution in three years and four mouths. Having found that from 1786 to 1795 the time of its revolution had diminished from 1208·11 days to 1207·88, and between 1795 and 1805 from 1207·88 to 1207·42 days, he concluded that the diminution was produced by the action of Jupiter; but upon using a more correct value of the mass of that planet, he found that the difference between the observed and computed places of the comet could be accounted for only on the hypothesis of a resisting medium—a doctrine which, in its astronomical relations, must remain in abeyance, till it is exhibited in the motions of other celestial bodies.

Upon his removal to Berlin, Encke became editor of the *Astronomisches Jahrbuch*, which contains many of his papers on physical astronomy. He visited Scotland in 1839, and took an active part in the proceedings of the British Association which met at Glasgow. He was a member of many foreign academies, and a Corresponding Member of the Imperial Institute of France. He died at Berlin in 1865, in the seventy-fifth year of his age.

Sir John Richardson, the distinguished Arctic traveller and navigator, was born at Dumfries in 1787, and was educated at the grammar school of that town. He entered the University of Edinburgh in 1801, with the view of following the medical profession. After obtaining the diploma of the Royal College of Surgeons, he was appointed assistant-surgeon to the Nymphe, one of Sir Richard Keats' squadron, which accompanied Lord Gambier to the bombardment of Copenhagen. In 1807 the Nymphe was employed in the blockade of the Tagus; and Mr Richardson was present, as a volunteer, in two unsuccessful attempts to cut out vessels anchored higher up the river. After serving in different ships in various parts of the world, he returned to Edinburgh to pursue his medical studies; and in 1817 he took the degree of doctor of medicine. In 1819 he was appointed surgeon and naturalist to the expedition under Lieutenant Franklin, which was sent to survey the northern coast of North America. He returned to England in 1822, and in 1824 he was appointed surgeon to the royal marines at Chatham. In the expedition under Captain Franklin, which was carried on in the years 1825–6–7, Dr Richardson surveyed with great ability the sea-coast between the Mackenzie and the Coppermine Rivers; and after his return, he resumed and continued his duties at Chatham till 1838, when he was promoted to the rank of physician to Haslar Hospital, and Inspector of Naval Hospitals and Fleets— a situation which gave him leisure to pursue the studies to which he had been so long devoted. His services, however, were too valuable to be dispensed with; and though now in the sixtieth year of his age, he set out with Dr Rae, in 1848, in search of Sir John Franklin and his party. After encountering perils both on land and sea, and surmounting difficulties of no ordinary kind, he returned to England in 1849, and continued for six years in the charge of Haslar Hospital. In 1855 he retired from the public service, to which he had devoted himself for nearly half a century, and settled at Lancrigg, in Westmoreland, where he died on the 5th January 1865, in the seventy-eighth year of his age.

Sir John received the honour of knighthood in 1846, and was afterwards made a Companion of the Bath. He was a Fellow of the Royal, Linnean, and Geological Societies, and a member of various philosophical societies, both in this country and the Continent.

Sir John is the author of the *Fauna Borealis Americana*, and of works on almost every branch of natural history, several of which appeared as appendices to the voyages of different Arctic navigators. He contributed several articles to the "British Encyclopædia," and was one of the editors of the "Museum of Natural History."

Sir William Jackson Hooker, a distinguished botanist, was born at Norwich on the 6th of July 1785, and received his early education at the High School of that city. His father, who was a man of literary tastes, possessed a collection of rare and curious plants; and it was no doubt from this circumstance that he was led to the early study of botany. Having inherited from his godfather, William Jackson, Esq., a considerable landed property, he resolved to devote himself to scientific pursuits; but in order to improve his lands, he spent some time in the study of agriculture at Starston in Norfolk.

Here, however, he devoted most of his time to the study of natural history, making a fine collection of the birds and insects of Norfolk. Having discovered a new and curious British moss, the *Buxbaumia aphylla*, he took it to Sir James Edward Smith, and was encouraged by that eminent botanist to pursue the study which he had so successfully begun. In 1806, when he came into possession of his fortune, he made extensive botanical tours in the remotest parts of Scotland in company with Dawson Turner, Esq., whose eldest daughter he married in 1815. By the advice of Sir Joseph Banks, with whom he became acquainted during his residence in London, he visited Iceland in 1809, and made large collections there in every department of natural history. The ship, however, in which he returned was burned at sea, and he himself miraculously escaped by the help of another vessel, with the loss of all his manuscripts, drawings, and specimens. His account of this journey, drawn up from memory, was published in 1811 under the title of "Recollections of Iceland," the first of a series of works which raised him to a high place in the scientific world.

In 1810–11 he made great preparations to accompany Sir Robert Brownrigg, who was going out as governor to Ceylon, but the sanguinary disturbances which took place in that island prevented him from visiting it.

In 1814 he made a botanical tour of nine months in France, Switzerland, and the North of Italy, and thus became acquainted with many of the most distinguished botanists in Europe. In 1812 he began his first botanical work, on the British Jungermanniæ, which was completed in 1816. This work was followed by his *Muscologia Britannica* and his *Musci Exotici*, the first of which was published in conjunction with Dr Taylor in 1817.

While engaged in these and other works, he found it necessary to look out for some permanent employment. He had sold his landed property in 1811, and vested the proceeds in different securities, which had so rapidly deteriorated, that in 1820, on the advice of Sir Joseph Banks, he accepted of the vacant Professorship of Botany in the University of Glasgow, which was then worth little more than L.100 a year, but which afterwards rose to upwards of L.800.

During the twenty years he resided in Glasgow he published his

Flora Scotica, which appeared in 1821; his *Flora Exotica,* in 1823–27; his *Icones Filicum,* in conjunction with Dr Greville; and in 1839 the first edition of his *British Flora,* in the 12th edition of which he was assisted by Professor Walker Arnott.

In 1836 he received the honour of knighthood, and through the influence of Earl Russell he was appointed, in 1841, Director of the Royal Gardens at Kew, a situation which he held during the rest of his life. In this favoured position he improved the arrangements of the Gardens, and prevailed upon Government to build a noble palm-house and extensive conservatories, and he founded a library and botanical museum, in which his noble herbarium, the largest in Britain, is deposited.

The works of Sir William Hooker, comprising upwards of fifty volumes of descriptive botany, illustrated chiefly by drawings from his own exquisite pencil, are too numerous to be mentioned in detail in a brief notice of his life.

Sir William was a Knight of the Hanoverian Order and a Chevalier of the Legion of Honour, and he received from Oxford the degree of D.C.L., and from Glasgow that of LL.D. He was a Fellow of the Royal, Linnean, Antiquarian, and other English Societies, and a Corresponding Member of the Imperial Institute of France, and of all the principal Academies in Europe and America.

He died at Kew on the 12th of August 1865, in the 80th year of his age, and is succeeded in the direction of the Royal Gardens by his distinguished son, Dr Joseph Dalton Hooker.

Our list of British Honorary Fellows has sustained an irreparable loss by the recent death of Sir William Rowan Hamilton, one of the greatest mathematicians that have ever lived.

At an early age he displayed uncommon talents, especially in the study of languages. He is said to have acquired nearly a dozen different languages when only thirteen years old. In his fifteenth year he had already mastered all the branches of mathematics usually taught in a university; and in his twenty-second year, while but an undergraduate of Trinity College, Dublin, was appointed Andrews' Professor of Astronomy, and Astronomer-Royal for Ireland, as successor to Dr Brinkley, who had been one of the first to recognise his wonderful mathematical powers, and to guide his early investigations.

These early investigations, which had reference chiefly to Geometrical Optics, were gradually developed into an elaborate "Theory of Systems of Rays," which was communicated to the Royal Irish Academy in 1828. In the third supplement to this essay, he predicted from theory the existence of the two species of Conical Refraction, the experimental verification of which has given so much additional probability to the hypothesis of luminiferous undulations.

His next great papers were entitled "On a General Method in Dynamics," and appeared in the Philosophical Transactions in 1833–34. In these he developed the principle of Varying Action, the discovery of which constitutes one of the most important steps which dynamical science has yet made. In these investigations, both optical and dynamical, the novel and remarkable feature is the discovery of the existence of a single function (adapted to each particular problem), from which, if known, the complete solution of the problem is to be found by differentiation alone. These papers soon gave him a European fame, and procured for him the honorary diploma of all the most important scientific societies abroad, as well as at home. Though much has been done, especially by Jacobi, in extension of Hamilton's results, it has been almost entirely confined to their analytical aspect; the physical discoveries which must abundantly flow from them have, as yet, been barely sought for.

But perhaps Hamilton was most widely known by his splendid invention of "Quaternions." A profound general principle in optics or dynamics is heard of only by the few who can understand it; but a new mathematical method is, at least in its elements, accessible to all. Little has yet been done to disseminate elementary knowledge of this important Calculus. Hamilton's "Lectures on Quaternions" (1853) is adapted only to a high class of readers; but it is to be hoped that his posthumous work, to which he devoted the last six years of his life, and which (under the title of "Elements of Quaternions") is announced for speedy publication, will put within the reach of the intelligent beginner a branch of mathematics which for simplicity of conception, symmetry, variety of expression, and almost irresistible power, may well challenge comparison with any yet devised.

Hamilton's other numerous publications, chiefly in scientific journals, such as the "Transactions of the Royal Irish Academy," the "Philosophical Magazine," &c., are devoted to the most varied subjects. "Algebra as the Science of Pure Time," "Abel's argument as to the impossibility of solving the general equation of the fifth degree," "Definite Integrals," "Fluctuating Functions," "Icosian Calculus," &c., may be taken as examples. But, besides all this, he is understood to have left an immense store of manuscript investigations on subjects of the greatest importance, from which, it is to be hoped, copious selections will be published. Hamilton was scrupulous, almost to excess, as to the exactness and symmetry of everything he published; and it may be that, among the investigations which he did not consider properly polished for the press, there are gems of even greater value than those which have seen the light.

In a life of but sixty years such a mass of original work has not often been accomplished; but when we consider that Hamilton retained to the last his love for languages (especially Persian), that he was no mean poet, that he was one of the most copious of correspondents, and that he willingly entered into the minutest details when applied to for explanations on subjects connected with his writings, we wonder how he found time for a mere fraction of what he has done.

Sir John Herschel once wrote thus :—"Here, whole branches of continental discovery are unstudied, and, indeed, almost unknown even by name. It is vain to conceal the melancholy truth. We are fast dropping behind. In mathematics we have long since drawn the rein and given over a hopeless race, &c." Hamilton, while second to none, was one of the earliest of that brilliant array of mathematicians who, since Herschel wrote, have removed this stigma, and well-nigh reversed the terms of his statement. Another was the late Professor Boole, who, though not a Fellow of this Society, claims notice in this address as having received our highest honour, the Keith Medal. Their death has made a gap in the ranks of British science which will not soon be filled; and our sorrow is but increased by the recollection that they have been removed in the full vigour of their intellect, and when their passion for work was, if possible, stronger than ever.

Dr David Maclagan was born in Edinburgh in February 1785. After receiving his classical education at the High School, he entered the University as a student of medicine, and was apprenticed to Mr Andrew Wood, one of the principal surgeons in the city. In 1804 he took his surgeon's diploma, and in 1805 his degree of M.D., and he prepared himself for the medical service of the army by studying at St George's Hospital, and becoming in 1807 a Member of the Royal College of Surgeons in England. Attached to the 91st regiment, he accompanied it to Walcheren, where he had the good fortune to escape the epidemic which decimated the flower of the British army. In 1811, after his return to England, he was under orders for Canada, when he received the appointment of staff-surgeon to the 9th Portuguese brigade, a part of the 4th division, which, under the Duke of Wellington, was investing the fortress of Badajos. He accordingly sailed for Lisbon in November 1811, and was present at the storming of Badajos, and at the subsequent battles of Salamanca, Vittoria, the Pyrenees, the Nivelle, and the Nive, receiving for these services the Peninsular medal, with six clasps. The professional skill which he exhibited on these occasions, and his active zeal for the recovery of the wounded, were frequently acknowledged by his military superiors, and led to his appointment as physician to the forces.

In 1816 Dr Maclagan quitted the army on half-pay; and having been admitted a Fellow of the Royal College of Surgeons, he settled in his native city, when his professional skill soon obtained for him an extensive practice. In 1826 he was elected President of the Royal College of Surgeons, and of the Royal College of Physicians in 1856. He presided also over the Medico-Chirurgical Society, and took an active and intelligent part in all our literary, scientific, and philanthropic institutions. In the cause of medical missions he took an early and zealous part; and the friends of every religious movement could always count upon his active and generous support.

To his professional accomplishments, Dr Maclagan added a taste for the fine arts, and he was intimately acquainted with the eminent artists who in his time adorned our metropolis.

Amid the distractions of his professional life, which lasted more than half a century, he found leisure to study the great social questions of the day, and was an ardent promoter of Parliamentary and burgh reform, free trade, Catholic emancipation, the education of the people, and the abolition of slavery. But while he thus took a zealous part in every question, and in every institution of secular interest, he had ever in his view the higher destinies of man. He was an exemplary member of the Presbyterian Church, and a true believer in those great truths which the wisdom of this world is unable to comprehend. Without any marked disease, but weakened gradually with age, this truly Christian physician and philanthropist expired on the 6th June 1865, in the midst of his family, lamented by a widow and seven sons, some of whom have obtained distinction in the service of their country.

Sir John Maxwell of Pollock succeeded his father as ninth baronet in 1844, and belonged to the twenty-ninth generation of his family. He was born in 1791, and received his early education, partly in Scotland, under the Rev. Dr MacLetchie of Mearns, and partly in England, at Market-Raisin, and subsequently at Westminster School. In 1809 he entered Christ Church, Oxford, as a gentleman commoner, and graduated in that University. In 1812 he attended several classes in the University of Edinburgh; and in the following year, at the age of twenty-two, he was appointed lieutenant-colonel of the Renfrew militia—an office which he very soon resigned, in consequence of the Government refusing to send relief to the starving operatives in Paisley. In 1813, 1814, and 1815, he made the tour of Europe, visiting part of Africa and Asia, accompanied by Mr John Bramsen, an ex-officer of the Prussian service, and afterwards Professor of German in the University of Oxford. A journal of his travels is preserved at Pollock; but a fuller account of them was published in 1818 by Professor Bramsen.

In 1818, Mr Maxwell was elected M.P. for the county of Renfrew, and represented that county in three successive Parliaments. In 1831 he contested the county of Lanark with the brother of Lord Douglas; but though defeated on that occasion, he was elected for that county in 1832, after the passing of the Reform Bill, and again in 1835. As a Member of Parliament, he took an active part in many of the leading measures of the day; and on several occasions when he spoke in the House of Commons, he was listened to with attention and respect.

In 1859, when the Prince of Wales, on the 15th August, visited for the first time his ancient barony of Renfrew—the cradle of his Stuart ancestors in Scotland—he was hospitably received at Pollock House.

Sir John Maxwell was liberal in his politics, and published several pamphlets on Parliamentary reform, and the other great questions which then agitated the country.

In 1839, he married Lady Matilda Bruce, second daughter of Thomas Earl of Elgin and Kincardine. She died on the 31st August 1857, without issue. Sir John died on the 6th of June 1865, in the seventy-fifth year of his age, and was succeeded in his estates by his nephew, William Stirling, Esq. of Keir.

Sir William Alexander Maxwell of Calderwood, descended from the oldest branch of the Maxwells of Pollock, and the seventh baronet, was born on the 30th April 1793. He entered the army at an early age, and held a commission in the 1st or Royal Dragoon Guards. Upon succeeding to his father in 1837, he retired from the service with the rank of colonel. In 1847 he married the fifth daughter of Walter Logan, Esq. of Fingalton. He died on the 4th of April 1865, in the seventy-fifth year of his age, and was succeeded by his brother, Mr Hugh Bates Maxwell, who had been called to the Scotch bar in 1818.

James Skene of Rubislaw, was born on the 7th March 1775. His father died in the following year, leaving a widow and a family of seven children. In 1783, Mrs Skene removed to Edinburgh for their education, and James, who was then the second son and youngest child, was placed at the High School; and was the last survivor of a host of distinguished men who were his class-fellows.

In 1791, after he had left the High School, he succeeded to the family-estate of Rubislaw, by the death of his elder brother; and at the age of twenty-one, he was sent to Germany to complete his studies. After acquiring a knowledge of the French and German languages he returned to Edinburgh, and was admitted to the Scotch bar in 1797. Here he formed an acquaintance with Sir Walter

Scott, which ripened into a close and life-long friendship. Mr Skene had early shown a love of art, and a singular talent for drawing, to which Sir Walter alludes in the introduction to the 4th canto of Marmion, which is dedicated to Mr Skene.

> "As thou with pencil, I with pen,
> The features traced of hill and glen."

In 1797 Mr Skene was appointed cornet of the Edinburgh Light Horse, one of the earliest regiments of volunteers, which was organised mainly by the efforts of Sir Walter Scott. After walking the Parliament House for a few years, Mr Skene revisited the continent in 1802, and travelled over the greater part of Europe during the next few years. In this journey he became acquainted with Mr Greenough, President of the Geological Society of London, and travelled for some time with that distinguished geologist. He thus acquired a taste for geology, and was afterwards elected a member of the Geological Society.

In 1806 Mr Skene married Jane, daughter of Sir William Forbes of Pitsligo, Bart., and settled on a small property he possessed in Kincardineshire, where he spent the next eight years of his life.

In 1816 Mr Skene returned to Edinburgh, for the education of his children, when he joined the different literary and scientific societies, which at that time were not in a very flourishing state. He became a member of the Royal Society in 1817, and as Curator of their Library and Museum, an office which he held for many years, he did eminent service to that important department of the Society. He was also a member of the Antiquarian Society, and took an active part in its reform and restoration.

During his residence in Edinburgh Mr Skene explored and sketched the various buildings in the Old Town that were remarkable for their antiquity or historical interest, and he has left a valuable collection of these sketches, which we trust may be given to the public.

Mr Skene held for many years the office of Secretary to the Board of Trustees and Manufactures, and in this capacity he did much for the promotion of the fine arts in Scotland.

In 1838, when the health of some of his family required a warmer climate, he went to Greece, and settled in the vicinity of Athens.

In an elegant villa, built by himself, he spent eight years; and he has left behind him a series of beautiful water-colour drawings, upwards of 500 in number, of the scenery and antiquities of that interesting country.

On his return to England in 1844, he took up his residence in Leamington. He afterwards went to Oxford, and resided in a curious old mansion, called Frewen Hall, where he enjoyed the best literary society in that seat of learning. After a residence there of nearly fifteen years, he died on the 27th of November 1864, in the 90th year of his age.

Mr Skene was a man of very elegant tastes and numerous accomplishments. He had a great general knowledge of science as well as of literature, and spoke with fluency French, German, aud Italian. He was, as Sir Walter Scott said, "the first amateur draughtsman in Scotland," and was the author of two volumes of Illustrations of the Waverley Novels. But though he used his pencil more than his pen, yet he made several contributions to the Transactions of the Societies to which he belonged, and was the author of the excellent article on painting in the Edinburgh Encyclopædia.

John Thomson Gordon was the only son of Dr John Gordon,—a distinguished teacher of anatomy in this city, and author of several valuable treatises on anatomy and physiology,—and of Miss Rutherfurd, sister of the late eminent lawyer and judge Lord Rutherfurd. He was born in Edinburgh, on the 19th March 1813; and, after gaining distinction as a classical scholar at the Edinburgh Academy and at this University, he prosecuted with great zeal and success the study of the modern languages at Aschaffenburg, in Bavaria. He was called to the bar in 1835, and was remarkable among his compeers for the extent of his scholarship, the richness of his fancy, and the natural eloquence of which he was possessed, and these, from the geniality of his nature, were always at the disposal of his friends and the public.

In 1837 Mr Gordon married the second daughter of Professor Wilson, and has left five sons and one daughter.

He was appointed Sheriff of Aberdeenshire in 1847, and of Mid-Lothian in 1848, an office which he held, and the duties of which he discharged with great ability, till his death, which took place suddenly, at Caen in Normandy, on 22d September 1865.

Thomas Herbert Barker, a distinguished member of the British Medical Association, was born in 1814. He received his professional education at Queen's College, Birmingham, and at University College, London. He was licensed by the Apothecary's Company in 1827, and became a member of the Royal College of Surgeons in 1842, and a Fellow of the same body in 1851. Although he obtained great distinction in the different departments of his profession, yet his reputation mainly rests upon his investigation of the cause of epidemic and endemic diseases.

In 1858, the Fothergill Gold Medal was awarded to him for his essay on Malaria and Miasmàta, which was published in 1862, and in the course of last summer he received from the British Medical Association the Hastings Gold Medal for his essay on Deodorisation and Disinfection. Dr Barker is also the author of a valuable work on the "Hygienic Management of Infants and Children," and of various articles in the medical journals. He died at Bedford of a severe attack of typhoid fever on the 24th October 1865.

William Edmonstoune Aytoun was born in June 1813. His father, who was an eminent writer to the Signet, died when his son was comparatively young. After receiving his elementary education at the Edinburgh Academy, he went through the usual curriculum of study at the University of Edinburgh, which he was destined afterwards to adorn. At the end of his course he went to Germany, where he acquired that knowledge of its literature which is so conspicuous in his writings. On his return to Scotland he passed as a writer to the Signet, but disliking the profession, he was called to the Scottish Bar in 1840, and practised for some time in criminal cases on the western circuit. His time, however, was devoted principally to literature, and, with some exceptions, his earliest productions were contributed to Tait's Magazine, where, in conjunction with his friend Mr Theodore Martin, he began his celebrated Bon-Gualtier Ballads, which have gone through many editions. In 1832 Mr Aytoun published his first separate work entitled "Poland, Homer, and other Poems." In 1833 he made the first contributions to Blackwood's Magazine, and from that time to his death they amounted to more than a hundred and twenty. In 1843 he contributed to that Journal the two beautiful poems entitled the "Burial March of Dundee," and "Charles Edward at Versailles," and in 1845, his celebrated satire on railway speculation, entitled "How we got up the Glenmutchkin." His "Life and Times of Richard III." appeared in 1840, and in 1849 his most popular work, "The Lays of the Scottish Cavaliers," the most interesting of which, "Edinburgh after Flodden," had appeared in Blackwood's Magazine for the preceding year.

In 1845 he succeeded Professor Spalding as Professor of Rhetoric and English Literature in the University. To the duties of this office he devoted himself with great energy and success, raising his class from thirty to upwards of one hundred and fifty students.

In 1849, Professor Aytoun married the youngest daughter of Professor Wilson, in the society of whom ten years of domestic happiness passed rapidly away.

In 1852 he was appointed Sheriff of Orkney and Shetland, spending in these islands several months in the year, and discharging the duties of his office with much assiduity and success.

In 1854 he published "Firmilian—a Spasmodic Tragedy;" in 1856, "Bothwell—a Poem;" in 1858, "the Ballads of Scotland;" and in 1861, a novel, entitled "Norman Sinclair." The last of his separate works was the "Nuptial Ode on the Marriage of H. R. H. the Prince of Wales."

In 1863 Professor Aytoun married Miss Kinnear—a happy union which he was destined not long to enjoy. His health had, in the following winter, begun to fail, and unfitness for intellectual pursuits began to indicate the commencement of some serious malady. In the beginning of last June he went to Blackhills, near Elgin, in the hope of recovering his strength while enjoying the hill and field sports of that delightful neighbourhood. This hope, however, was fallacious. Neither the salubrity of the climate, nor the bracing exercise of the fields, nor the skill of his physician, could arrest the progress of that fatal disease which was rapidly invading the seat of life. He sank gradually under its influence, and in the full possession of his faculties, and he died, as a Christian should die, on the 4th August 1865, in the 53d year of his age.

Among the eminent men whose loss this Society and the University have had recently to deplore, Professor Aytoun holds a distinguished place. As a poet of high talent and varied acquirements, distinguished alike by his genial humour, and by the force and purity of his satire, he will be long and warmly admired, but more warmly still by those who weep over the memories of that unfortunate dynasty which he has so ably and loyally immortalised. As an able and assiduous judge, he will be long and kindly remembered by the islanders among whom he annually laboured; and as a professor in the University which he adorned, his pupils will not soon forget his earnest sympathy with their studies, nor his colleagues his devotion to the interests of the University, and the happy hours which they spent in his society.

The following Donations to the Library were announced:—

Astronomical Observations made at the Royal Observatory, Greenwich, in the year 1862. London, 1864. 4to.—*From the Observatory.*

Seven-Year Catalogue of 2022 Stars, deduced from Observations, extending from 1854–60, at the Royal Observatory, Greenwich. 4to.—*From the Observatory.*

Philosophical Transactions of the Royal Society of London. Vol. CLIV. Parts 1–3; Vol. CLV. 4to.—*From the Society.*

Proceedings of the Royal Society of London. Nos. 75–77. 8vo.—*From the Society.*

Transactions of the Zoological Society, London. Vol. V. Part 4. 4to.—*From the Society.*

Proceedings of the Zoological Society, London. 1864. Parts 1–3. 8vo.—*From the Society.*

Transactions of the Linnean Society, London. Vol. XXV. Part 1. 4to.—*From the Society.*

Journal of the Linnean Society, London. (Botany.) Nos. 33–35. 8vo.—*From the Society.*

Journal of the Royal Geographical Society, London. Vol. XXXIV. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society, London. Vol. IX. Nos. 3–6. 8vo.—*From the Society.*

Quarterly Journal of the Geological Society, London. Vol. XXI. Nos. 82 and 83. 8vo.—*From the Society.*

Journal of the Statistical Society, London. Vol. XXVIII. Parts 2 and 3. 8vo.—*From the Society.*

Journal of the Chemical Society, London. Vol. III. Nos. 28 34. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society, London. Vol. V. Nos. 5–8. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, London. Vol. XXV. Nos. 6–8. 8vo.—*From the Society.*

Proceedings of the Royal Medical and Chirurgical Society, London. Vol. V. No. 2. 8vo.—*From the Society.*

Transactions of the Society of Antiquaries, London. Vol. XXXIX. 4to.—*From the Society.*

Proceedings of the Society of Antiquaries, London. Vol. II. No. 6. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Nos. 123–127. Calcutta, 1864. 8vo.—*From the Society.*

Proceedings of the British Meteorological Society. Vol. II. Nos. 19 and 20. London, 1865. 8vo.—*From the Society.*

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. I. Part 2. (New Series.) London, 1865. 8vo.—*From the Society.*

Proceedings of the Literary and Philosophical Society, Liverpool. No. 18. 8vo.—*From the Society.*

Journal of the Scottish Meteorological Society. Nos. 6–8. (New Series.) Edinburgh, 1864. 8vo.—*From the Society.*

Proceedings of the Geologists' Association, London. Vol. I. Part 2. 8vo.—*From the Association.*

Quarterly Returns of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. Nos. 41–43. Edinburgh, 1865. 8vo.—*From the Registrar-General.*

Monthly Returns of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland for April—October 1865. 8vo.—*From the Registrar-General.*

American Journal of Science and Arts. Nos. 117–119. New Haven, 1865. 8vo.—*From the Editors.*

Proceedings of the Academy of Natural Sciences, Philadelphia, 1864. Nos. 1–5. 8vo.—*From the Academy.*

Canadian Journal of Industry, Science, and Art. Nos. 56–58. Toronto, 1865. 8vo.—*From the Canadian Institute.*

Observations made at the Magnetical and Meteorological Observatory at Trinity College, Dublin. Vol. I., for 1840–43. 4to.—*From the Observatory.*

Plants Indigenous to the Colony of Victoria. Described by Ferdinand Mueller, M.D. Melbourne, 1865. 4to.—*From the Author.*

Report upon the Forests of the Punjab and the Western Himalaya. By H. Cleghorn, M.D. Roorkee, 1864. 8vo.—*From the Author.*

Proceedings of the Privy Council, in the Question as to the Precedence of the Corporations of Edinburgh and Dublin in presenting Addresses to the Sovereign. Edinburgh, 1865. 4to.—*From the Edinburgh Town Council.*

Report on the Sanitary Condition of the City of Edinburgh. By Henry D. Littlejohn, M.D. Edinburgh, 1865. 8vo.—*From the Edinburgh Town Council.*

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in 1862. Vol. XXII. 8vo.—*From the Observatory.*

Fragmenta Phytographiæ Australiæ. By Ferdinand Mueller. Vol. IV. Melbourne, 1864. 8vo.—*From the Author.*

Essays on the Invasion of Britain by Julius Cæsar, Plautius, and Claudius; Early Military Policy of the Romans in Britain, and the Battle of Hastings, with Correspondence. By George Biddell Airy, Esq. London, 1865. 4to.—*From the Author.*

Meteorological Papers (No. 13), published by authority of the Board of Trade. Nova Scotia, 1865. 4to.—*From the Board.*

Catalogue of the Melbourne Public Library for 1861. 8vo.—*From the Library.*

Hippocratis et aliorum Medicorum veterum Reliquiæ. Edited by F. Z. Ermerius. Amsterdam, 1864. 4to.—*From the Royal Academy, Amsterdam.*

Verhandelingen der Koninklijke Akademie van Wettenschappen.

Letterkunde, Deel III.; Natuurkunde, Deel X. Amsterdam. 4to.—*From the Royal Academy, Amsterdam.*

Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Letterkunde, VIII.; Natuurkunde, XVII. 8vo. —*From the Royal Academy, Amsterdam.*

Jaarboek van de Koninklijke Akademie van Wettenschappen, 1863–64. 8vo.—*From the Royal Academy, Amsterdam.*

Musée Vrolik.—Catalogue de la Collection d'Anatomie humaine, Comparée et Pathologique de MM. Ger et W. Vrolik. Par J. L. Dusseau. Amsterdam, 1865. 8vo.—*From the Author.*

Memorie del Reale Istituto Lombardo di Scienze et Lettere. Classe di Scienze Matematiche e Naturali, Vol. X. 1 della serie, III. Fasc. 1; Classe Morali e Politiche, Vol. X. 1 della serie, II. Fasc. 1. Milano, 1865. 4to.—*From the Institute.*

Rendiconti, Classe di Scienze Matematiche e Naturali. Vol. I. Fasc. 9, 10; Vol. II. Fasc. 1, 2. Classe di Lettere e Scienze Morali e Politiche, Vol. I. Fasc. 8–10; Vol. II. Fasc. 1, 2. 8vo.—*From the Institute.*

Mémoires Couronnés et Mémoires des Savants étrangers publiés par l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XXXII. Bruxelles, 1865. 4to.—*From the Academy.*

Mémoires Couronnés et autres Mémoires. Tome XVII. 8vo.—*From the Academy.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tomes XVIII., XIX., XX. Nos. 6–8. 8vo.—*From the Academy.*

Annuaire de l'Académie Royale de Belgique, 1865. 12mo.—*From the Academy.*

Annuaire de l'Observatoire Royal de Bruxelles, 1865. 12mo.—*From the Observatory.*

Atti dell' Imp.-Reg. Istituto Veneto di Scienze, Lettere, ed Arti. Tomo nono, serie terza, dispensa sesta-decima, 1863–64. Tomo decimo, serie terza, dispensa prima-quarta, 1864–65. 8vo.—*From the Institute.*

Bulletin de la Société de Géographie. Tome VIII. Paris, 1864. 8vo.—*From the Society.*

Annales des Mines. Tome VI. Liv. 6; Tome VII. Liv. 1–3. Paris, 1865. 8vo.—*From the Ecole des Mines.*

Mémoires de l'Académie Impériale des Sciences, Belles-Lettres, et Arts, de Lyon. Classe des Sciences, Tome XIII.; Classe Lettres, Tome XI. Lyon, 1863. 8vo.—*From the Academy.*

Bulletin des Séances de l'Académie Impériale. Lyon, 1865. 8vo. —*From the Academy.*

Memorias de la Reale Academia de Ciencias Exactas, Fisicas y Naturales, de Madrid. Tomo VI. Part. 1, 2. 4to.—*From the Academy.*

Resumen de las Actas de la Reale Academia de Ciencias Exactas, Fisicas y Naturales, de Madrid, 1862–63. 8vo.—*From the Academy.*

Libros del Saber de Astronomia del Rey D. Alfonso X. de Castilla, copilados, anotados y comentados por Don Manuel Rico y Sinobas. Tom. III. Madrid, 1864. Fol.—*From the Academy.*

Rendiconto della Reale Accademia di Archeologia, Lettere, e Belle Arti, 1864. Napoli, 1864. 4to.—*From the Academy.*

Statistique Internationale (population) publiée avec la Collaboration des Statisticiens Officiels des différents états de l'Europe et des Etats-unis d'Amerique. Par Ad. Quetelet et Cav. Henschling. Bruxelles, 1865. 4to.—*From the Authors.*

Histoire des Sciences Mathématiques et Physiques chez les Belges. Par Ad. Quetelet. Bruxelles, 1864. 8vo.—*From the Author.*

Bulletin de la Société Vaudoise des Sciences Naturelles. Tome VIII. Nos. 51 and 52. Lausanne, 1865. 8vo.—*From the Society.*

Sitzungsberichte der königl.-bayer. Akademie der Wissenschaften zu Munchen. Hefte 1–5. 1865. 8vo.—*From the Academy.*

Società reale di Napoli; Rendiconto delle Tornate e dei Lavori dell' Accademia di Scienza Morali e Politiche. Feb., March 1865. 8vo.—*From the Academy.*

Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt. Band XV. Nos. 1 and 2. Wien, 1865. 8vo.—*From the Archivar of the Reichsanstalt.*

Verhandlungen der schweizerischen naturforschenden Gesellschaft zu Zürich. 1864. 8vo.—*From the Society.*

Scheikundige Verhandelingen Ouderzoekingen nitgegeven door G. J. Mulder, 4 deel, 1st Stuk. Rotterdam, 1865. 8vo.—*From the Author.*

Annalen der königlichen Sternwarte bei Munchen. Band XIV. 8vo.—*From the Royal Observatory of Munich.*

Smithsonian Contributions to Knowledge. Vol. XIV. Washington, 1865. 4to.—*From the Smithsonian Institution.*

Annual Report of the Board of Regents of the Smithsonian Institution for 1863. 8vo.—*From the Smithsonian Institution.*

Review of American Birds in the Museum of the Smithsonian Institution. By S. F. Baird. Part I. 8vo.—*From the Smithsonian Institution.*

Report of the Superintendent of the U. S. Coast Survey, showing the Progress of the Survey during 1862. Washington, 1864. 4to.—*From the Survey.*

Results of the Meteorological Observations made under the direction of the U. S. Patent-Office and the Smithsonian Institution, from 1854 to 1859. Vol. II. Part 1. Washington, 1864. 4to. —*From the U. S. Patent-Office.*

Embryology of the Star-Fish. By Alexander Agassiz. Cambridge, Massachusetts, 1864. 4to.—*From the Author.*

Statistics of the Foreign and Domestic Commerce of the U. S. Washington, 1864. 8vo.—*From the Secretary of the Treasury of the U. S.*

Annual of the Natural Academy of Sciences for 1863–64. Cambridge, U. S. 1864. 8vo.—*From the Academy.*

Report of the Natural Academy of Sciences for 1863. Washington, 1864. 8vo.—*From the Academy.*

Proceedings of the American Philosophical Society, Philadelphia. Nos. 71, 72. 8vo.—*From the Society.*

List of the Members of the American Philosophical Society, Philadelphia. 8vo.—*From the Society.*

Proceedings of the American Academy of Arts and Sciences for 1864. 8vo.—*From the Academy.*

Proceedings of the Portland Society of Natural History. Vol. I. Part 1. 8vo.—*From the Society.*

Journal of the Portland Society of Natural History. Vol. I. No. 1. 1864. 8vo.—*From the Society.*

Transactions of the Literary and Historical Society of Quebec. Session 1864–65. 8vo.—*From the Society.*

The following Publications have been presented by the Dépôt de la Marine, Paris.

Annales Hydrographiques ; Recueil d'Avis, Instructions, Documents, et Mémoires, relatifs à l'Hydrographie et à la Navigation. Paris, 1864–65. 8vo.

Manuel de la Navigation dans la mer des Antilles et dans le golfe du Mexique. Paris, 1864. 8vo.

Routier de la Côte Nord d'Espagne. Traduit de l'Espagnol par A. le Gras. Paris, 1864. 8vo.

Mer du Nord. Par M. A. le Gras. Part IV. Paris, 1864. 8vo.

La Loi des Tempêtes considerée dans ses relations avec les mouvements de l'atmosphere. Par. W. H. Dove. Paris, 1864. 8vo.

Instructions Nautiques pour les principaux Ports de la Côte Est de l'Amérique du Nord, reimprimées d'apres les cartes de la Côte des États unis de 1858. Par M. MacDermott. Paris, 1864. 8vo.

Instructions pour le Micromêtre lugeol à Cadran Lorieux. Par M. Bose. Paris, 1865. 8vo.

Recherches sur les Chronomêtres et les Instruments Nautiques. Paris, 1864. 8vo.

Madagascar, partie Comprenant l'Ile Fong Tamatave, Foule Pointe, Mahambo, Fénérive, Sainte-Marie, et Tintingue. Par M. Germain. Paris, 1864. 8vo.

Instructions Nautiques sur les Côtes de Corse. Par M. Sallot des Myers. Paris, 1865. 8vo.

Annuaire des Marées des Côtes de France pour l'an 1865. Par M. Gaussin. Paris, 1865. 12mo.

Renseignements sur la Navigation des Côtes et des Rivières de la Guyane Française. Par M. Em. Couy. Paris, 1865. 8vo.

Memorie dell' Accademia delle Scienze dell' Istituto di Bologna. Tomo III. ; Tomo IV. Part 1. 4to.—*From the Academy.*

Rendiconto delle Sessioni dell' Accademia delle Scienze dell' Istituto Bologna, 1863–64. 8vo.—*From the Academy.*

Indici Generali della Collezione pubblicata dell' Accademia delle

Scienze dell' Istituto di Bologna dal 1850–61. 4to.—*From the Academy.*

Jahresbericht am 17 Mai 1864 dem Comite der Nicolai. Hauptsternwarte abgestattel von Dr der Sternwarte. St. Petersburg, 1864. 8vo.—*From the Author.*

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nr. 553–579. Bern, 1864. 8vo.—*From the Society.*

Sulla Causa specifica del Colera Asiatico it suo processo Patologico e la Indicazione Curativa che ne resulta. Dell Dott. Filippo Pacini. Firenze, 1865. 8vo.—*From the Author.*

Egy Continentáilis Emelkedé sés Sülyedesröl Európa Délkeletirészén. Elöadta A Magyar Tudom, Akademia köz üleseben 1861. Pest, 1862. 4to.—*From the Academy.*

Az Izomidegek Végzödéseiröl, Dr Th. Margo. Pest, 1862. 4to.—*From the Academy.*

A Temesi Bänsag földje gazdasági és Mülipari Tekintetben, 1863. Elöadta Nendtvich Károly. Pest, 1863. 4to.—*From the Academy.*

Budapesti Szemle Szerkeszti és Riadja Csengery Antal LVI. és LVII. Fuzet. Pest, 1863. 8vo.—*From the Academy.*

Ueber die Wurflinie im leeren. Raume von Dr Georg Sidler. Berne, 1865. 4to.—*From the Author.*

Revue Archéologique, on Recueil de Documents et de Memoires relatifs à l'étude des Monuments, à la Numismatique, et à la Philologie de l'antiquité et du moyen âge. Par M. Ad. Pictet. Paris, 1864. 8vo.—*From the Author.*

Observations des Phénomènes périodiques des Plantes et des Animaux, 1861–62. Par Ad. Quetelet. Bruxelles. 8vo.—*From the Author.*

Die Physiologicsche Optik eine Darstellung der Gesetze des Auges von Dr Hermann Scheffler. Parts 1, 2. Brannschweig, 1864–65. 8vo.—*From the Author.*

Correspondenzblatt des Vereins für Naturkunde zu Presburg, 1863. 8vo.—*From Professor E. Mack.*

Conséquences de l'impunité du Plagiat. Par F. Collardean. Paris, 1865. 8vo.—*From the Author.*

Journal of the North China Branch of the Royal Asiatic Society. No. 1. Shanghai, 1865. 8vo.—*From the Society.*

Exploration of Vancouver Island, 1864. Victoria, 1864. 8vo.—*From the Colonial Government.*

Thoughts on the Influence of Ether in the Solar System. By Alexander Wilcocks, M.D. Philadelphia, 1864. 4to.—*From the Author.*

Remarks in Explanation of the Map of the Upper Tertiaries of the Counties of Norfolk, Suffolk, Essex, Middlesex, Hertford, Cambridge, Huntingdon, and Bedford, with Parts of those of Buckingham and Lincoln, and accompanying Sections. By Searles V. Wood, Junior. 8vo.—*From the Author.*

Report of the Professor of Astronomy in the University of Glasgow. Glasgow, 1865. 8vo.—*From Professor R. Grant.*

On the Origin of the Alpine Lakes and Valleys. By M. Alphonze Favre. 1865. 8vo.—*From the Author.*

Pinetum Britannicum. Parts 10–13. Edinburgh, 1865. Fol.—*From Charles Lawson, Esq.*

Proceedings of the Boston Society of Natural History for 1865. 8vo. —*From the Society.*

Artificial Lactation. By Charles M. Wetherill, M.D. Indianapolis, 1860. 8vo.—*From the Author.*

Précis d'une Histoire du Terrain Houiller des Alpes. Par M. Alphonze Favre. 1865. 8vo.—*From the Author.*

Sitzungsberichte der kaiserlichen Akademia der Wissenschaften. Phil. Hist. Classe, Band XLVII. Hefte 1, 2; Band XLVIII. Hefte 1, 2. Math. Nat. Classe, Band L. Hefte 1–5; Band LI. Hefte 1, 2. Mineral. Classe, Band L. Hefte 2-5; Band LI. Hefte 1, 2. Wien. 8vo.—*From the Academy.*

Jahresbericht über die Fortschritte der Chemie und Verwandter Theile Anderer, Wissenschaften, fur 1864. Von Heinrich Will. Giessen, 1865. 8vo.—*From the Author.*

Nachrichten über Leben und Schriften des Herrn Geheimrathes, Dr Karl Ernst v. Baer, mitgetheilt von ihm Selbst veröffentlicht bei gelegenheit Seines Fünfzigjährigen Doctor-Jübiläums, am 29th Aug. 1864. Von der Ritterschaft Ehstlands. St Petersburg, 1865. 4to.—*From the Author.*

Das Fünfzigjährige Doctor-Jübiläum, des Geheimraths Karl Ernst von Baer, am 29th Aug. 1864. St Petersburg. 4to.—*From the Author.*

Annales de l'Observatoire Physique Central de Russie. Nos. 1, 2. St Petersburg, 1865. 4to.—*From the Russian Government.*

Giornale di Scienze Naturali ed Economiche pubblicato per Cura del Consiglio di Perfezionamento annesso aer Istituto tecnico di Palermo. Vol. I. Fasc. 2. Palermo, 1865. 4to.—*From the Institute.*

Nouveaux Phénomènes des Corps cristallisés, avec Quatorze Planches. Par Louis Lavizzari. Lugano, 1865. Fol.—*From the Author.*

Bulletin de la Société Impériale des Naturalistes de Moscou. Nos. 2–4 for 1864. No. 1, 1865. 8vo.—*From the Society.*

Discours prononcé la 21 Août 1863 à l'ouverture de la Quarante-Neuvième Session de la Société Helvétique des Sciences Naturelles, reunie à Genève. Par M. le Professeur Auguste de la Rive. Genève, 1865. 8vo.—*From the Author.*

Résumé Météorologique de l'Année 1864, pour Genève et le Grand St Bernard. Par E. Plantamour. Genève, 1865. 8vo.—*From the Author.*

Recherches sur la Distribution de la Température à la Surface de la Suisse pendant l'Hiver 1863-64. Par E. Plantamour. 8vo. —*From the Author.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XVIII. Part. 1. Genève, 1865. 4to.—*From the Society.*

Report of the Commissioner of Patents for 1862 (Arts and Manufactures). Vols. I. and II. Washington, 1864. 8vo.—*From the U. S. Government.*

Transactions of the Pathological Society, London. Vol. XVI. London, 1865. 8vo.—*From the Society.*

Transactions and Proceedings of the Royal Society of Victoria. Vol. VI. Melbourne, 1865. 8vo.—*From the Society.*

Transactions of the Geological Society, Glasgow. Vol. I. Part 2; Vol. II. Part 1. 8vo.—*From the Society.*

Proceedings of the Royal Institution of Great Britain. Vol. IV. Parts 5 and 6. London, 1865. 8vo.—*From the Institution.*

Journal of the Royal Geological Society of Ireland. Vol. I. Part 1. Dublin, 1865. 8vo.—*From the Society.*

Transactions of the Botanical Society of Edinburgh. Vol. VIII. Part 2. 8vo.—*From the Society.*

On the Silurian Formation of the Pentland Hills. By George C. Haswell. Edinburgh, 1865. 8vo.—*From the Author.*

Mazzaroth, or the Constellations. Part 1. London, 1862. 8vo.—*From the Rev. Francis Redford, F.R.S.E.*

Report of the Geological Formation of the Timaru District, in reference to obtaining a supply of Water. By Julius Haast, Ph.D. Christchurch, 1865. Fol.—*From the Author.*

Report on the Geological Exploration of the West Coast of New Zealand. By Julius Haast, Ph.D. Christchurch, 1865. Fol. —*From the Author.*

Meteorological Papers, published by Authority of the Board of Trade. No. 14. London, 1865.—*From the Board.*

Reply to Letter of G. W. Maunsell, Esq., of 21st Oct. 1865. By Andrew H. Bagot. 8vo.—*From the Author.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1865–66. No. 69.

Monday, 18th December 1865.

Sir DAVID BREWSTER, President, in the Chair.

At the request of the Council, Professor William Thomson of Glasgow delivered the following Address on the Forces concerned in the Laying and Lifting of Deep-Sea Cables.

The forces concerned in the laying and lifting of deep submarine cables attracted much public attention in the years 1857–58.

An experimental trip to the Bay of Biscay in May 1858, proved the possibility, not only of safely laying such a rope as the old Atlantic cable in very deep water, but of lifting it from the bottom without fracture. The speaker had witnessed the almost incredible feat of lifting up a considerable length of that slight and seemingly fragile thread from a depth of nearly 2½ nautical miles.* The cable had actually brought with it safely to the surface, from the bottom, a splice with a large weighted frame attached to it, to prevent untwisting between the two ships, from which two portions of cable with opposite twists had been laid. The actual laying of the cable a few months later, from mid ocean to Valencia on

* Throughout the following statements, the word mile will be used to denote (not that most meaningless of modern measures, the British statute mile) but the nautical mile, or the length of a minute of latitude, in mean latitudes, which is 6073 feet. For approximate statements, rough estimates, &c., it may be taken as 6000 feet, or 1000 fathoms.

one side, and Trinity Bay, Newfoundland, on the other, regarded merely as a mechanical achievement, took by surprise some of the most celebrated engineers of the day, who had not concealed their opinion, that the Atlantic Telegraph Cumpany had undertaken an impossible problem. As a mechanical achievement it was completely successful; and the electric failure, after several hundred messages (comprising upwards of 4359 words) had been transmitted between Valencia and Newfoundland, was owing to electric faults existing in the cable before it went to sea. Such faults cannot escape detection, in the course of the manufacture, under the improved electric testing since brought into practice, and the causes which led to the failure of the first Atlantic cable no longer exist as dangers in submarine telegraphic enterprise. But the possibility of damage being done to the insulation of the electric conductor before it leaves the ship (illustrated by the occurrences which led to the temporary loss of the 1865 cable), implies a danger which can only be thoroughly guarded against by being ready at any moment to back the ship and check the egress of the cable, and to hold on for some time, or to haul back some length according to the results of electric testing.

The forces concerned in these operations, and the mechanical arrangements by which they are applied and directed, constitute one chief part of the present address; the remainder is devoted to explanations as to the problem of lifting the west end of the 1200 miles of cable laid last summer, from Valencia westwards, and now lying in perfect electric condition (in the very safest place in which a submarine cable can be kept), and ready to do its work, as soon as it is connected with Newfoundland, by the 600 miles required to complete the line.

Forces concerned in the Submergence of a Cable.

In a paper published in the "Engineer" Journal in 1857, the speaker had given the differential equations of the catenary formed by a submarine cable between the ship and the bottom, during the submergence, under the influence of gravity and fluid friction and pressure; and he had pointed out that the curve becomes a straight line in the case of no tension at the bottom. As this is always the case in deep-sea cable laying, he made no farther reference to the general problem in the present address.

When a cable is laid at uniform speed, on a level bottom, quite straight, but without tension, it forms an inclined straight line, from the point where it enters the water, to the bottom, and each point of it clearly moves uniformly in a straight line towards the position on the bottom that it ultimately occupies.* That is to say, each particle of the cable moves uniformly along the base of an isosceles triangle, of which the two equal sides are the inclined portion of the cable between it and the bottom, and the line along the bottom which this portion of the cable covers when laid. When the cable is paid out from the ship at a rate exceeding that of the ship's progress, the velocity and direction of the motion of any particle of it through the water are to be found by compounding a velocity along the inclined side, equal to this excess, with the velocity already determined, along the base of the isosceles triangle.

The angle between the equal sides of the isosceles triangle, that is to say, the inclination which the cable takes in the water, is determined by the condition, that the transverse component of the cable's weight in water is equal to the transverse component of the resistance of the water to its motion. Its tension where it enters the water is equal to the longitudinal component of the weight (or, which is the same, the whole weight of a length of cable hanging vertically down to the bottom), diminished by the longitudinal component of the fluid resistance. In the laying of the Atlantic cable, when the depth was two miles, the rate of the ship six miles an hour, and the rate of paying out of the cable seven miles an hour, the resistance to the egress of the cable, accurately measured by a dynamometer, was only 14 cwt. But it must have been as much as 28 cwt., or the weight of two miles of the cable hanging vertically down in water, were it not for the frictional resistance of the water against the cable slipping, as it were, down an inclined plane from the ship to the bottom, which therefore must have borne the difference, or 14 cwt. Accurate observations are wanting as to the angle at which the cable entered the water; but from measurements of angles at the stern of the ship, and a

* Precisely the movement of a battalion in line changing front.

dynamical estimate (from the measured strain) of what the curvature must have been between the ship and the water, I find that its inclination in the water, when the ship's speed was nearly $6\frac{1}{2}$ miles per hour, must have been about $6\frac{3}{4}°$, that is to say, the incline was about 1 in $8\frac{1}{2}$. Thus the length of cable, from the ship to the bottom, when the water was 2 miles deep, must have been about 17 miles.

The whole amount (14 cwt.) of fluid resistance to the motion of this length of cable through it, is therefore about ·81 of a cwt. per mile. The longitudinal component velocity of the cable through the water, to which this resistance was due, may be taken, with but very small error, as simply the excess of the speed of paying out above the speed of the ship, or about 1 mile an hour. Hence, to haul up a piece of the cable vertically through the water, at the rate of 1 mile an hour, would require less than 1 cwt. for overcoming fluid friction, per mile length of the cable, over and above its weight in water. Thus fluid friction, which for the laying of a cable performs so valuable a part in easing the strain with which it is paid out, offers no serious obstruction, indeed, scarcely any sensible obstruction, to the reverse process of hauling back, if done at only 1 mile an hour, or any slower speed.

As to the transverse component of the fluid friction, it is to be remarked that, although not directly assisting to reduce the egress strain, it indirectly contributes to this result; for it is the transverse friction that causes the gentleness of the slope, giving the sufficient length of 17 miles of cable slipping down through the water, on which the longitudinal friction operates, to reduce the egress strain to the very safe limit found in the recent expedition. In estimating its amount, even if the slope were as much as 1 in 5, we should commit only an insignificant error, if we supposed it to be simply equal to the weight of the cable in water, or about 14 cwt. per mile for the 1865 Atlantic cable. The transverse component velocity to which this is due may be estimated with but insignificant error, by taking it as the velocity of a body moving directly to the bottom in the time occupied in laying a length of cable equal to the 17 miles of oblique line from the ship to the bottom. Therefore, it must have been about 2 miles in $17 \div 6\frac{1}{2} = 2{\cdot}61$ hours, or ·8 of a mile per hour. It is not probable that the actual motion of the cable lengthwise through the water can affect this result much. Thus, the *velocity of settling* of a horizontal piece of the cable (or velocity of sinking through the water, with weight just borne by fluid friction) would appear to be about ·8 of a mile per hour. This may be contrasted with longitudinal friction by remembering that, according to the previous result, a longitudinal motion through the water at the rate of 1 mile per hour is resisted by only $\frac{1}{17}$th of the weight of the portion of cable so moving.

These conclusions justify remarkably the choice that was made of materials and dimensions for the 1865 cable. A more compact cable (one for instance with less gutta percha, less or no tow round the iron wires, and somewhat more iron), even if of equal strength and equal weight per mile in water, would have experienced less transverse resistance to motion through the water, and therefore would have run down a much steeper slope to the bottom. Thus, even with the same longitudinal friction per mile, it would have been less resisted on the shorter length; but even on the same length it would have experienced much less longitudinal friction, because of its smaller circumference. Also, it is important to remark that the roughness of the outer tow covering undoubtedly did very much to ease the egress strain, as it must have increased the fluid friction greatly beyond what would have acted on a smooth gutta percha surface, or even on the surface of smooth iron wires, presented by the more common form of submarine cables.

The speaker showed models illustrating the paying-out machines used on the Atlantic expeditions of 1858 and 1865. He stated that nothing could well be imagined more perfect than the action of the machine of 1865 in paying out the 1200 miles of cable then laid, and that if it were only to be used for *paying out*, no change either in general plan or in detail seemed desirable, except the substitution of a softer material for the "jockey pulleys," by which the cable in entering the machine has the small amount of resistance applied to it which it requires to keep it from slipping round the main drum. The rate of egress of the cable was kept always under perfect control by a weighted friction brake of Appold's construction (which had proved its good quality in the 1858 Atlantic expedition) applied to a second drum carried on the same shaft with the main drum. When the weights were removed from the brake (which could be done almost instantaneously by means of a simple mechanism), the resistance to the egress of the cable, produced by "jockey pulleys," and the friction at the bearings of the shaft carrying the main drum, &c., was about 2½ cwt.

Procedure to Repair the Cable in case of the appearance of an electric fault during the laying.

In the event of a fault being indicated by the electric test at any time during the paying out, the safe and proper course to be followed in future (as proved by the recent experience), if the cable is of the same construction as the present Atlantic cable, is instantly, on order given from an authorised officer in the electric room, to stop and reverse the ship's engines, and to put on the greatest *safe* weight on the paying-out break. Thus in the course of a very short time the egress of the cable may be stopped, and, if the weather is moderate, the ship may be kept, by proper use of paddles, screw, and rudder, nearly enough in the proper position for hours to allow the cable to hang down almost vertically, with little more strain than the weight of the length of it between the ship and the bottom.

The best electric testing that has been practised or even planned cannot show within a mile the position of a fault consisting of a slight loss of insulation, unless both ends of the cable are at hand. Whatever its character may be, unless the electric tests demonstrate its position to be remote from the outgoing part, the only thing that can be done to find whether it is just on board or just overboard, is to cut the cable as near the outgoing part as the mechanical circumstances allow to be safely done. The electric test immediately transferred to the fresh-cut seaward end shows instantly if the line is perfect between it and the shore. A few minutes more, and the electric tests applied to the *two ends* of the remainder on board, will, in skilful hands, with a proper plan of working, show very closely the position of the fault, *whatever its character may be.* The engineers will thus immediately be able to make proper arrangements for resplicing and paying out good cable, and for cutting out the fault from the bad part.

But if the fault is between the land end and the fresh-cut seaward end on board ship, proper simultaneous electric tests on board ship and on shore (not hitherto practised, but easy and sure if properly planned) must be used to discover whether the fault lies so near the ship that the right thing is to haul back the cable until it is got on board. If it is so, then steam power must be applied to reverse the paying-out machine, and, by careful watching of the dynamometer, and controlling the power accordingly (hauling in slowly, stopping, or veering out a little, but never letting the dynamometer go above 60 or 65 cwt.), the cable (which can bear 7 tons) will not break, and the fault will be got on board more surely, and possibly sooner, than a "sulky" salmon of 30 lbs. can be landed by an expert angler with a line and rod that could not bear 10 lbs. The speaker remarked that he was entitled to make such assertions with confidence now, because the experience of the late expedition had not only verified the estimates of the scientific committee and of the contractors as to the strength of the cable, its weight in water (whether deep or shallow), and its mechanical manageability, but it had proved that in moderate weather the Great Eastern could, by skilful seamanship, be kept in position and moved in the manner required. She had actually been so for thirty-eight hours, and eighteen hours during the operations involved in the hauling back and cutting out the first and second faults, and reuniting the cable, and during seven hours of hauling in, in the attempt to repair the third fault.

Should the simultaneous electric testing on board and on shore prove the fault to be 50 or 100 or more miles from the ship, it would depend on the character of the fault, the season of the year, and the means and appliances on board, whether it would be better to complete the line, and afterwards, if necessary, cut out the fault and repair, or to go back at once and cut out the fault before attempting to complete the line. Even the worst of these contingencies would not be fatal to the undertaking with such a cable as the present one. But all experience of cable-laying shows that almost certainly the fault would either be found on board, or but a very short distance overboard, and would be reached and cut out with scarcely any risk, if really prompt measures, as above described, are taken at the instant of the appearance of a fault, to stop as soon as possible with safety the further egress of the cable.

The most striking part of the Atlantic undertaking proposed for 1866, is that by which the 1200 miles of excellent cable laid in 1865 is to be utilised by completing the line to Newfoundland.

That a cable lying on the bottom in water two miles deep can be caught by a grapnel and raised several hundred fathoms above the bottom, was amply proved by the eight days' work which followed the breakage of the cable on the 3d of August last. Three times out of four that the grapnel was let down, it caught the cable, on each occasion after a few hours of dragging, and with only 300 or 400 fathoms more of rope than the 2100 required to reach the bottom by the shortest course. The time when the grapnel did not hook the cable it came up with one of its flukes caught round by its chain; and the grapnel, the short length of chain next it, and about 200 fathoms of the wire-rope, were proved to have been dragged along the bottom, by being found when brought on board to have interstices filled with soft light gray ooze (of which the speaker showed a specimen to the Royal Society). These results are quite in accordance with the dynamical theory indicated above (see Appendix II.), according to which a length of such rope as the electric cable, hanging down with no weight at its lower end, and held by a ship moving through the water at half a mile an hour, would slope down to the bottom at an angle from the vertical of only 22° ; and the much heavier and denser wire-rope that was used for the grappling would go down at the same angle with a considerably more rapid motion of the ship, or at a much steeper slope with the same rate of motion of the ship.

The only remaining question is: How is the cable to be brought to the surface when hooked? The operations of last August failed from the available rope, tackle, and hauling machine not being strong enough for this very unexpected work. On no occasion was the electric cable broken.* With strong enough tackle, and a

* The strongest rope available was a quantity of rope of iron wire and hemp spun together, able to bear 14 tons, which was prepared merely as *buoy-rope* (to provide for the contingency of being obliged, by stress of weather or other cause, to cut and leave the cable in deep or shallow water), and was accordingly all in 100 fathoms-lengths, joined by shackles with swivels. The

hauling machine, both strong enough, and under perfect control, the lifting of a submarine cable, as good in mechanical quality as the Atlantic cable of 1865, by a grapnel or grapnels, from the bottom at a depth of two miles, is certainly practicable. If one attempt fails, another will succeed; and there is every reason, from dynamics as well as from the 1865 experience, to believe that in any moderate weather the feat is to be accomplished with little delay, and with very few if any failing attempts.

The several plans of proceeding that have been proposed are of two classes—those in which, by three or more ships, it is proposed to bring a point of the cable to the surface without breaking it at all; and those in which it is to be cut or broken, and a point of the cable somewhat eastward from the break is to be brought to the surface.

With reference to either class, it is to be remarked that, by lifting simultaneously by several grapnels so constructed as to hold the cable without slipping along it or cutting it, it is possible to bring a point of the cable to the surface without subjecting it to any strain amounting to the weight of a length of cable equal to the depth of the water. But so many simultaneous grapplings by ships crossing the line of cable at considerable distances from one another would be required, that this possibility is scarcely to be reckoned on practically, without cutting or breaking the cable at a point westward of the points raised by the grapnels. On the other hand, with but three ships the cable might, no doubt, be brought to the surface at any point along the line, without cutting it, and without subjecting it at any point to *much* more strain than the weight corresponding to the vertical depth, as is easily seen when it is considered that the cable was laid generally with from 10 to 15 per cent. of slack. And if the cable is cut at some point not far westward of the westernmost of the grapnels, there can be no doubt but it could be lifted with great ease by three grapnels hauled up simultaneously

wire and hemp rope itself never broke, but on two of the three occasions a swivel gave way. On the last occasion, about 900 fathoms of Manilla rope had to be used for the upper part, there not being enough of the wire buoy-rope left; and when 700 fathoms of it had been got in, it broke on board beside a shackle, and the remaining 200 fathoms of the Manilla, with 1540 fathoms of wire-rope and the grapnel, and the electric cable which it had hooked, were all lost for the year 1865.

by three ships. The catenaries concerned in these operations were illustrated by a chain with 15 per cent. of slack hauled up simultaneously at three points.

The plan which seemed to the speaker surest and simplest is to cut the cable at any chosen point, far enough eastward of the present broken end to be clear of entanglement of lost buoy-rope, grapnels, and the loose end of the electric cable itself; and then, or as soon as possible after, to grapple and lift at a point about three miles farther eastward. This could be well and safely done by two ships, one of them with a cutting grapnel, and the other (the Great Eastern herself) with a holding grapnel. The latter, on hooking, should haul up cautiously, never going beyond a safe strain, as shown by the dynamometer. The other, when assured that the Great Eastern has the cable, should haul up, at first cautiously, but ultimately, when the cable is got well off the bottom by the Great Eastern, the western ship should move slowly eastwards, and haul up with force enough to cut or break the cable. This leaves three miles of free cable on the western side of the Great Eastern's grapnel, which will yield freely eastwards (even if partly lying along the bottom at first), and allow the Great Eastern to haul up and work slowly eastwards, so as to keep its grappling rope, and therefore ultimately the portions of electric cable hanging down on the two sides of its grapnel, as nearly vertical as is necessary to make sure work of getting the cable on board. This plan was illustrated by lifting, by aid of two grapnels, a very fragile chain (a common brass chain in short lengths, joined by links of fine cotton thread) from the floor of the Royal Society. It was also pointed out that it can be executed by one ship alone, with only a little delay, but with scarcely any risk of failure. Thus, by first hooking the cable by a holding grapnel, and hauling it up 200 or 300 fathoms from the bottom, it may be left there hanging by the grapnel-rope on a buoy, while the ship proceeds three miles westwards, cuts the cable there, and returns to the buoy. Then, it is an easy matter, in any moderate weather, to haul up safely and get the cable on board.

The use of the dynamometer in dredging was explained; and the forces operating on the ship, the conditions of weather, and the means of keeping the ship in proper position during the process of slowly hauling in a cable, even if it were of strength quite insufficient to act, when nearly vertical, with any sensible force on the ship, were discussed at some length. The manageability of the Great Eastern, in skilful hands, had been proved to be very much better than could have been expected, and to be sufficient for the requirements in moderate weather. She has both screw and paddles—an advantage possessed by no other steamer in existence. By driving the screw at full power ahead, and backing the paddles, to prevent the ship from moving ahead, or (should the screw overpower the paddles), by driving the paddles full power astern, and driving at the same time the screw ahead with power enough to prevent the ship from going astern, "steerage way" is *created* by the lash of water from the screw against the rudder; and thus the Great Eastern may be effectually steered without going ahead. Thus she is, in calm or moderate weather, almost as manageable as a small tug steamer, with reversing paddles, or as a rowing boat. She can be made still more manageable than she proved to be in 1865, by arranging to disconnect either paddle at any moment; which, the speaker was informed by Mr Canning, may easily be done.

The speaker referred to a letter he had received from Mr Canning, chief engineer of the Telegraph Construction and Maintenance Company, informing him that it is intended to use three ships, and to be provided both with cutting and with holding grapnels, and expressing great confidence as to the success of the attempt. In this confidence the speaker believed every practical man who witnessed the Atlantic operations of 1865 shared, as did also, to his knowledge, other engineers who were not present on that expedition, but who were well acquainted with the practice of cable-laying and mending in various seas, especially in the Mediterranean. The more he thought of it himself, both from what he had witnessed on board the Great Eastern, and from attempts to estimate on dynamical principles the forces concerned, the more confident he felt that the contractors would succeed next summer in utilising the cable partly laid in 1865, and completing it into an electrically perfect telegraphic line between Valencia and Newfoundland.

Appendix I.

Descriptions of the Atlantic Cables of 1858 *and* 1865.

(Distance from Ireland to Newfoundland, 1670 Nautical Miles.)

Old Atlantic Cable, 1858.

Conductor.—A copper strand, consisting of seven wires (six laid round one), and weighing 107 lbs. per nautical mile.

Insulator.—Gutta percha laid on in three coverings, and weighing 261 lbs. per knot.

External Protection.—Eighteen strands of charcoal iron wire, each strand composed of seven wires (six laid round one), laid spirally round the core, which latter was previously padded with a serving of hemp saturated with a tar mixture. The separate wires were each 22 gauge; the stand complete was No. 14 gauge.

Circumference of Finished Cable, 2 inches.

Weight in Air, 20 cwt. per nautical mile.

Weight in Water, 13·4 cwt. per nautical mile.

Breaking Strain, 3 tons 5 cwt., or equal to 4·85 times the cable's weight in water per mile. Hence the cable would bear its own weight in nearly five miles depth of water, or 2·05 times the—

Deepest Water to be encountered, 2400 fathoms, being less than 2½ nautical miles.

Length of Cable Shipped, 2174 nautical miles.

New Atlantic Cable, 1865.

Conductor.—Copper strand consisting of seven wires (six laid round one), and weighing 300 lbs. per nautical mile, embedded for solidity in Chatterton's compound. Diameter of single wire ·048 = ordinary 18 gauge. Gauge of strand ·144 = ordinary No. 10 gauge.

Insulation.—Gutta percha, four layers of which are laid on alternately with four thin layers of Chatterton's compound. The weight of the entire insulation 400 lbs. per nautical mile. Diameter of core ·464 of an inch; circumference of core 1·46 inches.

External Protection.—Ten solid wires of diameter ·095 (No. 13 gauge) drawn from Webster and Horsfall's homogeneous iron, each wire surrounded separately with five strands of Manilla yarn, saturated with a preservative compound, and the whole laid spirally round the core, which latter is padded with ordinary hemp, saturated with preservative mixture.

Circumference of Finished Cable, 3·534 inches.

Weight in Air, 35 cwt. 3 qrs. per nautical mile.

Weight in Water, 14 cwt. per nautical mile.

Breaking Strain, 7 tons 15 cwt., or equal to eleven times the cable's weight in water per mile. Hence the cable will bear its own weight in eleven miles depth of water, or 4·64 times the—

Deepest Water to be encountered, 2400 fathoms, or less than $2\frac{1}{2}$ nautical miles.

Length of Cable Shipped, 2300 nautical miles.

II.

Let W be the weight of the cable per unit of its length in water; T the force with which the cable is held back at the point where it reaches the water (which may be practically regarded as equal to the force with which its egress from the ship is resisted by the paying-out machinery, the difference amounting only to the weight in air of a piece of cable equal in length to the height of the stern pulley above the water); P and Q the transverse and longitudinal components of the force of frictional resistance experienced by the cable in passing through the water from surface to bottom; i the inclination of its line to the horizon; D the depth of the water.

The whole length of cable from surface to bottom will be $\frac{D}{\sin i}$; and the transverse and longitudinal components of the weight of this portion are therefore $\frac{WD}{\sin i}\cos i$, and WD respectively. These are balanced by $P\frac{D}{\sin i}$ and $T+Q\frac{D}{\sin i}$.

Hence

$$P=W\cos i,\ Q=\left(W-\frac{T}{D}\right)\sin i \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

To find the corresponding components of the velocity of the cable through the water, which we shall denote by p and q, we have only to remark that the actual velocity of any portion of the cable in the water may be regarded as the resultant of two velocities,—one equal and parallel to that of the ship forwards, and the other obliquely downwards along the line of the cable, equal to that of the paying out, obliquely downwards along the line of the cable (since if the cable were not paid out, but simply dragged, while by any means kept in a straight line at any constant inclination, its motion would be simply that of the ship). Hence, if v be the ship's velocity, and u the velocity at which the cable is paid out from the ship, we have

$$p=v\sin i,\ q=u-v\cos i \quad . \ . \ . \ . \quad (2.)$$

Now, as probably an approximate, and therefore practically useful, hypothesis, we may suppose each component of fluid friction to depend solely on the corresponding component of the fluid velocity, and to be proportional to its square. Thus we may take

$$\mathrm{P}=\mathrm{W}\frac{p^2}{\mathfrak{p}^2},\quad \mathrm{Q}=\mathrm{W}\frac{q^2}{\mathfrak{q}^2} \quad . \ . \ . \ . \ . \quad (3.)$$

where $\mathfrak{p}$ and $\mathfrak{q}$ denote the velocities, transverse and longitudinal, which would give frictions amounting to the weight of the cable; or, as we may call them, the transverse and longitudinal *settling velocities.* We may use these equations merely as introducing a convenient piece of notation for the components of fluid friction, without assuming any hypothesis, if we regard $\mathfrak{p}$ and $\mathfrak{q}$ as each some unknown function of p and q. It is probable that $\mathfrak{p}$ depends to some degree on q, although chiefly on p; and *vice versa*, $\mathfrak{q}$ to some degree on p, but chiefly on q. It is almost certain, however, from experiments such as those described in "Beaufoy's Nautical Experiments," that $\mathfrak{p}$ and $\mathfrak{q}$ are each *very nearly* constant for all practical velocities.

Eliminating p and q between (1), (2), and (3), we have

$$\mathrm{W}\cos i=\mathrm{W}\left(\frac{v\sin i}{\mathfrak{p}}\right)^2,$$

which gives

$$\mathfrak{p}=\frac{v\sin i}{\sqrt{\cos i}} \quad . \ . \ . \ . \quad (4.)$$

and

$$(\mathrm{WD}-\mathrm{T})\sin i=\mathrm{WD}\left(\frac{u-v\cos i}{\mathfrak{q}}\right)^2 \quad . \ . \ . \ . \quad (5.)$$

which gives

$$\mathfrak{q}=(u-v\cos i)\sqrt{\frac{\mathrm{WD}}{(\mathrm{WD}-\mathrm{T})\sin i}} \quad . \ . \ . \ . \quad (6.)$$

These formulæ apply to every case of uniform towing of a rope under water, or hauling in, or paying out, whether the lower end reaches the bottom or not, provided always the lower end is free from tension; but if it is not on the bottom, D must must denote its vertical depth at any moment, instead of the whole depth of the sea. To apply to the case of merely towing, we must put $u = 0$; or, to apply to hauling in, we must suppose u negative.

It is to be remarked that the inclination assumed by the cable under water does not depend on its longitudinal slip through the water (since we assume this not to influence the transverse component of fluid friction), and that, according to equation (4), it is simply determined by the ratio of the ship's speed to the transverse "settling velocity" of the cable.

The following table shows the ratio of the ship's speed to the "transverse settling velocity" of the cable for various degrees of inclination of the cable to the horizon :—

Inclination of Cable to Horizon.	Ratio of Ship's Speed to "*transverse settling velocity*" of Cable.	Inclination of Cable to Horizon.	Ratio of Ship's Speed to "*transverse settling velocity*" of Cable.
i	$\frac{v}{\mathfrak{p}}=\frac{\sqrt{\cos i}}{\sin i}$	i	$\frac{v}{\mathfrak{p}}=\frac{\sqrt{\cos i}}{\sin i}$
5°	11·4518	45°	1·1892
angle whose sine is $\frac{1}{8\frac{1}{2}}$ } 6° 45′	8·4784	50	1·0466
		51° 50′	1·0000
10	5·7149	55	·9232
15	3·7973	60	·8165
20	2·8343	65	·7173
25	2·2013	70	·6224
30	1·8612	75	·5267
35	1·5779	80	·4231
40	1·3616	85	·0875

If the inclination of the cable had been exactly 6° 45′ when the speed of the Great Eastern was exactly $6\frac{1}{2}$ miles per hour, the value of $\mathfrak{p}$ for the Atlantic cable of 1865 would be exactly $6\frac{1}{2} \div 8{\cdot}478$, or ·765 of a mile per hour.

The following Communications were read :—

1. On the Dynamical Theory of Heat. Part VII. By Professor W. Thomson.

This paper commences with a condensed re-statement of the fundamental principles and formulæ of the Dynamical Theory of Heat, from the first six parts of the author's treatment of the subject previously communicated to the Royal Society of Edinburgh, and his articles "On the Thermo-elastic Properties of Matter," in the "Quarterly Mathematical Journal" (April 1855), and on "Thermo-magnetism," and "Thermo-electricity," in Nichol's Cyclopedia (Edinburgh 1860).

The chief object of the paper is the deduction of numerical values in absolute measure for the thermo-electric effects which form the subject of Part VI. of this series ("Transactions of the Royal Society of Edinburgh," 1854; and "Phil. Mag." 1854, second half year, and 1855, first half year), especially for differences of temperature produced by electric convection of heat, and for the changes of temperature due to strain in elastic solids, investigated in the article on thermo-elastic properties of matter above referred to. The very valuable results, recently published, of the experiments of Forbes and Ångström for determining in absolute measure the thermal conductivities of iron and copper, supply a very important element, previously wanting, for definite estimates of those changes of temperature, and are taken advantage of in the present paper. Thus, the author has been enabled to give that practical character to some of his former conclusions, of which, when they were first published, he pointed out the want. In particular, with reference to elastic solids, the *apparent* value of Young's modulus * when the stress is applied and removed, or reversed so rapidly that the loss of thermal effect by conduction and radiation is insensible, is proved to be given by the following formula :—

$$M' = M\left(1 + \frac{e^2 tM}{Js\rho}\right)$$

* The amount of the force divided by the elongation produced by it, when any force within practical limits of elasticity is applied to elongate a bar rod or wire, of the substance, one square centimetre in section.

where M denotes the Young's modulus of the substance for constant temperature, s its specific heat (per unit mass, as usual), e its longitudinal (linear) expansion per degree of elevation of temperature, ρ its density or specific gravity,* and t its actual temperature from absolute zero (" Dynamical Theory of Heat," Part VI., § 100), that is, temperature centigrade with 274 added. Of course, if M is reckoned (" Thomson and Tait's Natural Philosophy," §§ 220, 221, 238), in gravitation measure (weight of one gramme, the unit of mass), J must be reckoned in gravitation measure (grammes weight working through one centimetre), in which case its numerical value is 42,400, being Joule's number (1390), reduced from feet to centimetres. Values of surface resistance to gain or loss of heat in absolute measure, derived from experiments by the author, are used to estimate the effect of radiation and convection in dissipating energy in virtue of the thermo-dynamic change of temperature in a rod executing longitudinal vibrations. The velocity of propagation of longitudinal vibrations (as in the transmission of sound along a bar) being equal to the velocity acquired by a body in falling through a height equal to half the "length of the modulus,"† is, of course, half as much affected as the modulus, by changes of temperature. In iron, for instance, the effect of change of temperature, when there is no dissipation, is an increase of about one-third per cent. on the Young's modulus, and of about one-sixth per cent. on the velocity of sound along a bar. The effect of the conduction of heat in diminishing the differences of temperature in a rectangular bar executing flexural vibrations, is investigated from the solution invented by Fourier for expressing periodical variations of underground temperature. Its absolute amount for bars of iron or copper, of stated dimensions, vibrating in stated periods, is determined from Forbes' and Ångström's conductivities. It is proved that the loss of energy due to this effect at its maximum is not by any means insensible, though it is not sufficient to account for the whole loss of energy which the author has found in experi-

* Which, when the French system (unit bulk of water being of mass unity) is followed, mean the same thing

† The "length of the modulus" is $M \div \rho$, if M be the modulus in grammes weight per square centimetre.—*Thomson and Tait's Natural Philosophy*, § 689.

ments on flexural vibrations of metal springs, which therefore prove imperfectness in the elasticity of flexure, such as he had previously proved for the elasticity of torsion.*

2. The "Doctrine of Uniformity" in Geology briefly refuted. By Professor William Thomson.

The "Doctrine of Uniformity" in Geology, as held by many of the most eminent of British Geologists, assumes that the earth's surface and upper crust have been nearly as they are at present in temperature, and other physical qualities, during millions of millions of years. But the heat which we know, by observation, to be now conducted out of the earth yearly is so great, that if *this* action had been going on with any approach to uniformity for 20,000 million years, the amount of heat lost out of the earth would have been about as much as would heat, by 100° Cent., a quantity of ordinary surface rock of 100 times the earth's bulk. (See calculation appended.) This would be more than enough to melt a mass of surface rock equal in bulk to the *whole earth*. No hypothesis as to chemical action, internal fluidity, effects of pressure at great depth, or possible character of substances in the interior of the earth, possessing the smallest vestige of probability, can justify the supposition that the earth's upper crust has remained nearly as it is, while from the whole, or from any part, of the earth, so great a quantity of heat has been lost.

Appendix.

Estimate of present annual loss of heat from the earth.

Let A be the area of the earth's surface, D the increase of depth in any locality for which the temperature increases by 1° Cent., and k the conductivity per annum of the strata in the same locality. The heat conducted out per annum per square foot of surface in that locality is $\frac{k}{D}$. Hence, if we give k and D proper average

* Proceedings of the Royal Society of London, May 1865.—*W Thomson*, "*On the Elasticity and Viscosity of Metals.*"

values for the whole upper crust of the earth, the quantity conducted out across the whole earth's surface per annum will be $\frac{kA}{D}$. The bulk of a sphere being its surface multiplied by $\frac{1}{3}$ of its radius, the thermal capacity of a mass of rock equal in bulk to the earth, and of specific heat s per unit of bulk is $\frac{1}{3}$ Ars. Hence $\frac{3k}{Drs}$ is the elevation of temperature which a quantity of heat equal to that lost from the earth in a year, would produce in a mass of rock equal in bulk to the whole earth. The laboratory experiments of Peclet; Observations on Underground Temperature in three kinds of rock in and near Edinburgh, by Forbes; in two Swedish strata, by Ångström, and at the Royal Observatory, Greenwich, give values of the conductivity in gramme-water units of heat per square centimetre, per 1° per centimetre of variation of temperature, per second, from ·002 (marble, Peclet) to ·0107 (sandstone of Craigleith quarry, Forbes); and ·005 may be taken as a rough average. Hence, as there are 31,537,600 seconds in a year, we have $k = \cdot 005 \times 31{,}537{,}600$, or approximately 15×10^4. The thermal capacity of surface rock is somewhere about half that of equal bulk of water; so that we may take $s = \cdot 5$. And the increase of temperature downwards may be taken as roughly averaging 1° Cent. per 30 metres; so, that, D = 3000 centimetres. Lastly, the earth's quadrant being according to the first foundation of the French metrical system, about 10^9 centimetres, we may take, in a rough estimate such as the present, $r = 6 \times 10^8$ centimetres. Hence,

$$\frac{3k}{Drs} = \frac{3 \times 15 \times 10^4}{3000 \times 6 \times 10^8 \times \cdot 5} = \frac{30 \times 10^4}{10^{11} \times 6} = \frac{5}{10^7}$$

This, multiplied by $20{,}000 \times 10^6$, amounts to 10,000, or to 100 times as much heat as would warm 100 times the earth's bulk of surface rock by 1° Cent.

3. Note on the Atomicity of Sulphur. By Dr Alexander Crum Brown.

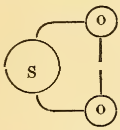
We now know a considerable number of elements which exhibit, in their compounds, two or more distinct degrees of atomicity. Thus we have N triatomic in ammonia and its analogues, in nitrous acid, the nitrites and the nitroso-substitution products; pentatomic in the ammonia salts, in nitric acid, and the nitro-substitution products. P triatomic in PH_3, PCl_3, phosphorous acid, and the phosphites; pentatomic in PCl_5, $POCl_3$, H_3PO_4, HPO_3, &c.; C diatomic in CO, and tetratomic in almost all other compounds; a large number of such examples might be adduced, but these may suffice.

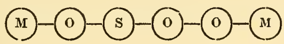
No chemist, however, as far as I know, except Kolbe and v. Oefele has assumed a similar variety in the atomicity of sulphur. I had long suspected that such a variable atomicity must be attributed to sulphur, but the remarkable discoveries of v. Oefele have to my mind placed it beyond a doubt. Indeed, so strong does the evidence appear to me, that I should not have thought it necessary to trouble the Society with this note, had I not observed that some of our most eminent theoretical chemists, as Hofmann and Foster, still represent S as diatomic in such compounds as SO_2 and $H_2\,SO_4$. I have therefore gathered together what seem the most cogent arguments in favour of the variable atomicity of sulphur.

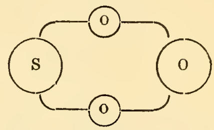
That S is diatomic in H_2S and the corresponding metallic sulphides, in the mercaptans and alkyl-sulphides, is quite obvious, and is admitted by all. I need therefore spend no time on this part of the subject. Let us then turn to those compounds in which there is reason to suspect the presence of tetratomic sulphur. These are SO_2, $SO\,Cl_2$, M_2SO_3, $S(C_2H_5)_3I$, and its derivatives. The latter series of substances discovered by v. Oefele seem to me quite inexplicable, except by the assumption of tetratomic sulphur, and I have never seen an attempt to explain their constitution in any other way.* But even leaving them out of the question, the most natural explanation of the constitution of SO_2 and M_2SO_3 is, that their sulphur atom is tetratomic. Formulæ can, indeed, be constructed with diatomic sulphur, which represent the *composition* of these bodies; but if we examine these formulæ we easily see that

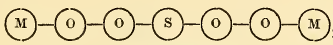
* Wurtz, in a note to a paper by v. Oefele on "Diethyl Sulphan" in the Bulletin de la Société Chimique de Paris for February 1865, formulates that among other sulphur compounds on the assumption of diatomic sulphur. But it must be remembered that this body $(C_2H_5)_2SO_2$, contains in the molecule only two monad radicals, so that it takes its place beside chloride of sulphuryl rather than in the series, since discovered by v. Oefele, of which the starting-point is the iodide of triethyl sulphin $S(C_2H_5)_3I$.

they are in many points of view forced and unnatural; in other words, that they are not what an unbiased consideration of the composition and properties of the substances would naturally lead to. This is still more the case with those substances in which the sulphur appears to be hexatomic. These are SO_3, M_2SO_4, $M_2S_2O_6$, and the numerous derivatives of H_2SO_4, which contain $(SO_2)''$; as these bodies, like the sulphites, contain, in the molecule, only two monad atoms, it is, of course, *possible* to represent their composition by formulæ containing diatomic sulphur.* Thus—


Sulphurous Anhydride.


Sulphite.

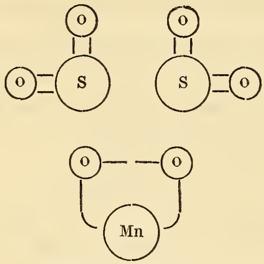

Sulphuric Anhydride.

, &c.
Sulphate.

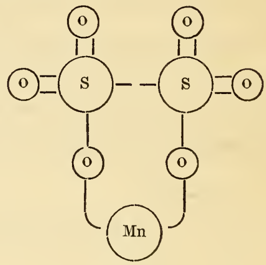
Examining these formulæ we find that these stable substances have some of the oxygen equivalents saturated by oxygen; this is, of course, possible; indeed we know bodies such as H_2O_2, BaO_2, Ag_2O_2, Brodie's peroxides, &c., in which this arrangement is probable; but all these bodies are remarkable for instability, and for the readiness with which they lose oxygen. They present absolutely no points of resemblance to the substances we are now considering. The striking analogy of SO_2 and SO_3 to CO and CO_2 also leads to the conclusion that the former is $S^{iv}O_2$ and the latter $S^{vi}O_3$, and that in both of them all the oxygen is combined with sulphur. If we accept this view, and follow out the analogy between the carbon and the sulphur compounds, we get a simple explanation of many relations otherwise difficult to be understood. For instance, hypo-sulphuric acid obviously stands in the same relation to sulphurous anhydride and sulphuric acid as oxalic acid

* I use here, for the purpose of representing the chemical structure of molecules, the graphic method which I first introduced in my thesis presented to the Medical Faculty of the University in 1861, and which I have more than once employed in papers read before this Society. I am happy to observe that its advantages are appreciated by others, Dr Hofmann, for instance, using a system almost identical in his lecture delivered before the Royal Institution on the 7th of April of this year.

does to carbonic oxide and carbonic acid; and the manner in which hypo-sulphuric acid is formed by the reaction of sulphurous acid on peroxide of manganese further confirms this view of its constitution. This reaction may be represented thus—

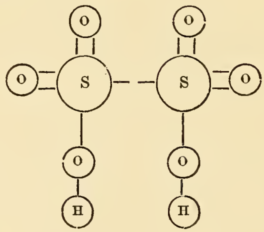


Before the reaction.

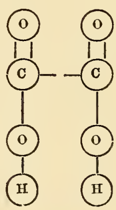


After.

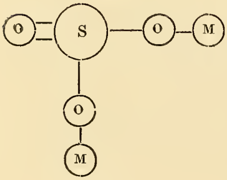
so that hypo-sulphuric acid is



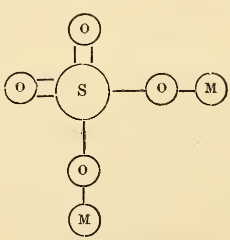
just as oxalic acid is



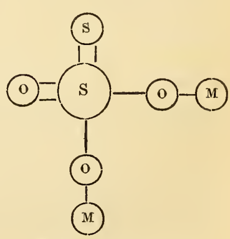
By means of the same assumption we get a simple explanation of the relations of the sulphites to sulphates, and to hypo-sulphites. Thus—



Sulphite.



Sulphate.



Hypo-sulphite.

The two latter bodies being respectively the oxide and the sulphide of the former, as their formation and decomposition indicate. It would be easy to give a much larger number of examples, but these are sufficient to show the way in which this view of the atomicity of sulphur may be applied to explain the constitution of its compounds.

4. Note on a paper by Balfour Stewart, Esq., in the Transactions of the Royal Society of Edinburgh, by I. Todhunter, Esq., M.A., St John's College, Cambridge. Communicated by Professor Tait.

In Volume XXI. of the Transactions of the Royal Society of Edinburgh, pages 407–409, a proposition in the Theory of Numbers is demonstrated. The proposition may be extended, and, at the same time, the demonstration simplified. I propose to establish the following result:—Let 1, α, β, γ, . . . μ, be the n roots of the equation

$$x^n - 1 = 0 \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

then, will

$$(1-t)(1-t\alpha)(1-t\beta)(1-t\gamma) \quad . \quad . \quad . \quad (1-t\mu) = 1 - t^n \qquad (2.)$$

where t is any quantity.

It is obvious that the term independent of t on the left-hand side of (2) is unity. Consider any other term,—for example, that involving t^3; the coefficient of this is equal to the sum of the products of every three of the quantities 1, α, β, γ, . . . μ, with the sign changed; and from (1) we know that this sum is zero. In this way (2) is established.

It is known that if n be a prime number, the quantities α, β, γ, . . . μ, may be expressed as the powers of *any* one of them; for example, as α, α^2, α^3 . . α^{n-1}. And if n be not a prime number, they may be expressed as powers of *some* of them.

Divide both sides of (2.) by $1-t$; thus—

$$(1-\alpha t)(1-\beta t)(1-\gamma t) \quad . \quad . \quad . \quad (1-\mu t) = 1 + t + t^2 + \quad . \quad . \quad . \quad + t^{n-1}.$$

In this result, suppose $t = 1$; then we obtain

$$(1-\alpha)(1-\beta)(1-\gamma) \quad . \quad . \quad (1-\mu) = n.$$

This is the Proposition established in Volume XXI.

[Mr Todhunter's elegant demonstration may be farther simplified, thus,—we have for all values of x,

$$x^n - 1 = (x-1)(x-\alpha)(x-\beta) \quad . \quad . \quad . \quad (x-\mu).$$

From this

$$x^{n-1} + x^{n-2} + \quad . \quad . \quad . \quad + x + 1 = (x-\alpha)(x-\beta) \quad . \quad . \quad . \quad (x-\mu)$$

or, putting $x = 1$

$$n = (1-\alpha)(1-\beta) \quad . \quad . \quad . \quad (1-\mu).$$

P. G. T.]

At the Meeting on 4th December, the following Gentlemen were elected Honorary Fellows of the Society:—

I. FOREIGN.

ANGELO SECCHI, *Observatory, Rome.*

II. BRITISH.

Lieut.-General EDWARD SABINE, R.A., *President of the Royal Society of London.*
CHARLES DARWIN, Esq., M.A., *Down, Bromley, Kent.*
ARTHUR CAYLEY, Esq., *Professor of Mathematics, Cambridge.*

The following Gentlemen were elected Ordinary Fellows at the Meeting of 18th December:—

The Right Rev. BISHOP MORRELL.
WILLIAM EUING, Esq., Glasgow.

The following Donations to the Library were announced:—

Proceedings and Transactions of the Nova Scotia Institute of Natural Science. Vol. II. Part 3. Halifax, 1865. 8vo.—*From the Institute.*

Medico-Chirurgical Transactions. Vol. XLVIII. London, 1865. 8vo.—*From the Royal Medico-Chirurgical Society.*

Quarterly Journal of the Geological Society. Vol. XXI. Part 4. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Society, London. Vol. XIV. No. 78. 8vo.—*From the Society.*

The Canadian Journal of Industry, Science, and Art. No. 49. Toronto, 1865. 8vo.—*From the Editors.*

Journal of the Chemical Society, London. No. 35. 8vo.—*From the Society.*

Journal of the Proceedings of the Linnean Society (Zoology). Vol. VIII. Nos. 31–32. London, 1865. 8vo.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XXXIII. London, 1865. 4to.—*From the Society.*

Researches on Solar Physics. By Warren de la Rue, Esq., Balfour Stewart, Esq., and Benjamin Loewy, Esq. London, 1865. 4to. —*From the Authors.*

Thirty-Eighth Annual Report of the Council of the Royal Scottish Academy. Edinburgh, 1865. 8vo.—*From the Academy.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland, November 1865. 8vo. —*From the Registrar-General.*

Mémoires de l'Académie Impériale des Sciences de St. Petersbourg. VII^e Série. Tome VII., Tome VIII. 4to.—*From the Academy.*

Bulletin de l'Académie Impériale des Sciences, de St Petersbourg. Tome VII. Nos. 3–6; Tome VIII. 4to.—*From the Academy.*

Norges Mynter i Middelalderen, samledeog beskrevne af C. I. Schive. Sjette Hefte, Femte Hefte. Christiania, 1865. Fol. —*From the Royal University of Norway.*

Nyt Magazin for Naturvidenskaberne. Trettende Binds, Fjerde Hefte; Fjortende Binds, Forste Hefte. Christiania, 1864–65. 8vo.—*From the Royal University of Norway.*

Norges Ferskvandskrebsdyr Forsted afsnit Branchiopoda, i Cladocera otenopoda, af Georg Ossian Sars. Christiania, 1865. 4to.—*From the Royal University of Norway.*

Om de i Norge Forskommende Fossile Dyrelevninger fra Quartær perioden, et Bidrag til vor Faunas Historie, af Dr Sars. Christiania, 1865. 4to.—*From the Royal University of Norway.*

Meteorologische Beobachtungen; aufgezeichnet auf Christiania Observatorium. Band I. 1837–63. Christiania, 1865. 4to. —*From the Royal University of Norway.*

Meteorologiske Iagttagelser paa, Christiania Observatorium, 1864. 4to.—*From the Royal University of Norway.*

Flateyjarbok en samling af Norske Konge-sagaer med imdskudte mindre fortallinger om begivenheder i og udenfor Norge Samt

Annaler, III. Binds, 1 Hefte. Christiania, 1865. 8vo.—*From the Royal University of Norway.*

Det Kongelige Norske Videnskabers-selskabs Skriften det 19de Aarhundrede, V. Binds, 1 Hefte. Throndhjem, 1865. 8vo.—*From the Royal University of Norway.*

Gaver til det Kgl. Norske Universitets i Christiania. 8vo.—*From the Royal University of Norway.*

Det Kongl. Norste Frederiks Universitets Aarsberetning for Aaret 1863. Christiania, 1865. 8vo.—*From the Royal University of Norway.*

Norske Universtets og Skole-Annaler udgivne af Universitetets Secretair; Mai, Oct. 1859; Marts, Juni 1860; Marts 1861; Marts 1862; Marts, Decr. 1863; Juni, Oct. 1864; Febr., Mai 1865. Christiania. 8vo.—*From the Royal University of Norway.*

Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XX. Nos. 9, 10. Bruxelles, 1865. 8vo.—*From the Academy.*

The Lord Provost's Statement to the Town-Council respecting Sanitary Improvement. Edinburgh, 1865. 8vo.—*From the Right Hon. The Lord Provost of Edinburgh.*

Tuesday, 2d January 1866.

Hon. Lord NEAVES, Vice-President, in the Chair.

The following Communications were read :—

1. Additional Observations on the Polarisation of the Atmosphere made at St Andrews in 1841, 1842, 1843, 1844, and 1845. By Sir David Brewster, K.H., D.C.L., F.R.S., &c.

In a former paper on this subject,* the author gave a selection from his observations on the polarisation of the atmosphere. After its publication, he received a long and elaborate memoir on the

* Transactions, vol. xxiii. p. 211.

same subject by Dr R. Rubenson,* containing a series of valuable observations made at Rome on the place of maximum polarisation, and on the intensity of the maximum polarisation at different hours of the day. Important observations on the polarisation of the atmosphere have also been made by M. Liais and M. Andres Poey, and the value of such observations, in determining the height and constitution of our atmosphere, has been universally recognised.

Under this impression, the author was induced to submit to the Society the rest of the four years' observations which he made at St Andrews, which, along with those already published, all exhibit the optical condition of the atmosphere during many days of every month of the year.

2. Notices of some Ancient Sculptures on the Walls of Caves in Fife. By Professor J. Y. Simpson.

The county of Fife abounds in caves or "weems"—a derivative from the Gaelic name for caves—and their existence gives a title to the earldom of Wemyss. Some of the caves in Fife are historical, as St Rule's at St Andrews, St Adrian's near Elie, and St Margaret's at Dunfermline. St Serf of Culross, the great patron saint of the west of Fife, is described by one of his biographers as having usually spent the forty days of Lent in a cave named, as such retreats often were, the *Desertum*. This cave at the *Desertum*—(or Dysart, to use the modern form of the name)—was used as a church up till near the time of the Reformation. About two miles eastward of Dysart, and near the village of Easter Wemyss, there is a range of large caves, seven or eight of which are at the present time open; but several more probably exist, having their openings covered over with debris. They stand about 15 or 20 feet above the level of high tide. Some of them are 80 to 100 feet in length, and of corresponding height and breadth. Two or three of them are perfectly dark, and require to be entered with candles. Last summer, when on a professional visit to Fife, Dr Simpson made a hurried visit to two of these caves, along with Dr Dewar,

* Acts of the Royal Society of Sciences of Upsal. Series iii. tom. v.

and saw some rude sculpturings in one of them. This discovery induced him to return for further search, accompanied by his friends, Drs Joseph Robertson, Duns, and Paterson, when two or three new caves were visited, and their walls found to be covered at different points with representations of various animals, figures, and emblems.

The cave sculpturings in Fife are of special interest to the Scotch archæologist, for this reason, that they exactly resemble, in type and character, the carvings on the so-called Sculptured Stones of Scotland. In his magnificent first volume on the Sculptured Stones of Scotland, Mr Stuart has collected one hundred and fifty examples; and latterly perhaps fifty more have been discovered. These Sculptured Stones extend along the whole east coast of Scotland, from the Forth northwards. Only two have been found south of the Forth. In general ornamentation, they resemble the sculptured stones of the west of Scotland, Ireland, Wales, and England; but the peculiarity of the Scotch stones is, that they have additional figures and symbols upon them that have been seen nowhere else in the world. These peculiar and characteristic symbols consist of the crescent or crescent-ornament, sometimes intersected with the V sceptre; of the so-called spectacle ornament—a double set of circles connected by middle lines—with or without the Z sceptre; of figures of elephants, fish, serpents, mirrors, combs, arches, or torcs, &c. The arrangement of these symbols upon the stones is in no two instances alike. On the oldest stones they are cut upon unhewn blocks, without any surrounding ornamentation. In the Sculptured Stones of a later date, they are cut in a raised form, with surrounding ornamentations, and often combined with figures of the Christian cross. Other figures are found carved on these stones, as portraits of priests and dignitaries, processions of men; the sacrifice of the bull; war and hunting scenes; animals, native and foreign, as the lion, tiger, camel, and monkey; the battling and devouring of men by wild animals; men with monster heads of beasts and birds; representations of dragons and monsters, &c. There is one instance of the representation of a boat and another of a chariot, at Meigle.

These rude sculpturings have, with one exception, been previously to the present time found only on sepulchral stones; but in the Fife caves they exist in great abundance on the cave walls.

These walls are usually comparatively smooth ; and in many places, though not in all, they retain the figures cut upon them. The cave figures consist of animals, as the elephant,—exactly of the form seen on the Sculptured Stones,—the deer, the dog, the swan, the peacock, fish, serpents, and monsters. On them we see also representations of the mirror, comb, and arch or horse-shoe. No perfect example of the crescent ornamentation exists in these cave sculpturings; but many specimens of the spectacle ornament are to be found on their walls, both with and without the intersecting Z sceptre.

One of the cave-figures is specially interesting, from the fact that it is the exact counterpart of the only analogous carving found on aught except a monolith, viz., a scale of silver armour presented to the Antiquarian Museum of Scotland by Mrs Durham of Largo, and whose history is this :—A man still living in Fife—a huckster —acting, it is said, upon an old tradition, that a knight lay buried in silver armour in a small barrow called Norrie's Law, stealthily dug into it, found in reality the silver armour, and removed and sold it in pieces to the amount, it is alleged, of four hundred ounces. By the time this spoliation was discovered, the silver armour was all melted, except a few fragments. One of these fragments is a scale, having cut upon it a spectacle ornament traversed by the Z sceptre, and having appended to one end of it the head and shoulders of a dog, as in some modern Orders of European knighthood. Precisely a similar figure, with the appended dog's head, is carved upon the interior of one of the Wemyss caves.

On the walls of some of the caves there are crosses of various forms; and in two or three parts appearances somewhat resembling letterings, and symbolic arrangements of figures or hieroglyphics. On the walls of St Adrian's caves are lines which some have believed to be half obliterated Runes; and the Rev. Mr Skinner of St Andrews has a loose stone from this spot which presents, he thinks, Runic characters.

Among the cave sculpturings at Wemyss, there is a figure of a man of diminutive form; and Mr Stuart has traced among them faded outlines of a full sized human figure, apparently tailed, as if he formed one of the provokingly missing links which some enthusiastic ethnologists are so anxiously and vainly searching after.

The caves of Fife, both those that have sculptures and those without them, have almost all occasional complete perforations or holes cut in their sides, and in their floors and roof, capable of allowing a thong or rope to be passed through, as if they were intended to suspend or to affix objects.

The age of these cave-sculptures can only be fixed by approaching the age of the analogous figures upon the Sculptured Stones. The earliest of the Sculptured Stones are perhaps very old—possibly as far back, if not farther, than the period of the Roman invasion. In opening last year a large cairn at Linlethan in Forfarshire, a figure of the elephant, exactly similar to those existing on our sculptured stones, was found on a stone lying upon the covering of the stone-enclosed cist. This cist contained a bronze weapon and an urn. The elephant sculpture was as old, therefore, as the era of urn burial and bronze weapons—except the carved fragment of stone had got by pure accident into its present position when the barrow was opened twenty years ago. The ancients sometimes buried both stone and bronze relics with their dead, after apparently they had iron instruments and weapons. But if the bronze dagger at Linlethan was a weapon used by the person buried under the cairn, the date is probably pre-Roman. For when Agricola invaded Scotland in A.D. 81, our Caledonian forefathers had apparently already passed through the bronze era, as, according to Tacitus, they fought the Roman legions with swords "long and without a point;" in other words, with iron swords.

But most of the Sculptured Stones, particularly the more elaborate varieties of them, were of comparatively later date, and were probably erected as late as the eighth or tenth century. An elaborate specimen found buried in the old churchyard of St Vigeans, having upon its surface the spectacle ornament, the crescent, the mirror, the comb, &c., in raised figures, has an inscription on it, which is probably the only Pictish inscription and sentence now remaining. It speaks of the stone as erected to Drosten, the son of Voret; and a Pictish king Drosten was killed in the battle of Blathmig or Blethmont—a mile or two off—in the year 729, as we learn from the Annals of Tighearnach. The Fife cave sculptures at Wemyss are mixed up with numerous forms of crosses, particularly of equal-limbed Greek crosses, showing that they were cut after the introduction of Christianity; and in one or two spots there are appearances of Christian monograms. Within St Adrian's cave at Caplawchy, near Elie, there are many crosses on the walls; stone seats cut out, &c.; but no animals or symbols.

The purposes for which they were cut, and the meaning of the mysterious symbols on the caves and sculptured stones, are archæological enigmata that no one has yet solved. As long as they were found on sepulchral monoliths only, they were supposed to be hieroglyphic or heraldic *funeral* inscriptions or emblems. This doctrine is so far gainsaid by this late discovery of them on the walls of caves. But possibly they may be sacred symbols of some description, or of some unknown form and meaning. For around and upon his gravestones man has always been in the habit of cutting emblems of his religion when he has cut anything; things sacred and things sepulchral being found united in his earliest carvings.

Other Scotch caves have sculptures cut upon them. The so-called Cave of Bruce, in the Island of Arran, has been found by Dr Mitchell and Mr Stuart to have deer and serpents carved on its walls; and many years ago, within St Maloe's cave in Holy Island, Dr Daniel Wilson found ancient Scandinavian inscriptions written in Runes.

In many counties in Scotland, both on the sea shore and inland, there exist large caves, the walls of which require to be now carefully examined, in order to find if our ancient forefathers had carved upon them any such emblems and sculpturings as have been traced in Fife. The Fife caves have formerly been inhabited. Dr Simpson showed from one of the Wemyss caves a collection of bones which had been split to remove their marrow, like the bones found in the old Danish midden heaps, &c. Among the bones were those of the deer, sheep, ox, &c. There were also shells of limpets, &c.; and microscopic remains of cereals were found in cavities in the rocks that had been apparently used as rubbers or querns. Perforated stones and two implements from the tyre of the deer's horn were picked up from the rubbish upon the floor; but the debris of these caves requires to be most carefully searched, before all that could be ascertained on this point becomes known to archæologists. In Scotland, there is one cave still occasionally inhabited, at Wick, and within which Dr Mitchell has seen living a family of eight or ten. But cave men are common elsewhere. Mr Barnwell has lately recorded the curious fact, that in the neighbourhood of Charters there are at present living, in caves, 150,000 men, in the very centre of France. In Africa, Asia, &c., caves are still inhabited, as they were by the Troglodites and Horites of old.

In England, we know that in archaic times caves were inhabited by the men of those distant ages, such as Kent's Hole, the Brixham Cave, the Kirkdale caves, &c. In these caves the bones of man have been found with his stone weapons, and along with them the bones of long extinct animals, as the mammoth, the cave bear, the hyæna, &c. But in his earliest and rudest times, man has been a sculpturing and painting animal; and his old attempts in this way may yet be found upon the walls of those ossiferous English caves. Sir Charles Nicolson had stated to Dr Simpson, as a proof that man, in his savage state, was a sculpturing being, the curious fact, that at the head of Sydney harbour rude sculpturings of the kangaroo, &c., had been found cut on the rocks, when the turf was removed in building operations there. Mr Graham had likewise informed him that at the Cape, the Bushmen, one of the rudest existing races of humanity, live much in caves, and constantly paint on the walls of them the animals in their neighbourhood, and sometimes battle and hunting scenes, always in profile. Mons. Lartet has lately shown that the caves of Perigord have been inhabited by archaic man, at a time when apparently he had no metallic weapons, when the reindeer still inhabited the south of France, and when even the dog was not yet a domestic animal. Yet amongst the relics found in these Perigord caves have been discovered sculpturings upon stone, bone, and ivory, of different animals; and latterly a rude sketch of the mammoth itself. All this entitles us to hope that, if these cave researches are prosecuted, we may yet find on the cave walls sculpturings done by man in the most ancient times, and containing fragments of his earliest history.

[Dr Simpson's communication was illustrated by numerous drawings of the Fife cave sculptures, made by Mr Drummond, R.S.A., and Dr Paterson of Leith.]

3. Observations on New Lichens and Fungi from Otago, New Zealand. By Dr Lauder Lindsay.

The paper consists mainly of the author's observations on the microscopic anatomy of the reproductive organs (with illustrative figures) of the following *new species and varieties of Lichens and Fungi* collected by him in the province of *Otago*, New Zealand, in 1861:—

I. Lichens.

1. Abrothallus Curreyi, *Linds.*
2. Lecidea Otagensis, *Nyl.*
3. L. flavido-atra, *Nyl.*
4. L. melanotropa, *Nyl.*
5. L. amphitropa, *Nyl.*
6. L. leucothalamia, *Nyl.* and *var.* melachroa, *Nyl.*
7. L. allotropa, *Nyl.*
8. L. coarctata, *Ach.* *var.* exposita, *Nyl.*
9. L. trachona, *Nyl.* *var.* marginatula, *Nyl.*
10. Lecanora homologa, *Nyl.*
11. L. peloleuca, *Nyl.*
12. Lecanora thiomela, *Nyl.*
13. Placopsis perrimosa, *Nyl.*
14. Opegrapha subeffigurans, *Nyl.*
15. O. agelæoides, *Nyl.*
16. O. spodopolia, *Nyl.*
17. Arthonia platygraphella, *Nyl.*
18. Platygrapha longifera, *Nyl.*
19. Pertusaria perfida, *Nyl.*
20. P. perrimosa, *Nyl.*
21. Pannaria immixta, *Nyl.*
22. P. gymnocheila, *Nyl.*
23. Psoroma sphinctrina, *Mnt.*, and *var.* pholidotoides, *Nyl.*
24. Physcia plinthiza, *Nyl.*
25. Ricasolia herbacea, *DN.* *var.* adscripta, *Nyl.*
26. Sticta subcoriacea, *Nyl.*
27. S. episticta, *Nyl.*
28. S. filix, *Hffm.*, and *var.* parvula, *Nyl.*
29. S. damæcornis, *Ach.* *var* subcaperata, *Nyl.*

These additions to the Lichen Flora of New Zealand and of the world may be thus tabulated :—

	Tribe.	Genus.	No. of New Species and Vars.	
I.	Lecideaceæ,	Lecidea,	8	9
		Abrothallus,	1	
II.	Lecanoreaceæ,	Lecanora,	3	9
		Pertusaria,	2	
		Pannaria,	2	
		Placopsis,	1	
		Psoroma,	1	
III.	Parmeliaceæ,	Sticta,	4	6
		Ricasolia,	1	
		Physcia,	1	
IV.	Graphideaceæ,	Opegrapha,	3	5
		Platygrapha,	1	
		Arthonia,	1	
		Total,		29

In the "Flora Novæ-Zelandiæ" of Dr Hooker there is no record of any species of *Opegrapha*, *Platygrapha*, *Umbilicaria*, or *Abrothallus*; and Professor Churchill Babington therein specially remarks, indeed, on the supposed absence of the genera *Opegrapha* and *Umbilicaria* (*Gyrophora*) from the Lichen-Flora of New Zealand. Subsequent researches have, however, shown that these genera are really represented, their apparent absence having been due probably to their not having been specially looked for. The foregoing list exhibits three species of *Opegrapha*, all new, being all the *Opegraphæ* contained in the author's collection; and Dr Knight and Mr Mitten have described other three species,* two of them new, as occurring in the North Island. The author's Otago collection also contains at least one species of *Umbilicaria*—a British one—*U. polyphylla*, L., and he has little doubt others will be discovered when the Lichens of the New Zealand *Alps* are specially collected.

II. Fungi.

1. Sphæria Lindsayana, *Currey.*
2. S. Otagensis, *Linds.*
3. S. Martiniana, *Linds.*
4. S. perrugosaria, *Linds.*
5. S. Cargilliana. *Linds.*
6. S. Usnearia, *Linds.*
7. Sphæria vermicularia, *Linds.*
8. S. Ramalinaria, *Linds.*
9. S. Stictaria, *Linds.*
10. Nectria armeniaca, *Currey.*
11. Æcidium Otagense, *Linds.*

Of these, Nos. 4 to 9 are types of a group, which is as yet virtually unknown to Fungologists, viz., the *Fungi parasitic on Lichens;* while No. 11 possesses interest in connection with the deformities or diseases it produces in the Phænogamous plant which it affects.

4. Orthogonal Isothermal Surfaces. By Professor Tait.

The Council reported that they had awarded the Keith Prize for the biennial period 1863–65, to Principal Forbes, St Andrews, for his "Experimental Inquiry into the Laws of Conduction of Heat in Iron Bars," which was printed in the last Part of the Transactions of the Society.

The Council also reported that they had awarded the Neill Prize

* "Contributions to the Lichenographia of New Zealand," Trans. Linnean Soc. vol. xxiii. p. 101.

for the triennial period 1862–65 to Andrew Crombie Ramsay, F.R.S., Professor of Geology in the Government School of Mines, and Local Director of the Geological Survey of Great Britain, for his various works and memoirs published during the last five years, in which he has applied the large experience acquired by him in the Direction of the arduous work of the Geological Survey of Great Britain to the elucidation of important questions bearing on Geological Science.

The following Gentlemen were duly elected Fellows of the Society:—

Fraser Thomson, M.D., Perth.
John M'Culloch, Esq.
T. Grainger Stewart, M.D., F.R.C.P.E.
Joseph M. Joseph, M.D., F.R.C.P.E.
Colonel Sir James Alexander of Westerton.

The following Donations to the Library were announced:—

Transactions of the Royal Irish Academy. Antiquities, Vol. XXIV. Parts 2–4. Science, Vol. XXIV. Parts 4 and 6. Literature, Vol. XXIV. Part 2. Dublin, 1864–65. 4to.—*From the Academy.*

Proceedings of the Royal Irish Academy. Vols. VII., VIII., IX. Part 1. Dublin, 8vo.—*From the Academy.*

Transactions of the Bombay Geographical Society. Vol. XVII. Bombay, 1865. 8vo.—*From the Society.*

Catalogue of the Printed Books in the Advocates' Library. Part II. Edinburgh, 1864. 4to.—*From the Library.*

On the Mechanical Principles of the Action of Propellers. By Professor W. J. Macquorn Rankine, LL.D. 4to.—*From the Author.*

Observations on the Functions of the Liver. By Robert M'Donnell, M.D. Dublin, 1865. 8vo.—*From the Author.*

Monthly Notices of the Royal Astronomical Society. Vol. XXVI. No. 1. London, 1865. 8vo.—*From the Society.*

Proceedings of the Royal Geographical Society. Vol. X. No. 1. London, 1865. 8vo.—*From the Society.*

Monday, 15th January 1866.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. Notes for a Comparison of the Glaciation of the West of Scotland with that of Arctic Norway. By Archibald Geikie, Esq., F.R.S.

In the course of the detailed investigations which, during the past six or seven years, have been carried on by the officers of the Geological Survey into the history of the glacial period in Britain, the desire naturally arose to compare the phenomena of glaciation so familiar in this country with those of some other region where they might be linked on to the action of still existing glaciers. No other part of Europe offered so many facilities for such a comparison as were to be found in Scandinavia. It was accordingly planned by my colleague, Dr John Young, and myself, to visit Norway in the summer of 1863. Unforeseen circumstances delayed the journey, and ultimately deprived me of the companionship of my friend. Nor was it until June of last year (1865) that, accompanied by two of my associates in the Geological Survey, Mr W. Whitaker and Mr James Geikie, I reached the Arctic Circle. All the Norwegian observations recorded in this paper were made conjointly with these companions.

The objects proposed to be accomplished in this excursion were—to compare, as minutely as time would allow, the ice-marks on the rocks of Scotland with those on the rocks of Scandinavia; to ascertain, from personal exploration, how far the glaciation of the Norwegian coasts and fjords could be traced to the action of land ice or of floating bergs; to trace, if possible, the connection between the ancient ice-work and the work of the living glaciers; and, generally, to watch for any facts that might help to throw light upon the history of the glacial period in the British Isles. Having only a few weeks at our disposal, we were far from aiming at original discovery in Norwegian geology. The main features of the disposition of the snow-fields and glaciers had already been given in the masterly sketch of Principal Forbes—a work which was of inestimable value to us.* More detailed descriptions of parts of the glaciation of Norway had been published by Scandinavian geologists—Esmark,† Hörbye,‡ Kjerulf,§ Sexe,|| and others. Yet I was not without the hope that, besides adding to our own experience, we might also be fortunate enough to find in the Norwegian fjords materials for making still more clear the geological history of our own western sea-lochs.

The close resemblance between the general outline of Scotland and that of Scandinavia is too well known to need more than a passing allusion. The numerous deep and intricate indentations, the endless islands and skerries, the mountainous shores, the host

* "Norway and its Glaciers." 8vo. 1853. Mr Chambers also has referred to the striated rocks in different parts of Norway in his "Tracings of the North of Europe." 1850.

† Esmark. "Edin. New Phil. Journal," vol. ii. p. 116 *et seq.* (1826). In this paper the former presence of land ice over large areas from which it is now absent, and its powerful influence as a geological agent of abrasion, are, for the first time, distinctly recognised. The illustrations are taken from the south of Norway.

‡ Hörbye. "Observations sur les phénomènes d'erosion en Norvége."—*Programme de l'Université de Christiania pour* 1857. The author gives a careful *resumé* of all the observations made by himself and others upon the direction of the striæ on the rocks of Norway, and adds a number of maps, one of which shows the outward radiation of the striæ from the central mountain mass of Scandinavia. Yet he commits himself to no theory as to the nature of the agent by which the striæ were produced. In a concluding section upon the glacial theory, he says :—"Il est vrai sans doute qu'en général la direction des stries est parallèle à l'avancement des glaciers actuels; mais je ne vois pas que cette circonstance puisse suffisamment démontrer que les stries ont été gravées par les glaciers." "Je me joins à cette conclusion, que les sulcatures du Nord se presentent comme des produits d'un agent plus puissant et plus général que les glaciers dont l'action conserve toujours un caractère plus local." But he does not indicate what this more powerful and more general agent may be.

§ Kjerulf. "Uber das Friktions-Phaenomen." Christiania. 8vo. 1860. See also Programme de l'Université de Christiania pour 1860, and Zeitschrift der Deutsch. Geol. Geselschaft, 1863, p. 619, and plate xvii.

|| Sexe. "Om Sneebræen Folgefon." Christiania. Universitetsprogram for andet Halvaar 1864. This paper gives a detailed account, with map and sections, of the Folgefon snow-field and its glaciers, including the well-known glacier of Bondhuus.

of short independent streams on the western coast; and on the eastern side, the broad undulating lowlands sending their collected drainage into large rivers, which enter the sea along a comparatively little embayed coast-line, are familiar features on the maps of both countries. This general outward semblance, which at once arrests the attention of every traveller in Norway, to whom the scenery of the western Highlands is familiar, depends upon a close similarity in the geological structure of the rocks, and a coincidence in the geological history of the surface of the two regions. Norway, from south to north, is almost wholly made up of metamorphic rocks, not all of the same age, yet possessing a general similarity of character. In like manner, the west of Scotland, from the Mull of Cantyre to Cape Wrath, is in great measure built up of gneiss, schist, slate, quartz-rock, granite, and other metamorphic rocks, quite comparable with these of Norway.*

* My friend Herr Tellef Dahll, who, in conjunction with Dr Kjerulf, is carrying on the Government Geological Survey of Norway, wrote down for me the following order of superposition of the rocks of the south of Norway. He was not at the time acquainted with the order of succession in the north-west of Scotland, and expressed his surprise and pleasure to find that it corroborated so well the order established by his colleague and himself. I place in parallel columns the Norwegian and Scottish rocks, to show the general parallelism, without wishing to insist that the equivalents suggested here are in each case strictly exact.

Norway.		*N. W. Highlands.*
Devonian ?		Lower Old Red Sandstone.
Upper Silurian.		,,
Lower Silurian. Hornblende, schist, gneiss, &c. Quartzite.	Lower Silurian	Schists, gneiss, and gneissose and schistoze rocks. Quartz-rock and limestones.
Schists with *Dictyonema norvegica.*		
Sparagmite and schists, about 2000 ft.		? Slates of N.-W. of Islay = Lingula flags ?
Red Sandstone and conglomerate occasionally present here. These and the overlying strata rest quite unconformably upon the		Red Sandstone and conglomerate (Cambrian) lying unconformably on the
Tellemarken formation—a vast succession of metamorphic rocks.		Fundamental or Laurentian gneiss.

This parallelism may require considerable modification, but it is at least

Besides the external resemblance due to the lithological nature of the rocks, beneath there is a still further likeness dependent upon similarity, partly of geological structure, and partly of denudation. Many of the Scottish sea-lochs have had their trend determined by lines of strike or of anticlinal axis, and the same result seems to have taken place in Norway. In other cases, the lochs and glens of the one country, and the fjords and valleys of the other, cannot be traced to any determining geological structure, but must be referred to the great process of denudation which has brought the surface to its present form.* In short, Norway and the Scottish Highlands seem to be but parts of one long table-land of palæozoic (chiefly metamorphic) rocks. This table-land must be of venerable antiquity; for it seems to have been in existence, at least in part, as far back as the Lower Old Red Sandstone. Since that time it has been sorely defaced by long cycles of geological revolution; rains, rivers, ice, and general atmospheric waste, have carved out of it the present valleys, and to all this surface change must be added the results of dislocations, as well as unequal upheavals and depressions of the crust of the earth beneath. Nevertheless, it still survives in extensive fragments in Norway, where it serves as a platform for the great snow-fields, while it can even yet be traced along the undulating summits of the mountains of the Scottish Highlands. One of its latest great revolutions was a submergence towards the west, which extended from the coasts of Ireland to the north of Norway, and gave rise to some of the most distinctive features of that part of Europe. No one can attentively consider the maps of the countries between the headlands of Connaught and the North Cape, without being convinced that the endless ramifying sea-lochs and fjords, kyles and sounds, were once land valleys. Each loch and fjord is the submerged part of a valley, of which we still see the upper portion above water, and the

important at present in showing that, both in Norway and in Scotland, there is a bottom gneiss covered unconformably by strata containing fossils, and that these strata are again overlaid by an upper and later series of metamorphic rocks of Lower Silurian age.

* I have tried to trace the history of this process in the case of the Scottish Highlands, and I may be permitted to refer to "The Scenery of Scotland, viewed in connection with its Physical Geology," chap. vi.

sunken rocks and skerries, islets and islands, are all so many relics of the uneven surface of the old land. The indented form of the coast-line of the west of Scotland and of Norway is not evidence of the unequal encroachments of the sea, but is due to a general submergence of the west side of the two countries, whereby the tides have been sent far inland, filling from side to side ancient valleys and lakes.* Subsequent re-elevations are marked along both the Norwegian and Scottish shores by successive terraces or raised beaches.

But to one who has sailed and boated among the sea-lochs of Scotland, no feature of the Norwegian coast is at once so striking and so familiar as the universal smoothing and rounding of the rocks, which is now recognised as the result of the abrading power of ice. Every skerry and islet among the countless thousands of that coast-line is either one smooth boss of rock, like the back of a whale or dolphin, or a succession of such bosses rising and sinking in gentle undulations into each other. Such, too, is the nature of the rocky shore of every fjord; the smoothed surface growing gradually rougher, indeed, as we trace it upward from the sea-level, yet continuing to show itself, until at a height of many hundred feet it merges into the broken, scarped outlines of the higher mountain sides and summits.† In short, as is now well known, the whole of the surface of the country, for many hundred feet above the sea, has been ground down and smoothed by ice.

We sailed along the coast of Norway, between Bergen and Hammerfest, by the usual steamboat route, touching at many stations by the way, threading the narrow kyles and sounds that lie among the innumerable islands, and now and then running inland up some fjord far into the heart of the country. We halted here and there to spend a few days at a time in exploring some of the fjords and glaciers. What can be seen from the steamer on the coasting voyage is now familiar from the numerous descriptions which have been given of it in recent years. I shall therefore

* See a fuller statement of this subject in "Scenery of Scotland," pp. 125–137.

† The singularly ice-worn aspect of the Norwegian coast, as well as its strong resemblance to the west coast of Scotland, was succinctly described by Principal Forbes, "Norway and its Glaciers," p. 42 *et seq.*

content myself with offering to the Society an account of two excursions to some distance from the ordinary route.

A little to the north of the Arctic Circle lies the island of Melö, one of many which are here crowded together along the coast. It is only noticeable, inasmuch as it is a station at which the steamers call, and from which the great snow-fields of the Svartisen or Fondalen may be most easily visited. Here, as along all the rest of the Norwegian coasts, we find ourselves among bare bossy hummocks of rock thoroughly ice-worn. From the higher eminences the eye sweeps over the countless islets and skerries, and far across the Vest Fjord to the serrated peaks of the Lofodden Islands, which from the distance seem deep sunk in the north-western sea. The whole of the lower grounds is one labyrinth of *roches moutonnées*, raising their smooth backs like so many porpoises out of the sea, and out of a flat expanse of green pasture and dark bog which here covers an old sea-bottom. The striations and groovings are still fresh on many of the smoothed surfaces of gneiss, and invariably run straight out to sea in the line of the long valley up which the sea winds inland among the snowy mountains. It cannot be doubted that a vast mass of ice has come seawards down this valley, and that all these ice-worn hummocks of rock were ground down by it. The wide valley or opening which stretches inland from Melö, is formed by the converging mouths of a number of narrow fjords. Of these the most northerly is the Glommens Fjord, which is bounded along its northern side by a range of high mountains, with a serrated crest and abundant snowy clefts and corries. Southward lies a belt of lower ice-worn hills, cut lengthwise by the Bjerangs Fjord, and bounded on the south by the Holands Fjord, on the south side of which rises another range of scarped snow-covered mountains.*

From the *gaard* of Melö we boated eastwards among various small islets and channels, passing soon into the Holands Fjord, up which we continued until we rested underneath the great snow-field and

* Although I use the word *mountains*, there is no definite system of ridges; on the contrary, these fjords must be regarded as indentations along the edge of a great table-land, of which the average level may range from 3000 to 4000 feet above the sea, and which serves as the platform on which the wide snow-fields lie. See "Norway and its Glaciers," pp. 190, 232.

glaciers of Svartisen. In this excursion we started from the coast, amid islands, all moulded, like those of the west of Scotland, by the ice of the glacial period, and we ended among rocks on which the present glaciers are inscribing precisely the same markings. One of the first features which arrested attention was the contrast between the smoothed, ice-worn surface of the lower grounds and the craggy, scarped outlines of the mountain crests.

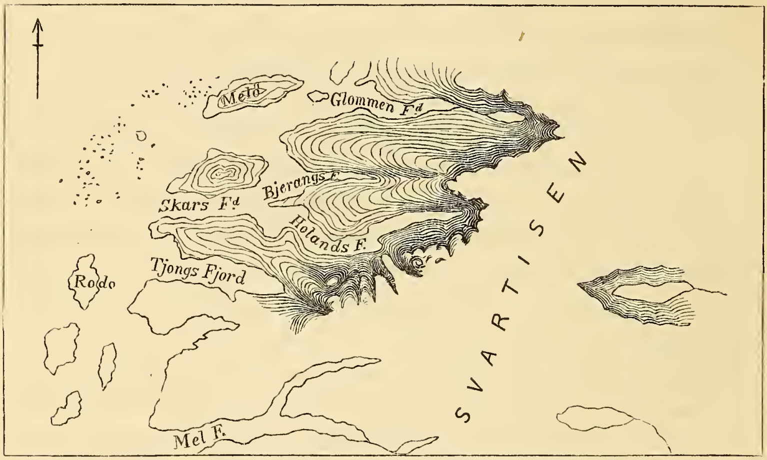


Fig. 1.—Map of the Neighbourhood of the Holands Fjord (Munch).

This was especially marked along the northern side of the Glommens Fjord, where the ice-worn rocks form a distinct zone along the side of the rough, craggy hills. To the north of Melövaer this ice-worn belt was estimated by aneroid to rise about 200 feet above the sea. Its smoothed rocks are abundantly rent along lines of joint and other divisional planes; their ice-worn aspect must thus be imperceptibly fading away. The rough rocks above them sometimes show traces of smoothed surfaces, as if they too had suffered from an older glaciation, of which the records are now all but obliterated. The line of division between the belt of rocks which have been smoothed by ice, and those which have been roughened and scarped by atmospheric waste, slopes gently upward in the direction of the central snow-fields of the interior. While at Melövaer it seemed to rise only about 200 feet above the sea; at Fondalen, twenty-five or thirty miles inland, it mounts to a height of fully 1500 feet. A tract of bare hills, lying between the Glommens and the Holands Fjord, and rising eastward into the snow-covered table-land, is well smoothed in the direction of these fjords. In short, the whole of the broad depression between the two fjords has been filled with ice, moving steadily downwards from the snow-fields to the sea.

It was interesting to watch, on every little islet and promontory under which we passed, the same details of glaciation so familiar along the margin of our Scottish fjords. The rocks are, as usual, smoothed into flowing lines, and slip sharply and cleanly into the water. They are well grooved and striated, these markings differing in no respect from those in Britain. Moreover, it was easy to see that the ice which had graven these lines must have moved down the fjord, for the *lee* or rougher side of the crag looked seawards. It was likewise clear that the scorings were not the work of drifting bergs or coast ice, for they could often be seen mounting over projecting parts of the banks, yet retaining all the while their sharpness, parallelism, and persistent trend. Another point of similarity to west Highland scenery, was found in the strange scarcity or absence of drift and boulders. I do not mean to assert that these are not to be met with at all, but they do not exist so prominently as to catch the eye even of one who is on the outlook for them. The rock everywhere raises its bare knolls to the sun as it does on the coasts of Inverness and Argyll. To complete the resemblance, the Norwegian fjord has its sides marked by the line of a former sea-margin, about 250 feet above the present. This terrace winds out and in among all the ramifications and curves of the fjord, remaining fresher and more distinct than the raised beaches of the west Highlands usually are, and even rivalling one of the parallel roads of Lochaber.

We rested for a week at the hamlet of Fondalen, on the south side of the Holands Fjord. It stands at the mouth of a deep narrow valley on the line of the terrace, which here runs along the crest of a steep bank of rubbish covered with enormous blocks of rock—an old moraine thrown across the end of the valley. There seems to have been at one time a lake behind this bank, formed by the ponding back of the drainage of the valley, and gradually emptied as the outflow-stream deepened its channel through the moraine.

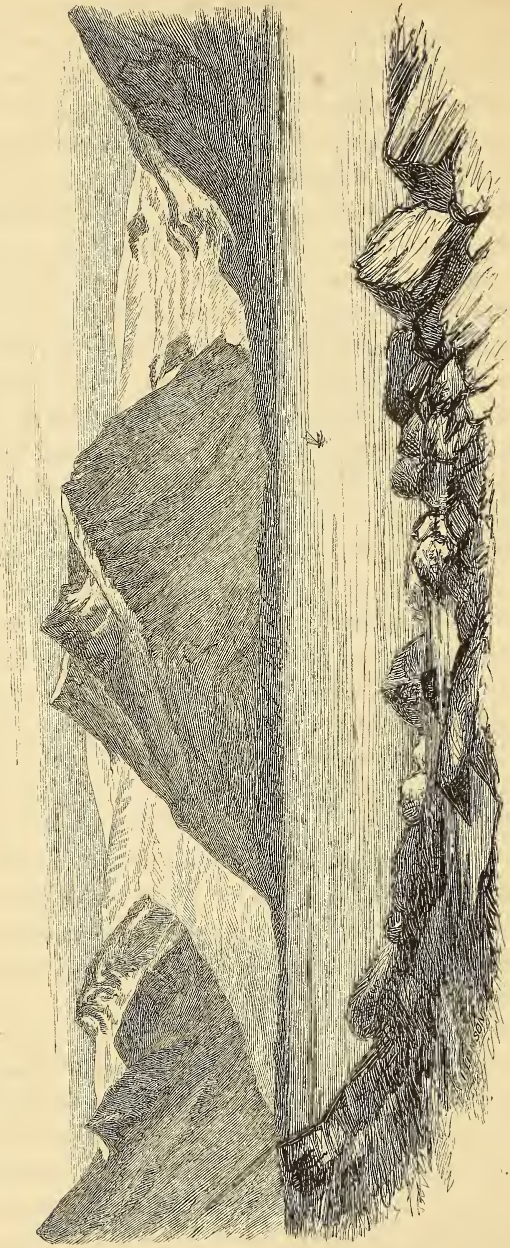


Fig. 2.—View of the two Glaciers of Fondalen, Holands Fjord.

At the head of the valley a small glacier descends from the snow-field of Svartisen. There could be no better locality for studying the gradual diminution of the glaciers, and for learning that it was land-ice that filled the Norwegian fjords, over-rode the lower hills and mountains, and went out boldly into the Atlantic and Arctic Sea. The Holands Fjord runs, as I have said, approximately east and west, and this short narrow valley descends from the south. The fjord was filled with ice, and is therefore polished and striated along the line of its main trend. The valley of Fondalen was likewise filled with ice, moving down to join the mass in the fjord; and its rocks, too, are striated in the length of the valley, or from south to north. The moraine of Fondalen is a proof that a glacier once descended to the Holands Fjord at that point. Farther evidence is found in the fact, that the sides of the valley are ground and striated for 700 feet and more above its bottom. Moreover, these polished and scored rocks can be traced up to and underneath the glacier. I crept for some yards under the ice, and found the floor of gneiss on which it rested smoothly polished and covered with scorings of all sizes, exactly the same in every respect as those high on the sides of the valley, in the fjord below, and away on the outer islands and skerries. Over this polished surface trickled the water of the melted ice, washing out sand and small stones from under the glacier.

We climbed the steep eastern side of the valley above the foot of the glacier, and found the hummocks of gneiss wonderfully glaciated up to a height of fully 700 feet. The gnarled crystalline rock has been ground away smoothly and sharply, so as to show its twisted foliation, as well as the patterns of a marble, are displayed on a polished chimney-piece. Even vertical or overhanging faces of rock are equally smoothed and striated. Many of the *roches moutonnées* are loaded with perched blocks of all sizes, up to masses 30 or 40 feet long. Above the limit to which we traced the work of the ice, the rocks begin to wear a more rugged surface, until along the summit of the ridges they rise into serrated crests and pinnacles. This rougher outline is, of course, the result of atmospheric waste, guided by the geological structure and chemical composition of the rocks.

The glacier descends from the snow-field, which was guessed to have there an elevation of about 3500 feet, to a point in the valley about 400 feet above the sea. The distance from the snow-field to the foot of the glacier looks not much more than one English mile—at least it is but short, compared with the rapidity of descent. Hence the glacier is steep, and in some places much crevassed. Issuing from the upper snow, in a steep, broken, and jagged slope of blue ice, it descends by a series of steps, till, getting compacted again in the valley below, it passes into a solid, firm glacier, with a tolerably smooth surface, forming a declivity of 12° or 15°.

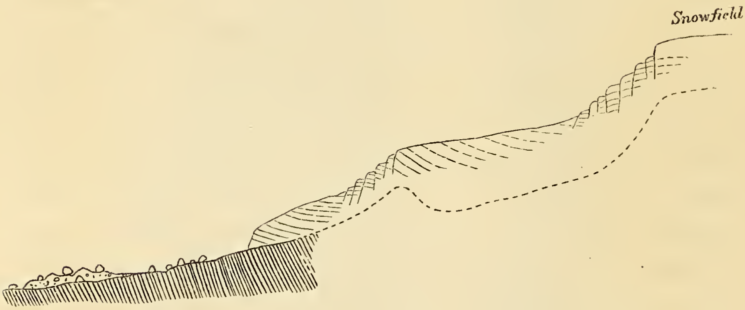


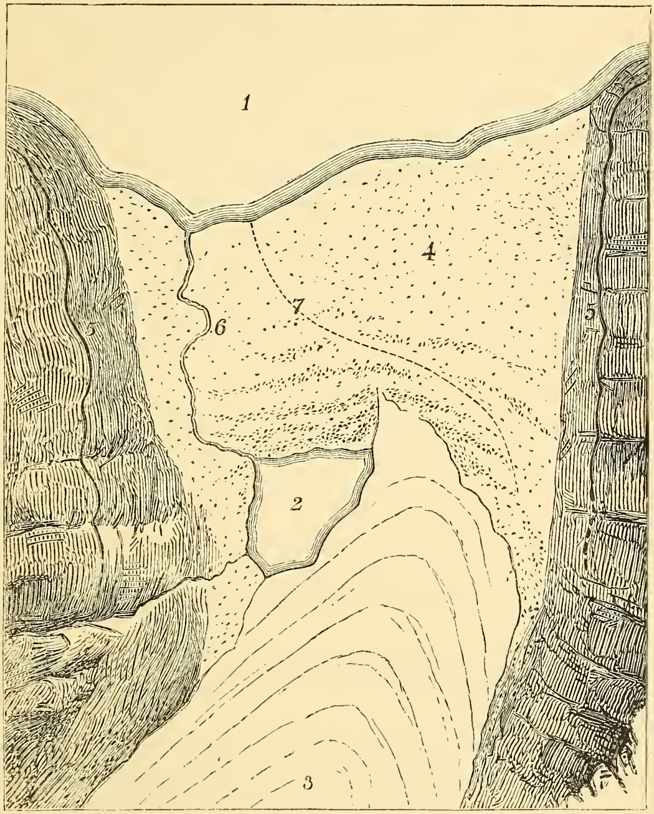
Fig. 3.—Longitudinal Section of smaller Glacier. Fondalen.

At a point about half a mile or less from the foot of the glacier the valley suddenly contracts, and the glacier, much narrowed and compressed, tumbles over a second steep declivity in a mass of broken ice. The crevasses speedily unite, and after another descent of 300 or 400 yards at an angle of 25°, the glacier comes to an end. At the point where the strangulation takes place, the glacier lies in a kind of basin, of which the lower lip presents proofs of the most intense erosion. On the western bank, in particular, a mass of the mountain side which projects into the ice has been ground away, and shows plainly enough, by its form and striæ, that the glacier, ascending from the basin, has climbed up and over this barrier, so as to tumble down its northern or seaward side.

The course of this little glacier is now too short to admit of the formation of moraines. Yet there are large heaps of rubbish and enormous masses of rock scattered over the valley below, and the moraine at Fondalen is a further proof that when the ice formerly filled the valley, its surface received abundant detritus from the mountain slopes on either side.

Opposite Fondalen, the Holands Fjord, passing through a deep and narrow channel on its northern bank, trends in an east-north-easterly direction, but just before taking this course, it sends eastward

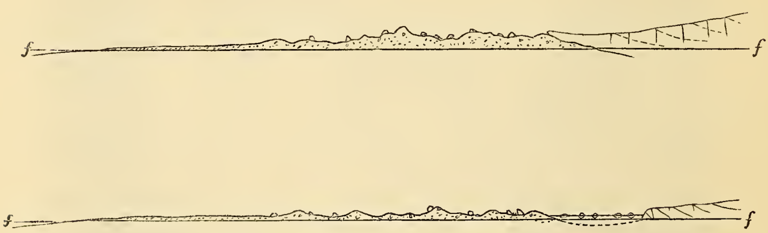
Fig. 4.—Sketch-map of lower end of larger Glacier. Fondalen.



1. Holands Fjord. 2. Small lake at end of glacier. 3. Glacier. 4. Alluvial plain rising into moraine mounds as it approaches the foot of the glacier. 5. Line of marine terrace or "raised beach," about 250 feet above sea-level. 6. Present course of stream. 7. Old course of stream.

a bay which terminates at the mouth of a valley about a mile above the hamlet. This valley is considerably larger than that just described, and it is occupied by a much longer and larger glacier. To one who looks up the valley from the opposite side of the fjord, it seems as if the ample glacier which fills up the bottom sweeps down from the snow-field in a rapid descent to the very edge of the sea. On a visit to the locality, however, it is found that between the foot of the glacier and the sea margin, there lies a plain of shingle and alluvium, which is partly covered with a brushwood of birch, and partly with a scanty pasturage. As it nears the ice it rises into ridges and hummocks, which increase in size as we ascend. These are true moraine mounds, rising often 60 or 70 feet above their base, and strongly reminding me of the moraines at Loch Skene, Peeblesshire. They consist of earth and stones, and are strewed over with large blocks of gneiss, porphyry, limestone, and other crystalline rocks. About a quarter of a mile from the margin of the fjord, along the eastern half of the breadth of the valley, these mounds come in contact with the foot of the glacier, which is there pushed in a long tongue down the valley. The ice overrides the moraine heaps, ploughing them and pushing them over.

Fig. 5.—Sections across the lower end of the larger Glacier. Fondalen.



In the upper section, the glacier is shown overriding its moraine; in the lower, the small lake with floating ice intervenes between the end of the glacier and the moraine. In each section *f f* marks the level of the fjord.

On the west side of this prolongation of the glacier, the ice is separated from the moraine mound by a small lake, of which the surplus waters find their way seaward by cutting through the moraine. Like Loch Skene and many lakes still existing in Britain, this sheet of water is formed by the dam of rubbish thrown down by the glacier across the valley. It is full of fragments of ice, which break off from the parent mass, and float across to the north or lower side, where they strand on the moraine heaps, and gradually melt away. The smaller pieces, however, often find their way into the stream by which the lake discharges itself, and are then carried down into the fjord. From the mean of several observations taken with the aneroid, I estimated the surface of this lake to be about 25 feet above the level of high water in the fjord. We had no means of measuring its depth, yet, from the slope of the glacier, it may be inferred that the bottom of the ice is probably lower than the level of the sea.

Proofs that the glacier was once much larger than it is now, may be well seen on the west side of the valley, a little above the lake. The shelving slopes of the mountain for several hundred feet upward have been shorn smooth, grooved, and striated, and every polished hummock of rock is loaded with huge fragments of stone, and heaps of earth and angular rubbish. Here, as at every glacier we visited, the glaciation of the rocks was exactly similar, down to the minutest detail, with that of the coast and outer islets, as well as with that of the Scottish glens and sea-lochs.

But the feature which most interested us was the relation of this large glacier of Fondalen to the marine deposits of the locality. The foregoing sketch (fig 4.) shows that the high terrace so marked along the sides of the Holands Fjord enters this valley, and extends on the western mountain side, at least, as far as the foot of the glacier. Hence the gravelly plain and the moraine mounds that separate the glacier from the fjord are overlooked on either side by a raised sea-beach. In examining attentively the nature of the material of which the mounds nearest the glacier were composed, we were struck with its difference from the loose, coarse character of the ordinary moraine rubbish, and its resemblance to the upper boulder-clay of Scotland. The glacier is pushing great noses of ice into and over those mounds, so that freshly exposed sections are abundant. The deposit is a loose sandy clay or earth full of stones, among which the percentage of striated specimens is not large. The larger blocks of gneiss and schist appeared to us not to occur in this clay, but to be tumbled down upon it from the surface of the glacier. We had hardly begun to look over a surface of the clay, ere we found fragments of shells, and in the course of a few minutes we picked up several handfuls, chiefly of broken pieces of *Cyprina Islandica*, but including also single valves of *Astarte compressa*, &c.

We even took out two or three fragments which were sticking in the ice of the glacier. These shells are not peculiar to one spot, but occurred more or less abundantly across the valley.

From the nature of the material of which these mounds consist, and from the occurrence of marine shells, it became evident that we were looking not merely upon ordinary moraine heaps—the detritus carried down on the surface of the ice and discharged upon the bottom of the valley. The glacier was engaged in ploughing up the sediment which had been formerly deposited in the valley by the sea, and on the heaps of earth and clay so formed were thrown the gravel and blocks brought down by the glacier. In short, we saw here actually at work a process of excavation, by which it had been conjectured that the marine drift was removed from certain valleys in the British Isles.*

We made two attempts, both unsuccessful, to climb to the vast table-land of snow from which these glaciers are fed. But we succeeded in reaching a point from which a good view of the seemingly boundless undulating plain of smooth snow could be obtained. We ascended the ridge that separates the two glacier valleys just described. After leaving the raised beach of Fondalen, with its massive erratics, we climbed a steep slope, clothed with a thick brushwood of birch, mountain-ash, and dwarf-willow, and luxuriant masses of ferns, bilberries, cloudberries, juniper, rock-geranium, lychnis, &c. The beech trees are often a foot or a foot and a-half in diameter at the base, and are the building material used at the hamlet of Fondalen below. These trees, at the height of 1320 feet above the sea, still often measure a foot across at the bottom, and 15 or 20 feet in height. At this height, and even considerably lower, there were large sheets of snow on the 12th of July, and these increased in number and depth as we ascended. The birch trees grow smaller and more stunted the farther they struggle up the bare mountain ridge, until they become mere bushes. The willows, in like manner, dwindle down till they look like straggling tufts of heather, though still bearing their full-formed catkins. At a height of 1690 feet, these stunted bushes at last give place to a scrub of bilberry, mosses, and lycopodia. The mountain consists

* See Prof. A. C. Ramsay, "Glaciers of Switzerland and Wales," 2d edition p. 60.

of gneiss, sometimes massive and jointed, sometimes fissile and flaggy, with a strike towards W. 15° S. The extent to which the higher portions have suffered from the disintegrating effects of the weather is remarkable. The gneiss is split up along its joints into large blocks, which lie piled upon each other in heaps of angular ruin. We noticed one or two masses which differed in lithological character from the rocks around; these may possibly have been ice-borne from some of the neighbouring eminences. On reaching a point 2700 feet above the fjord, our further passage was arrested by a narrow, shattered, knife-edge of gneiss, along which it was impossible to advance. But from this elevated point we could judge of the general aspect of the great snowy table-land of the Svartisen, which was sloping towards us, while the two glaciers were spread out as in a plan beneath.

The branch of the Holands Fjord, which opposite to the hamlet of Fondalen, strikes off to the north-east for seven or eight miles, is bordered on the south side, and closed in at its further end, by a range of steep, almost precipitous, walls of rock, the summits of which are on a level with, and indeed form part of the great table-land. Here, as in so many other parts of Norway, we are reminded that the fjords are, after all, mere long sinuous trenches, dug deeply out of the edge of a series of elevated plateaux. And, looking up to the crest of these dark precipices, we see the end of this snow-plain peering over, and sending a stream of blue glacier ice down every available hollow. We counted seven of these tiny glaciers, exuding like tears from under the snow, and creeping downward under the sombre cliffs of gneiss. None of them comes much below the snow line, and none, of course, reaches the sea. The largest of them is near the end of the fjord, and appears as a broken, crevassed mass of ice, moulded as it were over the steep hill side, and, when seen from below, seeming about to slip off and plunge into the fjord. Fragments of it are continually breaking away, and rolling, with the noise of thunder, and clouds of icy dust, down the shelving sides of the mountains. These glaciers are, for the most part, the icy drainage of the snow-field. But there are one or two lying in corries, and quite detached from the main snow-field, though probably connected with it in winter.

We left this delightful fjord not without regret, and catching again the coasting steamer at Melovaer, proceeded northwards. Between Melovaer and Bodö, the higher mountains have wonderfully craggy and spiry outlines, only their lower parts showing the smoothed contour of glaciation. But where the coast hills sank, as towards a fjord or bay, the ice-moulded forms could be traced to a greater height. To the north of Bodö, the contrast between the sharp weather-worn peaks above, and the flowing ice-worn hummocks and hill sides below, is singularly startling. Principal Forbes, who gave a characteristically faithful drawing to illustrate this feature, places the upper limit of glaciation at from 1500 to 2000.* We should have estimated it to be considerably lower. Through narrow kyles and intricate sounds, reminding one at every turn of detached portions of West Highland or Hebridean scenery, the steamer slowly wound its way, and then across the Vest Fjord to the Lofodden Islands. The weather now unfortunately proved unfavourable for geological observation. In sailing through the Rafte Sund, we saw what looked like moraines at the mouths of some of the valleys, and the lines of moraine terraces continued as marked as ever. Well ice-worn rocks were also observed at the openings of some of the valleys, but we were rather impressed with the general ruggedness and absence of glaciation among the Lofoddens.

To the north of Tromsö lies the island of Ringvatsö, noticed by Mr R. Chambers.† The moraine which he describes as damming up the circular sheet of water, whence the island takes its name, really coincides with the line of the higher of the two strongly marked terraces or sea-margins of this part of the Norwegian coast. It thus illustrates the history of the moraine and terrace, below the smaller glacier at Fondalen. It was further interesting to mark that the glacier of Ringvatsö, partially hidden under snow, lies in a hollow or corry surrounded with precipices, and quite cut off from any snow-field. The accumulation of snow in the corry itself must thus be sufficient to give rise to the glacier. In looking at this island, I was again forcibly reminded of the history of the glaciers of Tweedsmuir and Loch Skene, where, on dimples of the hill tops, and in deep cliff-encircled recesses, there must have gathered snow enough to form streams of ice, which caught and carried on their

* Norway and its Glaciers, p. 58.

† Tracings of the North of Europe, p. 145.

surface the piles of rubbish and huge blocks of greywacke that now form the moraines of Midlaw, and dam back the waters of Loch Skene. A large snow-field is not necessary for the production of a glacier that may form comparatively extensive moraines.*

The south-western side of the Lyngen Fjord is formed by a mass of high ground, which shoots up steeply from the sea to a height of 4000 feet or more. Every hollow and cliff is smothered with snow, which descends in straggling streaks and patches almost to the edge of the water. We sailed up the fjord for some miles, and had a full view of this truly magnificent coast line. We counted from ten to twelve small glaciers nestling in separate corries, and also two or three on the north-eastern side. There was here the same evidence of the formation of glaciers in small independent hollows of the mountains, quite detached, at least in the summer, from any large snow-field.

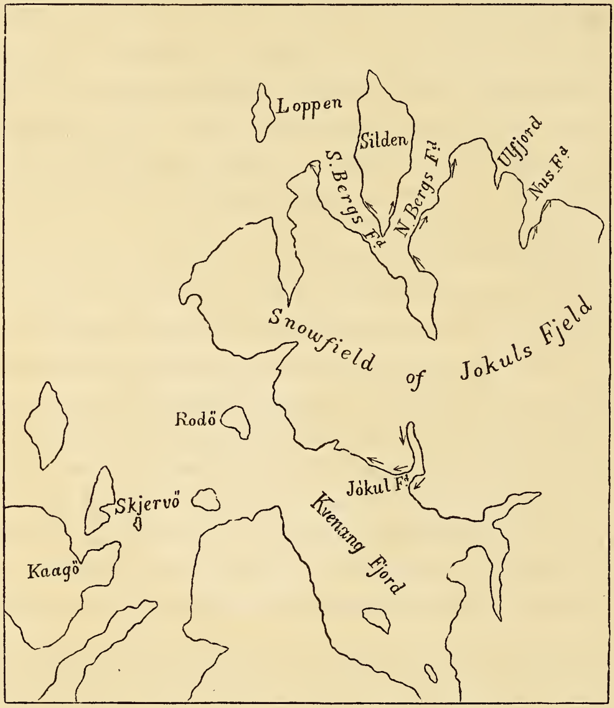
We halted at the island of Skjaervö (lat. 70°) for the purpose of making an excursion across the Kvenangen Fjord and up the Jökuls Fjord, to see the glacier which was said to reach the level of the sea.† The metamorphic rocks among which the Jökuls Fjord lies, are for the most part of a flaggy quartzose character. Sometimes, especially where they are most fissile, they are violently crumpled. Parts of them pass into hornblende rock and actinolite schist. Their average strike is on an east and west line. They are much jointed, and yield freely to the action of the weather. Hence, a rough and angular surface has very generally replaced the ice-moulded outlines, though these still here and there remain.

* North Wales presents a number of illustrations of this remark, such as Cwm Graianog, Cwm Idwal, &c. (see Professor Ramsay's Glaciers of North Wales).

† This glacier was noticed by Von Buch, and is mentioned by Principal Forbes. When we visited it, I was not aware that a brief account of it had been given in vol. ii. of "Peaks, Passes, and Glaciers," *second series.* Mr J. F. Hardy, the writer of that description, started overland from Talvik on the Alten Fjord, and reached the Jökuls Fjord below the glacier, to which he ascended by boat. Like my own party, he did not climb the glacier, but he seems to have regarded it as connected with the snow-field above. Though I did not succeed in ascending the rugged cliffs, I had no doubt that the lower glacier, from its colour, and the steepness and contraction of the gorge above it, is a true *glacier remanié,* and like the Suphelle glacier described by Forbes ("Norway and its Glaciers," p. 149), is quite disconnected, at least in summer, from the snow-fields above.

The same two prominent terraces already mentioned are well marked along the sides of the Jökuls Fjord. The lower one is about 60 feet, the higher about 152 feet (aneroid measurement) above high-water mark, and several others less distinct, occur between the higher and the sea. The upper is especially marked,

Fig. 6.—Map of the Jökuls Fjeld promontory (after Munch). The arrows show the direction of the old ice striae.

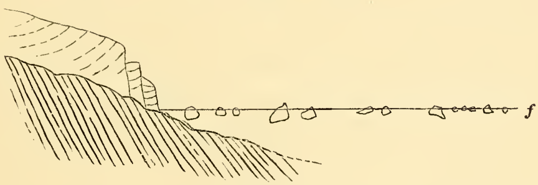


often running as a shelf cut out of the rock. This feature was noticed along many parts of the Norwegian coast, even (as in the Jökuls Fjord) in sheltered places where wave action cannot be supposed ever to have been very strong. As the date of these rock-terraces probably goes back into the glacial period, it occurred to me that they may have been due in large measure to the effects of the freezings and thawings along the old "ice-foot," and to the rasping and grating of coast ice. Such, too, may have been the origin of the higher horizontal rock-terraces of Scotland.

Fig. 7.—View of Jokuls Fjord Glacier.

At the head of the fjord the terraces disappear along the steep, bare sides of the mountains. A moraine mound of loose rubbish and large blocks lies on the west side, and extends a little way into the fjord, pointing towards a similar ridge on the opposite side, as if both were parts of a curved terminal moraine. The view from this ridge is singularly imposing. The sombre precipitous mountains sweep upward from the edge of the water, seamed everywhere with streaks and sheets of snow. Down even to the beach these snow-drifts lie; and it gives a vivid impression of the high latitude of the place, that even in July there should be deep masses of snow overhanging tangle covered rocks, and undermined by the wash of the waves. Over the crest of the mountains, at the head of the fjord, we see the edge of the great snow-field of the Jökuls Fjeld, and stealing down from underneath, the snow comes a broken, shattered mass of glacier ice, broadest at the top, and narrowing downwards till its point disappears in a deep cliff or ravine, perhaps a third of the way down from the surface of the snow-field to the sea. The eastern part of this glacier seems plastered as it were over the forehead of the mountain, and is ever sending off fragments down the dark precipice below. Indeed, the whole glacier is in constant commotion, cracking, and crashing, and discharging masses of ice and snow, which pour over the black rocks in sheets of white dust, with a noise like the unintermitted thunder of a battle. These ice-falls are in large measure intercepted at the point where the glacier disappears behind the side of the ravine. They seemed, indeed, to collect in the ravine, and to slide down through it; for at its lower end a second glacier begins, and expands with the expansion of the hollow in which it lies, till it reaches the edge of the fjord, where it may be a quarter of a mile broad. This lower glacier appeared to me not connected with the snow-field, but a true *glacier remanié*, deriving its materials entirely from the avalanches of snow and ice that pour down upon its surface from the precipices overhead. It has a white, or dull greenish white colour, varied with well-marked dirt-bands. The slope of its surface was judged to be fully 20° or 25°. A few longitudinal crevasses make their appearance along the middle of the glacier, and a little further down, the transverse crevasses increase in number and size, until at its foot the glacier, broken by large semicircular rents, becomes a tumbled mass of ruin. Last summer these cliffs of granular loose textured ice in some places overhung the waves. But the dark rock was likewise seen peering out along the water's edge, underneath the ice, which does not push its way out to sea in a mass, but ends abruptly where it meets the water. From these icy walls fragments and large slices break off, and fall either on the margin of rock or into the fjord, which is thus covered with hundreds of miniature icebergs, slowly drifted downwards against wind and tide, by the surface current of freshwater. This process is called "calving" by the natives, and so great is the commotion sometimes produced, that according to the information collected by Von Buch, the Lapp huts along the margin of the fjord are sometimes inundated by the waves propagated outwards from the falling masses. The floating fragments of ice look like little models of Arctic bergs; their forms are often singularly fan-

Fig. 8.—Section of Foot of Jökul's Fjord Glacier.



tastic; they may be seen shifting their position, and even capsizing, as their submerged parts melt away; some of them carry stones and earth on their surface; and many are aground along the margin of the fjord, and rise and fall with the tide, or the ripple of the waves. We passed two or three which were from 8 to 10 feet long, and rose from 3 to 4 feet out of the fjord. Our boat grated against several, which seemed only a foot or two in size, yet the shock of the collision shewed how much larger was the portion concealed under water.

To the east of the upper glacier the snow-field sends another icy stream down the face of the shelving precipices which descend into a higher valley. We could hear the roar of the avalanches even when the glacier itself became hidden behind the intervening spur of the mountain. From the rocky declivities of the Jökul's Fjord also, stones were heard and seen bounding from point to point in their descent towards the long heaps of debris at the bottom. In short, in this lonely uninhabited spot, the activity and ceaselessness of the wasting powers of nature come before the traveller with a memorable impressiveness. The wide snow-field that seems to lie so sluggish and still among the distant mists, is yet seen to be in slow but constant motion, pushing its ice-streams towards the valleys, and grinding down the hard rocks over which it moves. Frosts, rain, and springs have scarped the shoulders of every mountain, and poured long trains of rubbish down its sides. And if this can be now done under the present climate of Norway, how much more powerful must the abrasion have been when the ice, in place of being arrested on the brow of the mountain, filled up the fjord, and pushed its way into the Arctic Sea.

From the open mouth of the Kvenangs Fjord, in the passage between Skjaervö and the Jökul, the outline of the neighbouring land is well seen. The steep, serrated ridge of the Kvenangs Tinderne shows its tiny glaciers nestling in corries both on its northern and southern sides. The sides of the Kvenangs Fjord are ice-moulded and striated in the direction of the inlet, and its islands are only large *roches moutonnées*. In looking back at the mountainous tract of the Jökul's Fjeld, we see that it is another snowy table-land jutting out as a promontory into the Arctic Sea, deeply trenched with long, narrow fjords, and pushing glaciers down every glen and hollow that descends from the plateau of snow.

We visited the north-western and northern sides of this snow-field, boating up the Bergs Fjord to the hamlet of that name, and after ascending to its glaciers, continuing our excursion by boat into the Nus Fjord. (See fig. 5.) In ascending the South Bergs Fjord, we found the gneissic and schistose rocks polished and striated from east to west, which is the direction of the inlet, and in turning into the North Bergs Fjord, which runs nearly at a right angle to the other, the striæ were seen to turn out of the Lang Fjord and bend northwards through the northern limb of the Bergs Fjord. At the hamlet of Bergsfjord these ice-mouldings are especially well shown, and there, as well as along many parts of the fjord, occur lines of rock-terraces, often strewed with quantities of angular blocks. Two of the most marked of these horizontal bars have an elevation of about 50 and 150 feet respectively.

Behind the hamlet the ground slopes up to a point about 250 feet above the sea, beyond which lies the mouth of a valley that runs up into the heart of the mountains. We climbed the terraced slope leading to this recess, and found that the lower half of the valley is occupied by a lake about a mile long, and said to be 30 fathoms deep. It lies in a rock basin, and the rocks around its margin show that they have been powerfully abraded by ice. We were told that three weeks before our visit this lake was solidly frozen over; great sheets of snow, indeed, still descended to the water's edge, and were melting away under the glare of a fierce July sun. At the far end of the valley mounds of angular rubbish, cumbered with huge blocks of stone, stretched from side to side, while overhead two glaciers came out of the edge of the snow-field, and hung down the steep mountain side—the longer one almost reaching the bottom of the valley. Here, too, the ice was ever breaking up and crashing down the precipices in clouds of snowy dust. The debris of ice gathered into talus heaps below, like the *cones de dejection* at the foot of a winter torrent.

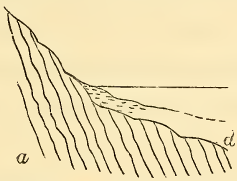
From Bergsfjord we continued our boating voyage down the fjord, and found fresh proofs that a vast body of ice, descending from the lofty Jökuls Fjeld, had moved northwards along the length of the inlet. Every promontory was beautifully smoothed and polished; while the grooves and striæ slanted up and over the projecting bosses of rock, as they do in Loch Fyne and the other western sea-lochs of Scotland. Round the headland at the mouth of the Bergs Fjord we turned eastward, and soon passed the mouth of the Ulfjord. We could see that, at the far end of that inlet, the snow of the great table-land moves outward to the edge of the dark precipices which encircle the Ulfjord, and actually forms on the crest of these precipices a white cliff, from which, of course, avalanches are constantly falling. Yet the under part of this snowy cliff is not snow, but ice, as shown by its blue colour contrasting with the whiteness of the upper layer, which is snow. At the foot of the precipice a glacier, derived probably in part, like that of Jökul's Fjord, from the ice-falls from above, creeps towards, but does not reach, the bottom of the valley. Continuing our eastward journey we saw the same terraces still skirting the hill sides, now as green platforms of detritus loaded with angular blocks, and now as sharp horizontal notches in the bare rocks. We were likewise struck here, as in other parts of the Norwegian coast, with the greater freshness of the ice-markings near the sea-level, when compared with those higher up—a difference which is likewise very noticeable in the west of Scotland.

The Nus Fjord is about six miles long, and lies between the Ulfjord and Oxfjord. Its margin is terraced by the same horizontal lines so constant in this region. Its south-western side presents a singularly arctic scene. A range of deeply cleft and embayed crags and precipices, plentifully streaked with snow, rises up to the edge of the snow-field, which, as usual, presses down every larger valley in a stream of blue ice. Eight or ten distinct glaciers may be counted, of which at least three descend from the snow-field. The others lie in corries detached from the snow-field, though in some cases connected with it by nearly perpendicular streaks of snow. Here, as in the Ulfjord, the edge of the great sheet of snow which covers the table-land may be seen ending off abruptly as a cliff upon the crest of a dark precipice of rock, and from the colour of the lower part of the cliff, it is plain that from pressure and motion, the under portion of the snow sheet is converted into ice, and as ice, reaches the verge of the table-land, where it breaks sharply off, and sends its ruins to the bottom of the precipice underneath. There the debris, mingled with the winter snow, is anew converted into solid ice, and creeps downward as a glacier.

At the head of the fjord, on the south-east side, the mouth of a valley which terminates inland at the foot of a glacier is blocked up by an old moraine. Behind this rampart of detritus the valley spreads out as an alluvial plain, evidently at one time a lake formed by the moraine barrier at the foot. The moraine itself is strewed with enormous angular blocks of rock, beside which the huts of a miserable Lapp encampment look like mere pebbles. The side of this moraine facing the fjord is cut by the 50 foot beach. On the opposite side of the fjord a valley, at the head of which a glacier comes down from the Snée-fond, opens upon the shore, and is curtained across by a terrace, the surface of which is mottled with a number of irregular concentric mounds. We had not an opportunity of examining these, but they seemed to be moraine heaps left by the glacier when it came down to the fjord. They vividly recalled the singular concentric mounds that overlie the terrace at the mouth of the old glacier valley of the Brora in Sutherlandshire.

We walked along the north-east side of the fjord, and found the rocky declivity terraced with old sea-margins, which ran along like ancient and ruined roadways. They occur up to perhaps 200 or 250 feet above the sea-level, and are cut in the hard rock. They are covered with loose blocks, partly derived from the rocks around, but probably in part also transported from a higher part of the valley. On the beach we met with well ice-worn bosses of gneiss, slipping

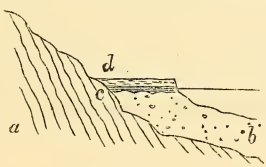
Fig. 9.—Section on beach at Nus Fjord.



d Sandy-grey clay, with *Tellina proxima*, *Saxicava rugosa*, *Astarte elliptica*, *Cyprina Islandica*, &c. *a* Ice-worn gneissose rocks.

beneath a grey sandy clay full of arctic shells—a conjunction which is closely paralleled by one on the shores of Loch Fyne.

Fig. 10.—Section on beach at Ardmarnock, Loch Fyne.



d Sandy-grey clay, full of *Tellina proxima*, *Astarte borealis*, *Natica clausa*, *Cyprina Islandica* (in fragments sometimes seven-twelfths of an inch thick) and other northern shells. *c* Finely striated red clay, without shells. *b* Boulder-clay. *a* Ice-worn gneissose rocks.

In each case the rocks are beautifully smoothed and grooved, and show that the ice which moulded them moved down the length of the inlet. To the north and east of the Jökuls Fjeld the ground becomes lower, and descends wholly below the snow-line. The hills that bound the Alten Fjord, instead of rising into serrated peaks, like the higher tracts to the south, have a well ice-worn aspect, and recall the hills of Cantyre, or the scenery of parts of the Hebrides. Indeed, the whole of this northern district of Norway, from the Alten Fjord to beyond the North Cape, has the smoothed outline which further southward is found only on the lower zone of the mountains.* It seems as if a sheet of ice, descending from the south, had overriden all the fjords here and the comparatively low hills between them, and had advanced northwards to the Arctic Sea.

In fine, this short excursion into the Northern part of Scandinavia, furnished us with abundant proofs that the glaciation of the west of Norway was produced by a mass of land-ice, of which the present glaciers are the representatives. It likewise confirmed, in a most impressive way, the conclusion which has gained ground so rapidly within the last few years, that the glaciation of the Scottish Highlands, as well as of the rest of the British Isles, is in the main the work, not of floating bergs, but of land ice. This conclusion may, indeed, be regarded as demonstrated beyond all cavil by the ice-marks of Norway. Much good work might be done by trying to work out a detailed comparison of the glaciation of the Scandinavian peninsula with that of this country. More especially would it be of importance to ascertain how far the glacial deposits of the two countries can be compared. Doubtless the drift-covered slopes of Sweden, and those of the east and centre of Scotland, must have many geological features in common. It will perhaps be found that some of the difficulties which our Scottish drift presents are explained by the more extensive deposits of the north, while the latter may likewise suggest new explanations of phenomena, supposed to be already sufficiently intelligible.

2. On the Third Co-ordinate Branch of the Higher Calculus. By Edward Sang, Esq.

The object of the paper was to point out that the theory of variables has a third branch, bearing to the Differential and Integral Calculus a relation somewhat analogous to that which the theory of Logarithms bears to Involution and Evolution.

In the theory of Functions there are three connected variable

* We did not go further than Hammerfest, but the same contour is retained over the low, tame district that separates Hammerfest from the North Cape.

quantities, viz., the Primary, the Function, and the Derivative. When the relation between the primary and the function is given, the discovery of the derivative belongs to the Differential Calculus. When that between the primary and the derivative is given, the function is found by help of the Integral Calculus. And the general problem to find the primary when the relation between the function and its derivative is given, belongs to a third branch, which may be called the Calculus of Primaries.

It was stated, in the course of the paper, that, by help of well-known artifices, problems involving the first derivative or the second derivative can be converted into problems of integration, and that thus the first two chapters of the Calculus of Primaries are, as it were, abstracted; but that, whenever the order of derivation is higher than the second, the equations cannot be transformed so as to be rendered integrable.

The following Gentlemen were duly elected Fellows of the Society:—

Charles Morehead, M.D., F.R.C.P. Lond.
Professor David Masson.
David Douglas, Esq.

The following Donations to the Library were announced:—

Abstracts of the Proceedings of the Geological Society of London. No. 139. 8vo.—*From the Society.*

Bulletin de la Société Impériale des Naturalistes de Moscou. No. 2. 1865. 8vo.—*From the Society.*

Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München 1865. II. Heft 1, 2. 8vo.—*From the Academy.*

Astronomical, Magnetical, and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1863. London, 1865. 4to.—*From the Observatory.*

Transactions of the Linnean Society of London. Vol. XXV. Part II. 4to.—*From the Society.*

List of the Linnean Society of London for 1865. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XIV. No. 79. 8vo.—*From the Society.*

Monthly Returns of the Births, Deaths, and Marriages, registered in the Eight principal Towns of Scotland. December 1865. 8vo.—*From the Registrar-General.*

Address of Lieut.-General Sabine, delivered at the Anniversary Meeting of the Royal Society, London, on 30th November 1865. 8vo.—*From the Author.*

Meteorologische Waarnemingen in Nederland en Zijne Bezittingen en Afwijkingen van Temperatuur en Barometstand op vele plaatsen in Europa Uitgegeven door het Koninklijk Nederlandsch Meteorologische Instituut 1861–1863. Utrecht. 4to. —*From the Utrecht Society of Arts and Sciences.*

L'appareil Épisternal des Oiseaux décrit. Par. P. Harting. Utrecht 1864. 4to.—*From the Utrecht Society of Arts and Sciences.*

Bijdragen tol de ontwikkelings der Zoetwater Planarien. Utrecht 1865. 4to.—*From the Utrecht Society of Arts and Sciences.*

Verslag van het Verhandelde in de Algemeene Vergadering van het provinciaal Utrechtsche genootschap van Kunsten en Wetenschappen 1862–63–64–65. Aanteekeningen 1860–61–62–63–64. Utrecht. 8vo.—*From the Utrecht Society of Arts and Sciences.*

Abhandlungen der Philosophisch-Philologischen classe der Koniglich bayerischen Akademie der Wissenschaften. Band X. Historischen classe. Band IX. Band X. Erste Abtheilungen. Munchen. 4to.—*From the Academy.*

Journal of the Statistical Society of London. Vol. XXVIII. Part IV. 8vo.—*From the Society.*

Proceedings of the American Philosophical Society. Vol. X. No. 73. Philadelphia. 8vo.—*From the Society.*

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. V. 1865–66. No. 70.

Monday, 5th February 1866.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read:—

1. On the Laws of the Fertility of Women. By J. Matthews Duncan, M.D.

This paper was a sequel of a paper read to the Royal Society, and published in the 23d volume of the "Transactions." That paper was entitled, "On the Variations of the Fertility and Fecundity of Women, according to age;" and among other conclusions therein announced, was one to the effect that fecundity, or likelihood of child-bearing after marriage, increased from the earliest child-bearing age till about twenty-five, and thereafter gradually decreased. In the present paper, the laws regulating such fertility after marriage are demonstrated. The chief data on which the arguments for these laws are based are derived from an analysis of 16,301 families, in connection with which entries were made in 1855 in the public registers for Edinburgh and Glasgow.

The fertility of marriages in Scotland is shown by the reports to the Registrar-General to be about 4·64 children to a marriage. But this statement is of no physiological value, since all marriages are included in it, comprising those at all ages and of all durations, &c. A statement of the fertility of Scottish wives, a little more exact, is got by dividing the number of married women of child-bearing age by the number of legitimate children born, all in the same year. It is thus found that every 3·55 wives, aged from fifteen to forty-five, add one to the population annually.

The fertility of all marriages in Edinburgh and Glasgow that were fertile in 1855 is found to be 3·7 children to a marriage. The fertility of fertile marriages enduring for the whole child-bearing period of life is shown to be on an average ten children to a marriage; and as the average interval between successive births is about twenty months, fertile women, living in wedlock, from fifteen to forty-five, are fecund for about seventeen years.

The fertility of persistently fertile marriages, lasting during the whole child-bearing period of life, is shown to be at least fifteen children to a marriage. Persistently fertile wives, taken at any duration of marriage, are found to have born at the rate of a child very nearly every two years.

It is shown that, at any epoch in married life, the average number of a fertile woman's family is one-third of the number of years elapsed since her marriage, and that the number of a persistently fertile woman's family is one-half of the number of years elapsed since her marriage. These numbers vary according to the age of the wives at marriage — a circumstance which is subsequently explained.

The average interval between marriage and the birth of a first child is shown to be seventeen months. Inclusive of this period, the interval between the births of successive children is twenty months. In average families, the first four children succeed one another more rapidly than the next six—that is, on to the tenth. But in large families, or those above ten, the children, from the first, do comparatively hurry after one another with brief intervals.

Fertile women, married at different ages, have an amount of fertility which decreases as the age at marriage increases; and this greater total fertility arises from the greater continuance or persistence in fertility of the younger married. Women married at higher and higher ages have a shorter career of fertility. This perseverance in fertility explains why the women married from fifteen to twenty years of age have a greater fertility than those married from twenty to twenty-five, who have the highest fecundity or likelihood to have children, and specially a greater probability of being fertile than those married from fifteen to twenty.

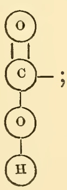
Wives who are persistently fertile are more fertile the older they were at the time of marriage. In other words, the older a woman, destined to be fertile, is at the time of marriage, the greater will be her fertility so long as it lasts. The fertility of a woman old at marriage is greater than that of a woman young at marriage; yet the total fertility of women married young far exceeds that of women married when elderly, reckoning for both sets equal durations of marriage, and all within the child-bearing period; because of the younger a far larger proportion are fecund, and because the younger have a far longer continuance of fertility.

The increasing frequency of twin-births as age advances is explained by this law of increasing intensity of fertility as age advances.

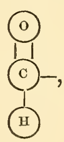
Women married when elderly have been supposed by some authors to have a special postponement of the generative orgasm, to enable them to bear children beyond ordinary periods. But this is shown not to be the case, by the circumstance that most women child-bearing at very high ages are already mothers of considerable families.

2. On the Classification of Chemical Substances by Means of Generic Radicals. By Dr Alexander Crum Brown.

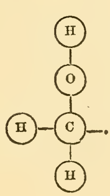
In this paper the author proposes to use for purposes of classification those radicals or parts of molecules which are common to *genera* of substances, and within which the changes characteristic of these genera take place. Thus the carbon acids contain the group or radical



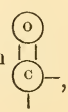
; the aldehydes



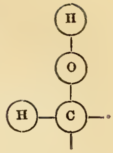
, and the "true" alcohols



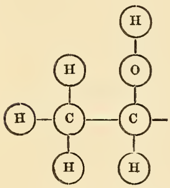
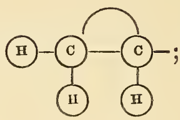
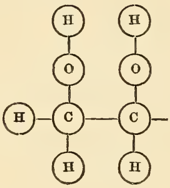
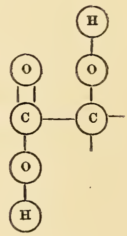
. In the same way, as the acetones contain

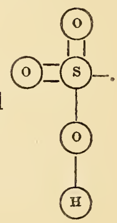


,

the pseudo-alcohols derived from them must contain 

By a comparison of various reactions it is shown that the group characteristic of the olefine-hydrates is probably

 ; that of the olefines, ; that of the glycols ; that of the lactic acid class 

and that of the organic acids derived from sulphuric acid .

Such groups of atoms may be called generic radicals, as the distinguishing characters of a genus depend on the presence of one of them, and the individual substances may be classified as compounds of these radicals. In conclusion, some substances are mentioned which consist entirely of such radicals, as glycol $(CH_2HO)_2$, glyoxal $(COH)_2$, oxalic acid $(CO\ HO)_2$, hypo-sulphuric acid $(SO_2HO)_2$, glycolic acid $(CH_2HO)\ (CO\ HO)$, glyoxylic acid $(COH)\ (CO\ HO)$, glycerine $(CH\ HO)''\ (CH_2HO)_2$, tartronic acid $(CH\ HO)''\ (CO\ HO)_2$, glyceric acid $(CH\ HO)''\ (CH_2HO)\ (CO\ HO)$, mesoxalic acid $(CO)''\ (CO\ HO)_2$.

3. Note on the Compression of Air in an Air-bubble under Water. By Professor Tait.

In an air-bubble of moderate dimensions the pressure is very little greater than that of the atmosphere; but, as the difference of pressures within and without a bubble is proportional to its curvature, it appeared to me possible that the so-called solution of air in water might be due in some degree to the extreme compression of the air when divided into small bubbles invisible perhaps even under the microscope.

For a rough attempt at a solution, let us assume air to follow Boyle's law for all pressures, and suppose the common formula

$$p - p_0 = \frac{2T}{r}$$

to hold for the smallest bubble.

Both of these assumptions are probably far from correct—the first, when the condensation of the air is great; and the second, when the dimensions of the bubble are so small as to be comparable with the greatest distance at which molecular forces are sensible.

If R be the radius of the sphere which the contained air would occupy at the pressure of the atmosphere p_0; r the radius of the bubble, and p the pressure inside,

$$p = \frac{R^3}{r^3} p_0.$$

Eliminating p by the help of the first equation,

$$\left(\frac{r}{R}\right)^3 + \frac{2T}{Rp_0}\left(\frac{r}{R}\right)^2 - 1 = 0.$$

Now, by experiments on the rise of water in capillary tubes, it is found that the value of $\frac{2T}{p_0}$ is, roughly, ·0001 inch, if T be the tension per linear inch, p_0 the pressure per square inch. From the smallness of this quantity it appears that unless R be very small, the second term of the above cubic is of little consequence, and therefore the dimensions of the bubble are little altered.

But if R be very small the second term is of more importance than the first. The following are rough approximations only:—

R in.	$\frac{r}{R}$	$\frac{p}{p_0}$
0·0001	·75	2·3
0·00001	·3	35
0·000001	·1	1000
0·0000001	·03	33,000.

An air-bubble whose radius is ·00001 inch, which is about the smallest that can be observed by means of a good microscope, contains air compressed to 11 atmospheres only.

When the bubble is detached from the fluid each of its surfaces contributes its share to the excess of internal, over external pressure. (W. Thomson, *Proc. R. S.* 1858.) In this case the equation above becomes

$$\left(\frac{r}{R}\right)^3 + \frac{4T}{Rp_0}\left(\frac{r}{R}\right)^2 - 1 = 0,$$

at least until r becomes so small that the thickness of the film must be taken into account. The following numbers, therefore, refer to the case of vesicular vapour which is supposed by Clausius and others to account for the blue of the sky and the morning and evening red. As I have considered it unnecessary to allow for the thickness of the film, the later results are too large:—

R in.	$\frac{r}{R}$	$\frac{p}{p_0}$
0·0001	·62	4·3
0·00001	·22	94
0·000001	·07	2740
0·0000001	·022	98,000.

Little is gained towards a closer approximation by applying analysis such as that of Laplace or Gauss to this question. If we express by $\phi(r)$ the law of molecular action as depending on the distance, we know merely that ϕ is insensible for sensible values of r. The complete solution of the problem can, no doubt, be given by a direct application of Laplace's process. Thus, if we write

$$\psi(r) = \int r dr \int \phi(r) dr,$$

the attraction of a uniform spherical shell, of radius a, on an external unit of matter placed at a distance r from its centre is represented by

$$2\pi\rho a d a \frac{d}{dr}\left\{\frac{\psi(r+a)-\psi(r-a)}{r}\right\}.$$

Integrating between the limits 0 and a $(a<r)$ for a, we have the attraction of a uniform sphere on an external point. Forming the equation of fluid equilibrium on the supposition that such a spherical portion ceases to exert molecular force, we find the expression for the pressure in the fluid at a distance r from the centre of the bubble. This contains the following new functions

$$\omega(r)=\int rdr\int rdr\int\phi(r)dr,$$

and

$$\chi(r)=\int dr\int rdr\int\phi(r)\,dr,$$

but, from the manner in which they appear in the final expression, it is impossible to determine the relative importance of the terms containing them.

We see, however, that the terms in ω, which are multiplied by the curvature, become somewhat less as the radius of the bubble diminishes—so that the calculated pressures given above are possibly too large.

4. On some Geometrical Constructions connected with the Elliptic Motion of Unresisted Projectiles. By Professor Tait.

In "Tait and Steele's Dynamics of a Particle," chap. iv., a number of geometrical constructions are given, some possibly for the first time, connected with the motion of projectiles in parabolic paths in vacuo. I have recently been led to remark that most of these propositions still hold when we substitute, for the uniform action of gravity in parallel lines, the action of gravity supposed to be directed to the earth's centre, and to vary inversely as the square of the distance from that point. My excuse for bringing so simple a matter before the Society is, that the propositions are in themselves curious and elegant, and that I am not aware of their having been before mentioned. A very few examples will suffice to indicate the change of form required by the more general assumed conditions. The following may be taken for this purpose:—

1. The locus of the second foci of the paths of all projectiles leaving a given point, with a given velocity, in a vertical plane, is a circle.

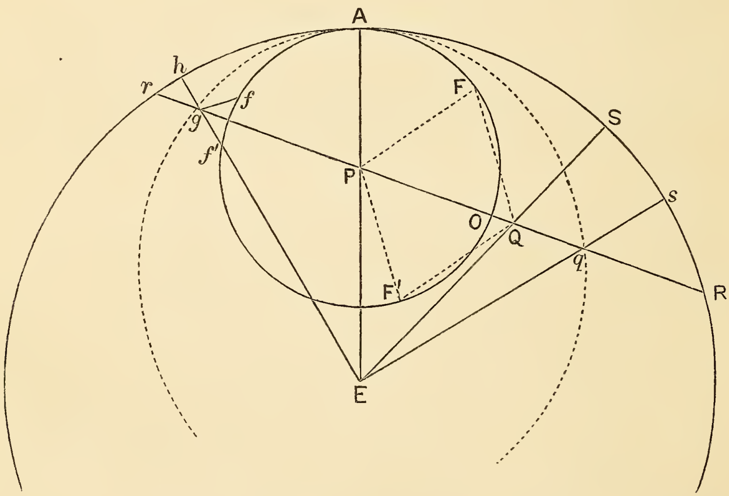
2. The direction of projection for the greatest range on a given line, passing through the point of projection, bisects the angle between the vertical and the line.

3. Any other point on the line which can be reached at all, can be reached by *two* different paths, and the directions of projection for these are equally inclined to the direction which gives the maximum range.

4. If a projectile meet the line at right angles, the point which it strikes is the vertex of the other path by which it may be reached.

5. The envelop of all possible paths in a vertical plane is an ellipse, one of whose foci is the centre of the earth, and the other the point of projection. (In the simpler case this is a parabola.)

The proofs of these propositions are extremely simple. Thus, let E be the earth's centre, P the point of projection, A the point



which the projectile would reach if fired vertically upwards. With centre E, and radius EA, describe a circle in the common plane of projection. This corresponds to the common directrix of the parabolic paths in the ordinary theory. If F be the second focus of any path, we must have EP + PF constant, because the axis major depends on the *velocity*, not the *direction*, of projection. Hence (1) the locus of F is the circle AFO. Again, since, if F be the focus of the path which meets PR in Q, we must have FQ = QS; it is obvious that the greatest range Pq is to be found by the condition Oq = qs. O is therefore the second focus of this trajectory, and therefore (2) the direction of projection for the greatest range on PR bisects the angle APR. If QF = QF′ = QS, F and F′ are the second foci of the two paths by which Q may be reached; and, as $\angle$ FPO = $\angle$ F′PO – we see the truth of (3). If Q be a point reached by the projectile when moving in a direction perpendicular to PR – we must evidently have PQF′ = $\angle$ PQF = $\angle$ SQR = $\angle$ EQP; *i.e.*, EQ passes through F′. This case is represented on the other side of the diagram—where $f'g = gh = fg$. The ellipse whose second focus is f evidently meet Pr at right angles: and that whose second focus is f' has (4) its vertex at g. The locus of q is evidently the envelop of all the trajectories. Now

$$Pq = PO + Oq = PA + Oq,$$

$$Eq = Es - sq = EA - Oq.$$

Hence

$$Pq + Eq = PA + AE,$$

or (5) the envelop is an ellipse, whose foci are E and P, and which passes through A.

5. On the Fairy Stones found in the Elwand Water near Melrose. By Sir David Brewster, K.H., F.R.S.

On the banks of the Elwand Water, which runs into the Tweed, about two miles above Melrose, there is a picturesque glen called the Fairy Dean, which has become a favourite place of resort, from its association with the incidents in "The Monastery" by Sir Walter Scott. It has acquired an interest of a different kind from certain mineral concretions which have received the name of *Fairy Stones*, from their being found in that part of the rivulet which runs through the Fairy Dean.

When the Waverley Novels were not acknowledged by their author, facts or incidents to which they referred, were always welcome subjects of conversation at Abbotsford; and on one occasion when I happened to mention that singular stones were found in the Fairy Dean, Sir Walter Scott expressed a desire to see them, and to know how they were formed. I accordingly sent some young persons to search for them in the bed of the rivulet, and I was fortunate in thus obtaining several specimens of great variety, and singular shape, and showing, very clearly, the manner in which they were formed.

It did not then occur to me that a description of these stones would excite any other than a local interest; but, some years ago, when in company with our distinguished countryman Mr Robert Brown, the *Botanicorum facile Princeps* of Humboldt, he asked me to accompany him to his museum, to see some remarkable mineral productions which had been sent to him, and which he had not seen before. These minerals were exactly the same as the Fairy Stones from Roxburghshire, but none of them were so remarkable, either in their shape or their mode of formation, as those which I now present to the Society.

The Fairy Stones are generally of a grey colour, like common freestone, but some of them are coated to the thickness of about the seventieth of an inch, with a black substance, so soft as to produce a black streak upon paper like a crayon.

These stones are generally formed of concentric layers more or less regular round a single centre, as in figs. 1 and 2, some of them

Fig. 1.

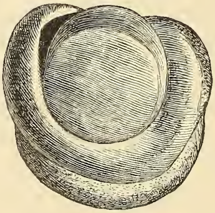


Fig. 2.

having the form of a lens, ocasionally so deep, as to be almost a sphere. In many specimens the concentric layers are formed round two centres, as in fig. 3; in some round three centres, and in others round many centres, as in figs. 4 and 5.

In a few specimens, when the concentric rings round two centres

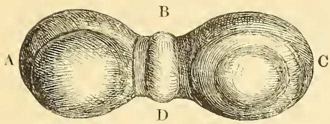


Fig. 3.

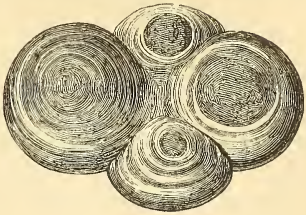


Fig. 4.

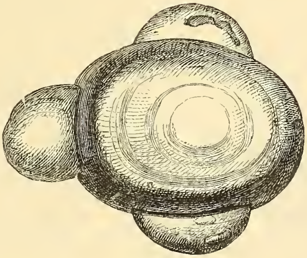


Fig. 5

have come into contact, as in fig. 3, the rings take the shape ABCD like the Lemniscates in biaxal crystals.

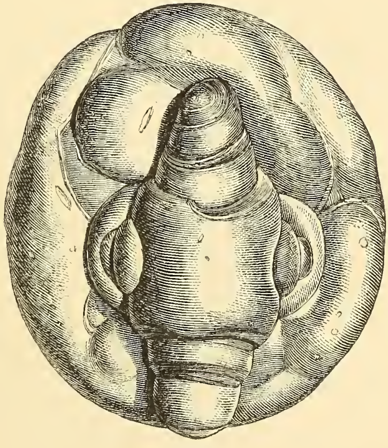


Fig. 6.

In one remarkable specimen, shown in fig. 6, the different portions are disposed with such extraordinary symmetry as to give it the appearance of a fossil.

It is obvious, from the inspection of the specimens on the table, that the Fairy Stones are formed by the dropping of water containing the matter of which they are composed. This is clearly shown in two of the specimens on the table, where the fluid matter has been deposited upon fragments of whinstone, though in one of these specimens (fig. 7) the deposits at AA are so deeply imbedded as to have the appearance of contemporaneous formations.

When the stones have a symmetrical structure on the under as well as on the upper side (as in fig. 8), it is difficult to understand

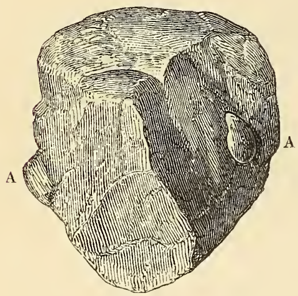


Fig. 7.

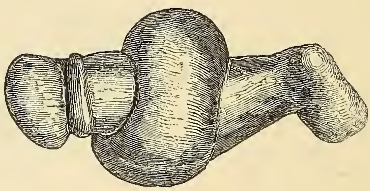


Fig. 8.

the mode of their formation, unless we suppose that the deposit has been made upon a soft stratum of clay or sand, or any other material with which the deposited matter will not combine, and from which it may be easily separated.

This difficulty is increased when the specimen has the form of a ring, as in fig. 9.

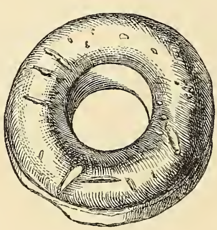


Fig. 9.

According to a rough analysis, which Dr Dalzell has been so good as to make for me; the specific gravity of the Fairy Stones is 2·65, and their odour, when breathed upon, argillaceous. They effervesce with mineral acids, and contain the following ingredients proportionally in the order in which they are written :—*Alumina*, *Silica*, *Lime*, *Magnesia*, *Oxide of Iron*, and a trace of *Manganese*.

The black coating on many of these stones, which is too minute for analysis, and which may be easily removed, is very remarkable. If it is not carbonaceous it must be an aluminous deposit, when the particles of the aluminous solution have become so small as to be unable to reflect light. This supposition will not appear unreasonable to those who have seen the surfaces of fracture of certain specimens of quartz, where the separated fibres are so minute as to be incapable of reflecting the lowest order of tints in Newton's scale. The specimen of quartz in which I observed this very remarkable phenomenon was, I believe, exhibited to the Society. Mr Haidinger afterwards found a less perfect specimen in which the surfaces of fracture were equally black.

The following Gentlemen were admitted Fellows of the Society :—

John M'Nair, Esq.
Professor Spence.
Thomas Nelson, Esq.

The following Donations to the Library were announced :—

Transactions of the Royal Scottish Society of Arts. Vol. VII. Part 1. 8vo.—*From the Society.*

Philosophical Transactions of the Royal Society of London. Vol. CLV. Part 2. London, 1865. 4to.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XV. No. 80. 8vo.—*From the Society.*

List of the Royal Society of London, 30th Nov. 1865. 4to.—*From the Society.*

Sketch of the History of the High Constables of Edinburgh. By James Marwick, F.R.S.E, Edinburgh, 1865. 8vo.—*From Charles Lawson, Esq.*

Journal of the Royal Horticultural Society of London. New Series. Vol. I. Part 1. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society of London. Vol. V. No. 9. 8vo.—*From the Society.*

Transactions of the Historic Society of Lancashire and Cheshire. New Series. Vol. IV. Session 1863–64. Liverpool, 1864. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal, 1865. Part 1. No. 3. Part 2. No. 3. Calcutta, 1865.—*From the Society.*

Journal of the Chemical Society of London. No. XXXVI. 8vo. —*From the Society.*

The Canadian Journal of Industry, Science, and Art. No. 60. Toronto, 1865. 8vo.—*From the Editors.*

Die Fortschritte der Physik in Jahre, 1863. Dargestellt von der Physikalischen Gesellschaft zu Berlin XIX. Jahrgang Erste. Zweite Abtheilung. Berlin, 1865. 8vo.—*From the Society.*

Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1864. Nos. 1–10. Stockholm, 1865. 8vo.—*From the Academy.*

Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bd. 5. Hft. 1. 1863. 4to.—*From the Academy.*

Meteorologiska Iakttagelser i Sverige Utgifna af Kongl. Svenska Vetenskaps-Akademien auställda ach bearbetade under Insende af Er. Edlund. Bd. 5. 1863. 4to.—*From the Academy.*

Bulletin de L'Academie Royale des Sciences, des Lettres, et des Beaux Arts, de Belgique. Tome 20, Nos. 11, 12. Tome 21, No. 1. Bruxelles. 8vo.—*From the Academy.*

Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome VII. No 1. 8vo.—*From the Society.*

Bulletin de la Société Vaudoise des Sciences Naturelles. Tom. VIII., No. 53. Lausanne, 1865. 8vo.—*From the Society.*

Annales des Mines ou recueil de Mémoires sur L'exploitation des Mines. Tome VIII. 4e. Livraison, Paris, 1865. 4to.—*From the Ecole des Mines.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Band XV. No. 3. Wien. 8vo.—*From the Society.*

Schriften der Universität zu Kiel aus dem Jahre, 1864. Band XI. Kiel, 1865. 4to.—*From the University.*

Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857–58–59 unter den Besehen des Commodore B. von Wullerstorf-Urbair Nautisch-Physicalischer Theil. II. Abtheil. Magnetische Beobachtungen. Wien, 1865. 4to.—*From the Austrian Navy Board.*

Monday, 19th February 1866.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. Report on the Hourly Observations made at Leith Fort in 1826 and 1827, by Direction of the Society. By Sir David Brewster, K.H , D.C.L., F.R.S., &c.

In 1823 the Royal Society established a register of hourly observations of the thermometer at Leith Fort. They were made by the non-commissioned officers of artillery, and were continued for four years, from 1824 to 1827 inclusive. A report on these observations for the years 1824 and 1825 was published in the tenth volume of the Society's Transactions; but from causes to which it is unnecessary to refer, the report on the observations of 1826 and 1827 were not then published.

The great interest which was attached to meteorological observations, but specially to those made every hour, has induced the author to publish the results which he has obtained from the original registers in the Library of the Society.

The agreement of these results, with those obtained from the observations in 1824 and 1825, is very remarkable.

2. On a New Property of the Retina. By Sir David Brewster, K.H., D.C.L., F.R.S., &c.

In a paper on hemiopsy,* the author had shown that the parts of the retina affected with this disease were susceptible of luminous impressions and insensible to visual ones, and that the light by which they were impressed was derived by irradiation from the adjacent parts of the retina. The parts of the retina affected with hemiopsy were, however, so small, so irregularly distributed, and the phenomenon of such short duration, that it was difficult to study it and deduce any satisfactory results.

From an accidental observation the author discovered that a

* Transactions, vol. xxiv. p. 15.

portion of the retina of his right eye, though the vision of the eye was perfect, was actually blind or insensible to visual impressions, while it was so sensible to luminous impressions, that no spot of the slightest darkness or shade was seen in the field of vision when directed to the sky or any extended white surface. When the image of a bright object, or of the setting sun, was received on this portion of the retina, which was about the twenty-eighth part of an inch in breadth, it was wholly invisible, and therefore the light with which it was impressed must have been derived by irradiation from the adjacent parts of the retina, or from those parts of it which underlie the insensible part. But for this property the patient would constantly see a black spot disfiguring the aspects of nature, and ever reminding him of his misfortune.

The author mentioned a temporary affection of the same eye, observed thirty years ago, on which two lines, radiating from the foramen centrale, were *absolutely black.*

3. On some Laws of the Sterility of Women. By J. Matthews Duncan, M.D.

In this paper absolute sterility is held to mean the condition of a woman who, under ordinary favourable circumstances for breeding, produces no living or dead child, nor any kind of abortion. Sterility is held to mean the condition of a woman who, under ordinary favourable circumstances for breeding, produces no living and viable child, or adds not one to the population. Relative sterility is held to mean the condition of a woman who, while she may or may not be absolutely sterile, while she may or may not be sterile, is, under ordinary favourable conditions for breeding, sterile in relation to the circumstance of time, or, in other words, in relation to her age and the duration of her married life.

The sterility of marriages in our population is estimated as 19 per cent.

The sterility of wives, married at ages from 15 to 44 inclusive, is shown to be 15 per cent, or about 1 in $6\frac{1}{2}$.

The absolute sterility of wives may be held to approximate closely to the sterility of wives; for to the data used in calculating the sterility of wives there would only have to be added the wives bearing dead children only, or abortions only, or both (and the number of these is probably inconsiderable), in order to get the absolute sterility of wives.

Sterility varies according to the age of the woman at marriage. About 7 per cent. of the women married from 15 to 19 years of age are sterile. Of those married from 20 to 24 years of age, almost none are sterile. After 24 years of age, sterility reappears and increases progressively with the age at marriage.

Expectation of sterility begins after three years' of marriage, for only 7 per cent. of fertile wives commence child-bearing after that period has elapsed.

The probability of a woman's being sterile is soonest decided at the ages at which the probability of fertility is greatest.

Relative sterility is sooner arrived at according as the age at marriage is greater. This is merely the converse of the law of continued fertility, that being greater according as the age at marriage is less.

Expectation of relative sterility commences after three years of cessation of fertility, and increases as more time elapses.

4. On certain Points in the Morphology of Cleft Palate. By John Smith, M.D., F.R.C.S.E. Communicated by William Turner, M.B.

In cases of cleft palate with alveolar fissure, the maxillary bones are, during infancy, not only ununited, but, in general, if not always, more widely separated from one another than in the natural condition. This has been frequently observed in such cases as come under the care of the surgeon, although little attention appears to have been bestowed upon the fact beyond its mere casual mention. Measurements, however, have been lately made by Dr Engel,* showing that the difference between certain fixed points—such as the two infra-orbital foramina, the nasal processes of the upper jaw, &c., is very well marked, when the distance is measured in a healthy new-born child, compared with one having a cleft palate.

* Prag. Vierteljahrschrift. 1864. P. 115.

In these cases, he describes the width of the nostril on the affected side as greater, the bridge of the nose less arched, and the distance between the two orbits increased. In all cases, the lower ends of the nasal bones project further forwards than in healthy new-born children. The nasal processes of the frontal bone in bilateral cleft palate are shown by him to be broader, the width between the tubera frontalia to be increased; and besides the two eyes being further removed from each other, the form and size of the orbits are altered; and both in bilateral and unilateral cases are seldom equal in size. The minute details of a case are also given by him where, associated with double cleft palate, there was a great addition both to the breadth and depth of the basis cranii in the ethmoid and orbital portions of the frontal region: a condition he considers to bear a "causal relation" to the occurrence of cleft palate.

The increased breadth of the anterior part of the head he considers as necessitating a greater distance between the superior maxillæ than can be filled up by the development of the intervening structures. And the cause, again, of this increased breadth of the head he believes due to various circumstances, such as congenital hernia cerebri, dropsy of the third ventricle, or anterior cornua of the lateral ventricles, or excessive development of the anterior cerebral lobes. Owing to such distension within the cranium of the embryo, he shows the parts on each side of the palatal fissure to be, in the young subject, not only deficient in the middle line, but further asunder than in the normal condition.

These circumstances become somewhat more interesting if we contrast them with what appears to occur in the adult. Here the transverse distance between the palatal sides of the upper right and left anterior bicuspids will, in an ordinarly well-formed jaw, be found to measure from one and an eighth to one and a quarter of an inch. The measurements afforded at the same spot, in sixteen adult cases of cleft palate, of which I have collected casts, are somewhat less than this; and in others, of which I have not preserved a record, the same peculiarity was observed. Among the cases noted, the measurements at the point already described, are as follows; the canines of the opposite sides—which, by the way, are always present in these cases—being in some, of course, much closer than the bicuspids.

In six cases where the intermaxillary bones seemed altogether absent—probably cases originally of double cleft—where these bones had been removed by the surgeon—or of others where they had never been developed—

1 case	measured	$\frac{3}{8}$ths of an inch.
1 ,,	,,	$\frac{5}{8}$ths ,,
2 cases	,,	$\frac{7}{8}$ths ,,
1 case	,,	1 inch.
1 ,,	,,	$1\frac{1}{8}$th of an inch.

giving an average measurement of between $\frac{6}{8}$ths and $\frac{7}{8}$ths of an inch.

In ten cases of simple cleft palate alone, or of cleft palate combined with only unilateral fissure—

1 case	measured	$\frac{5}{8}$ths to $\frac{6}{8}$ths of an inch.
1 ,,	,,	$\frac{5}{8}$ths ,, ,,
4 cases	,,	$\frac{7}{8}$ths ,, ,,
3 ,,	,,	1 inch.
1 case	,,	$1\frac{1}{8}$th of an inch.

giving an average measurement of $\frac{7}{8}$ths of an inch.

I have selected the inter-bicuspid point of measurement, as being that in which the relative width in the infantile, compared with the adult jaw, seems to vary least. The increase by expansion of the jaw in this direction amounting to very little comparatively from infancy to adult age in the healthy subject.

It would thus appear that while in the infant there is abnormal *separation*, in the adult there occurs abnormal *approximation* of the parts on each side of the fissure. To a certain extent this approximation of parts may be fortuitous: a misdirection of growth dependant upon the absence of the mesial structures, while the superior maxilla is becoming, as age advances—elongated downwards by the expansion of the antrum. But as the same approximation seems to occur even where only a partial fissure exists,—the cleft being limited to the palate, while the maxillary arch is throughout complete,—there is reason to conclude that it is in some measure to be considered as a reparative, or rather an ameliorative effort on the part of nature towards remedying the defects existing. And such a view becomes practically interesting, as pointing to the probability of a certain amount of assistance likely to be obtained in this manner, by a judicious delay in surgical interference with such cases.

Further, the perfect development of the true maxillaries, indicated by the invariable presence of the canines, is significant of the lesion being one chiefly affecting or originating in the interposed structures; and in the more characteristic cases the disease no doubt is best marked in its effects on the intermaxillary bones. Without homologating any hypothesis advanced on such subjects, this proclivity to irregular or arrested development in these bones —the hæmal spines of the nasal vertebra, as described by Owen— the hæmapophyses of the catacentric vomerine sclerotome, as described by Goodsir,—seems to afford a confirmation of the theory, that the tendency to return to a manifestation of what have been described as archetypal characters; or, on the other hand, to assume an erratic development, becomes greater as we depart from the vertebral centrum. This part of the subject is one, however, which, without mature elaboration of many as yet undetermined facts bearing on it, cannot be treated in either a positive or an exhaustive manner. But in a further acquaintance with those great principles of morphology, of late beginning to be revealed in the vertebrate skeleton, we may expect that the nature of malformation and metrological disease will be presented in a new and more intelligible light.

5. Notes more especially on the Bridging Convolutions in the Brain of the Chimpanzee. By Wm. Turner, M.B., F.R.S.E.

The late Professor Gratiolet, in his elaborate and beautifully illustrated memoir, "Sur les Plis Cérébraux de l'Homme et des Primates," attaches great weight in his differential diagnosis of their cerebral characters to the presence or absence of one or more members of a series of convolutions, which he designates as the *plis de passage*. When present, these convolutions bridge over the external perpendicular fissure of the hemisphere, and connect the parietal and temporal with the occipital lobes. By various anatomists in this country they are called bridging, connecting, or annectent convolutions. In the brain of the Chimpanzee M. Gratiolet states that the first bridging convolution is altogether wanting; that the second is present, but concealed under the operculum of the occipital lobe; that the third and fourth are superficial.

In his comparison of the brain of the Chimpanzee with the brain of the Orang, he attaches great importance to the absence of the first bridging convolution in the former, and to its presence in a well-marked manner in the brain of the latter ape. In his general *résumé* (p. 98) of the mode of arrangement of the second bridging convolution in the brains of the monkeys of the old world, he states that in them it is constantly concealed under the operculum, and never comes to the surface; whilst the third and fourth connecting convolutions are always superficial.

All anatomists who have inquired into this subject since the publication of M. Gratiolet's memoir agree with him in recognising the superficial position of the third and fourth, and the concealment of the second bridging convolution within the perpendicular fissure in the brain of the Chimpanzee. But with regard to the complete absence of the first bridging convolution in the brain of this ape, evidence has been advanced which proves that M. Gratiolet's statement, although correct in some specimens—as, for example, in the one which he described and figured—yet is not universally applicable.

Thus Professor Rolleston states* that on the right side of the Chimpanzee's brain, in the Oxford University Museum, a well-marked superior bridging convolution came, for a considerable part of its length, nearly or quite to a level with the lobes it connects; and Professor Marshall describes† on the right side of the brain of a Chimpanzee, which he dissected, a rudimentary superior connecting convolution of very small size passing from the outer margin of the lobule of the second ascending convolution outwards, and then bending inwards and backwards across the perpendicular fissure to join the occipital lobe.

Whilst dissecting the brain of a young male Chimpanzee, which was given to me about two years ago by my former pupil, Mr Alfred Pullar, I obtained evidence of a greater extent of variation in the arrangement of the convolutions in this ape than had up to that time, I believe, come under the notice of anatomists. This

* Natural History Review, 1861, p. 211.

† Natural History Review, 1861, p. 309.

brain I shall designate in the following remarks as *A*. By permission of Professor Goodsir I have also had the opportunity of examining two as yet undescribed brains of this animal, both females, in the anatomical museum of the University of Edinburgh. It will be convenient to refer to these as *B* and *C*.

In all three specimens the antero-posterior convolutions of the frontal sub-division of the frontal lobe corresponded so generally in their arrangement with each other, and with the brains of the

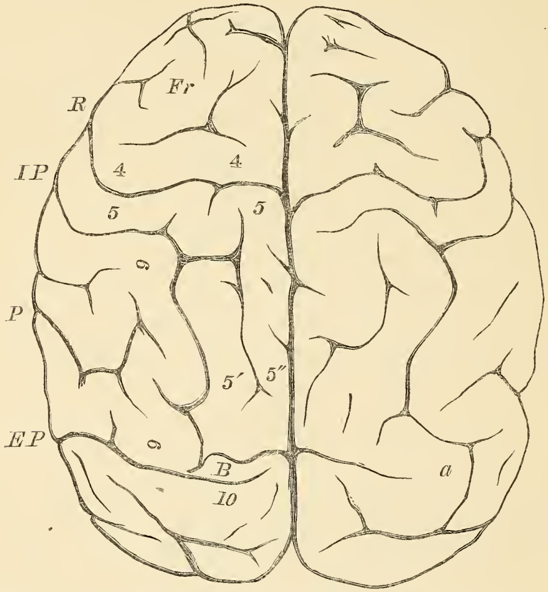


Fig. 1.—Vertex view of the brain *A*. *Fr*. Frontal lobe. *R*, Fissure of Rolando. *I P*, Intra-parietal fissure. *P*, Parallel fissure. *E P*, External perpendicular fissure. 4, 4, Ascending frontal gyrus. 5 5, Ascending parietal gyrus. 5″, Inner, 5′, Outer part of postero-parietal lobule. 6 6, Angular gyrus. 10, Superior occipital gyrus. *a*, Superior annectent gyrus. *B*, Second annectent gyrus.

Chimpanzee figured by Professors Gratiolet and Marshall, that no special description is necessary. In all, the olfactory sulcus was well marked; and in two specimens a triradiate arrangement of the sulci, situated in the outer part of the lobule, was distinct, though in the third specimen (*A*) this regular mode of arrangement did not exist. The ascending frontal (premier pli ascendant) (4 4) and ascending parietal (deuxième pli ascendant) (5 5) convolutions also agreed very closely in their general arrangement;

and in all the specimens the fissure of Rolando (*R*) extended upwards as far as the great longitudinal fissure, and formed with its fellow the sides and apex of a V-shaped figure. The lobule of the second ascending parietal convolution of Gratiolet (postero-parietal lobule—*Huxley*) reached as far back as the external perpendicular fissure (parieto-occipital fissure), and presented a sub-division into an internal (5″) and external (5′) portion; each of which again, though somewhat more strongly marked in *B* than in *A* and *C*, exhibited signs of sub-division into secondary lobules. The bent or angular convolution (pli courbe) (6 6) varied somewhat in its arrangement in the three specimens. In *A* it commenced much lower down in front of the Sylvian fissure than in *B* and *C*. The length of its ascending part, from its commencement to the apex of the fissure, was in the first named $1\frac{1}{10}$th inch, whilst in the others it was considerably less. In all three brains it was partially broken up into smaller convolutions by secondary fissures. In *A* its descending part was directly prolonged into the middle temporo-sphenoidal convolution, as in the brains figured by Gratiolet and Marshall. In *B* and *C* its continuity superficially with this convolution was broken by a cross intersecting fissure. Not only in the brain of the Chimpanzee, but in those of all the apes in which the various parietal convolutions are differentiated, the fissure which separates the angular convolution from the second ascending parietal and its posterior lobule is so clearly marked that it deserves to be recognised by a distinctive term; but as none has as yet been applied to it, I would suggest that it should be called the intra-parietal fissure (*I P*). This fissure commences anteriorly behind the fissure of Rolando, at first ascends almost parallel to it, and then runs backwards and joins posteriorly the parieto-occipital fissure.

In the brain (*C*) the external perpendicular (parieto-occipital) fissure (*E P*) on each side was unbroken by the passage across of either the first or second bridging convolutions, and the opercular edge was as sharp and well-defined as in the brains figured by Gratiolet and Van der Kolk and Vrolik. But in *B*, whilst this arrangement existed in the right hemisphere, the left exhibited an important variation. From the posterior and outer angle of the left postero-parietal lobule a narrow, but clearly-marked convolution (*a*, fig. 2), half an inch long and $\frac{1}{6}$th of an inch wide, arose. It passed almost transversely inwards, and joined the supero-internal angle of the occipital lobe close to the longitudinal fissure. It was superficial in its entire extent, and consequently bridged across the external perpendicular fissure. From its position and connections it must be regarded as the homologue of the superior connecting convolution of Gratiolet. This brain, therefore, furnishes another example to those already recorded by Professors Rolleston and Marshall of the occurrence of this convolution on one side of the brain of the Chimpanzee, though in the opposite hemisphere to that found in their specimens.

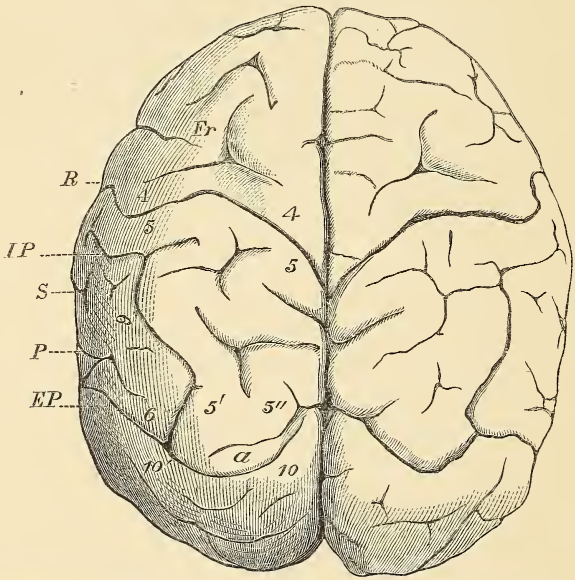


Fig. 2.—Vertex view of brain *B*. The lettering as in Fig. 1, with, in addition, S. Sylvian fissure.

In the brain (*A*) the amount of variation was still more strongly marked. On the right side the postero-parietal lobule gave off from its outer and posterior part a superficial convolution (*a*, fig. 1) $\frac{3}{10}$ths of an inch broad, which was almost immediately joined on its deep surface by a slender process from the superior angle of the bent convolution, the place of junction being concealed by the imperfectly defined occipital operculum. This convolution, then, passed across the external perpendicular fissure, inclined inwards, till it reached the longitudinal fissure of the cerebrum, of which it formed the boundary for half an inch, and then joined the inner end of the first occipital convolution. A secondary fissure passed for some distance into its substance before it joined the occipital lobe. Throughout its entire extent it formed a very distinct, superficial, first connecting convolution, almost as well marked, indeed, as that figured and described by Gratiolet as so remarkable and distinctive a feature of the brain of the Orang amongst the apes.

On the left side no first connecting convolution existed; but from the superior angle of the bent convolution, where it became continuous with the descending limb, a narrow convolution (*B*, fig. 1), $\frac{1}{5}$th of an inch wide, arose. At its origin it was concealed by the occipital operculum; but almost immediately it became superficial in the parieto-occipital fissure, passed almost transversely inwards, and joined the inner angle of the superior occipital convolution close to the longitudinal fissure. The length of its superficial portion was $\frac{3}{5}$ths of an inch. From its origin it was evidently the second bridging convolution, and in its superficial position it exhibited an arrangement such as has not before been recognised in the brain of the Chimpanzee, and which Gratiolet, indeed, had not met with in any of the numerous brains of the Old World apes which he had examined.

The convolutions of the occipital lobe presented no variation in arrangement calling for special remark. They were joined, in the usual way, by the third and fourth superficial bridging convolutions proceeding from the temporo-sphenoidal lobe.

In the disposition of parts about the Sylvian fissure, the brains *B* and *C* corresponded closely to those figured by Professors Gratiolet and Marshall, but in the brain *A* an arrangement prevailed such as has not yet been described in the brain of the Chimpanzee. The anterior lip of the Sylvian fissure was as usual sharp and well-defined, but the posterior marginal convolution (*pli temporal supérieur*), instead of forming the posterior boundary of this fissure in its entire extent, became gradually narrower as it ascended, and at the same time receded from the surface. As a consequence, its upper end was entirely concealed, the Sylvian and parallel fissures became continuous superficially with each other, and the ascending and descending limbs of the bent convolution formed the anterior and posterior lips of the combined Sylvian and parallel fissures. The remarkable superficial continuity of these fissures might be apt, on a hasty glance, to lead to the impression that the Sylvian fissure mounted much higher on the outer surface of the hemispheres than is usual, but what at first sight seemed to be the upper end of the Sylvian was really the upper end of the parallel fissure, as was at once proved by separating the ascending and descending parts of the bent convolution from each other, when the upper concealed end of the Sylvian fissure became visible. A similar arrangement to that just described has been stated by Gratiolet (p. 29) sometimes to occur in the brain of *Cercopithecus Sabœus.*

The median or central lobe (Island of Reil) consisted on the left side of five short and almost straight convolutions, none of which possessed any great size, but on the right side only four were visible. The fissures which separated these gyri from each other were short and shallow. The gyri radiated outwards and backwards from the locus perforatus anticus. The most anterior joined superficially the inferior frontal gyrus; the rest were separated by

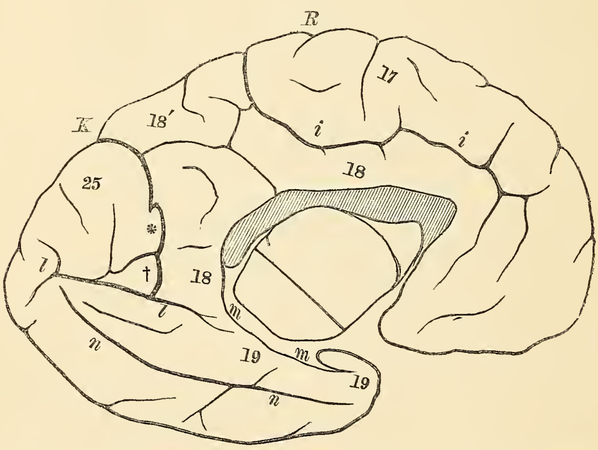


Fig. 3.—View of the inner face and postero-inferior surface of the Brain *A.* [illegible] In my explanation of the arrangement of the sulci and gyri of the inner face of the hemisphere, I have adopted the terms with the letters and numerals employed by Mr Huxley in his "Memoir on *Ateles Paniscus*" (*Proc. Zoological Soc.* 1861), and by Mr Flower, in his "Memoir on the Posterior Lobes of the Cerebrum, in the Quadrumana" (*Phil. Trans.* 1862).

a deep groove from the convolutions, which formed the anterior lip of the Sylvian fissure. The island was deeply situated within the fissure of Sylvius, and excepting a small part of the most anterior gyrus, where it joined the inferior frontal, was completely concealed so long as the lips of the fissure were *in situ*.

The brain *A* is the only specimen on the inner and tentorial surfaces of the hemisphere of which I have been enabled to study the arrangement of the fissures and convolutions. The calloso-marginal sulcus (*i i*) commenced anteriorly in front of the anterior end of the corpus callosum, and extended uninterruptedly backwards. When opposite the commencement of the posterior third of the corpus callosum it bifurcated,—one branch ascended and reached the margin of the great longitudinal fissure, the other ran backwards and joined the internal perpendicular fissure. From the calloso-marginal sulcus a few secondary fissures extended upwards and downwards into the marginal (17) and callosal (18) convolutions.

The internal perpendicular (occipito-parietal) fissure (*K*), slightly convex forward, was continuous at the upper margin of the inner face with the external perpendicular fissure, whilst inferiorly, it joined the calcarine sulcus (*l l*). Proceeding from its posterior lip, two connecting convolutions ran at once into the fissure; one, (*) deeply placed, except at its origin, mounted upwards and outwards, and joined the deeper aspect of the postero-parietal lobule. Its concealed part exhibited an indication of subdivision into two gyri. The other, or inferior annectent gyrus (†) partly projected into the perpendicular, and partly into the calcarine fissure, and joined the lower portion of the quadrate lobule. The dentate sulcus (*m m*) was well-marked, and at its lower end was prolonged into the recurved part of the uncinate gyrus (19). The calcarine sulcus (*l l*), which possessed great depth, commenced posteriorly in a bifurcated extremity, the two limbs of the forks being almost equal in length. It extended forwards close to the dentate sulcus, but did not quite join it, so that the callosal (18) and uncinate (19) gyri were continuous with each other in front of its anterior extremity. Within the calcarine sulcus two small gyri were found. One sprang from the floor of the fissure, and evidently corresponded to the calcarine gyrus, described by Mr Flower as so well developed in the brain of *Cercopithecus ;* the other and larger arose from the internal occipital lobule (25) which formed the roof of the sulcus; it projected towards the calcarine gyrus: anteriorly it became continuous with the quadrate lobule, and the inferior annectent gyrus, and posteriorly it turned round the upper branch of the sulcus, and joined the supero-occipital gyrus. The collateral sulcus (*n n*) reached almost the entire length of the tentorial aspect of the hemisphere, and although neither so deep, nor extending so far back as the calcarine sulcus, yet reached in front almost as far as the tip of the temporo-sphenoidal lobe. Some small secondary fissures proceeded from it. The internal occipital (25) and quadrate (18′) lobules were well seen, and the latter was considerably larger than the former.

The three specimens of the brain of the Chimpanzee just described prove that the generalisation which Gratiolet has attempted to draw of the complete absence of the first connecting convolution, and the concealment of the second, as essentially characteristic features in the brain of this animal, is by no means universally applicable. In only one specimen did the brain, in these particulars, follow the law which Gratiolet has expressed. As regards the presence of the superior bridging convolution, I am inclined to think that it has existed in one hemisphere, at least, in a majority of the brains of this animal which have up to this time been figured or described.* The superficial position of the second bridging convolution is evidently much less frequent, and has as yet, I believe, only been seen in the brain (*A*) recorded in this communi-

* But few specimens of the brain of the Chimpanzee have as yet been figured or described. In that figured by Tyson, only the base and an internal view of the brain are given. In the brains figured and described by Gratiolet, and Van der Kolk and Vrolik, and in my brain (*C*) no superior bridging convolution existed. In the brains described by Rolleston and Marshall, as well as in the brains *A* and *B* now described, it is precisely stated that it was present in one hemisphere. In the brain figured by Tiedemann (*Phil. Trans.* 1836), from a specimen in the Hunterian Museum, London, it is apparently present in the left hemisphere, though it is not referred to in the description; and from the drawing of a careful cast of the brain dissected by Dr Macartney (*Trans. Royal Irish Acad.* 1843), it seems probable that the first bridging convolution existed in his specimen.

Addendum, May 5.—Since the above paper was read, a fine young male Chimpanzee has been purchased by Professor Goodsir for the Anatomical Museum, the brain of which I removed and examined. In both hemispheres the parieto-occipital fissure was unbridged, and the opercular edge of the occipital lobe was as sharp and well defined as in my brain (*C*), or in the specimen figured by Gratiolet.

cation. The a-symmetrical arrangement of the convolutions in the two hemispheres which previous observers have referred to in their descriptions, is also well illustrated in these specimens. The higher differentiation of the cerebral convolutions in the Chimpanzee over that of the lower apes affords room for a greater amount of variability of arrangement in it than in them. Hence, in depicting the brain of this animal, just as in the representation of its face and figure, every drawing should be a portrait, and every description whilst embracing the great general outlines in which all the specimens probably agree, should yet indicate the special modifications in construction exhibited by the individual.

6. On the Theory of the Refraction and Dispersion of Light. Part I. By Alfred R. Catton, M.A., F.R.S.E., Fellow of St John's College, Cambridge, Assistant to the Professor of Natural Philosophy in the University of Edinburgh.

Supposing the phenomena of light to be caused by the indefinitely small vibrations of a highly elastic medium pervading space, it is a simple problem to determine the motion of such a medium *in vacuo*, or in space, where matter does not exist, as in these cases the problem is reduced to the determination of the motion of a *homogeneous* elastic medium.

On proceeding, however, to investigate the motion of the ethereal medium in crystals, for the purpose of accounting for the phenomena of crystalline refraction, the question arises, whether there is an action between the material molecules and the etherial medium. In other words, are the laws of the refraction of the ether within crystals, independent of the existence of material molecules, so that the ether may be treated as a single elastic medium, or are the phenomena of crystalline refraction produced, wholly or partially, by a direct action between the material molecules and the ether?

It is necessary, therefore, to consider at the outset, whether there are any physical facts which throw light on this question. For this purpose the observations of Sir David Brewster, De Senarmont, Des Cloizeaux, Mitscherlich, and others, are discussed at length in the paper.

The discoveries of Sir David Brewster show that the optical properties of crystals are connected with the arrangement in space of the material molecules of which they are built up. Thus when the material molecules are symmetrically arranged with respect to three planes at right angles to another (as in the prismatic system), or where there is only one plane of symmetry (as in the oblique system), or none (as in the anorthic), there are two optic axes. But when they are symmetrically arranged about one line as an axis, there is only one optic axis which coincides with the axis of symmetry of the crystal. In the cubic system, which is symmetrical in every direction, every straight line becomes an optic axis.

Again, in quartz and dextro- and lævo-tartaric acids (as observed by Pasteur), the direction of rotation of the plane of polarization is to the right or left according as the hemihedral forms which occur on crystals of these substances turn to the right or left. Here, then, a want of symmetry in the arrangement of the material molecules is connected with a want of symmetry (so to speak) in optical properties.

The bearing of the experiments of De Senarmont, Des Cloizeaux, and others, is then discussed, and it is shown that, in general, whenever and from whatever cause the arrangement of the material molecules is changed, the optical properties are also changed. The influence of heat and pressure on crystalline refraction is well-known. Thus in a rhombohedron of calcite, increase of temperature alters the angles between the faces, making them approach more nearly to a cube, and at the same time the extraordinary refractive index is increased. A similar observation has recently been made by Fizeau in quartz. From the facts brought forward in this paper, it is concluded that the ether within all bodies is of the same nature as *in vacuo*, and that the optical properties of crystals are caused entirely by the direct action of the material molecules on the ether. Of course the action which the ether exerts at a given point within a crystal is not, as *in vacuo*, the same in every direction. For in crystals of the prismatic system, the action of the material molecules is different in different directions; in other words, it tends to compress the ether more in one direction than in another, and in consequence the resistance of the ether to compression must also be different in different directions.

The great defect in the theories of crystalline refraction hitherto proposed, viz., the theories of Fresnel, Cauchy, Neumann, Macullagh, and Green, is the neglect of the action of the material molecules. In these theories the ether within crystals is supposed to possess special properties different from those which it possesses *in vacuo*, such as possessing different degrees of elasticity in different directions; the ether in every body being supposed to possess an elasticity peculiar to itself. In none of these theories are any considerations advanced to show how the ether might be supposed to have acquired the special properties which it is found necessary to assume that it possesses, in order that these theories may account for phenomena. So that, even if they were satisfactory in other respects, an important desideratum would still be left. A few remarks are then made on the question whether the ether is a *continuous* or *discontinuous* medium. In the present paper the general equations of motion are obtained on both suppositions. *In vacuo* the equations of motion are known to be of the same form whichever supposition is adopted.

With respect to the molecular action between matter and the ethereal medium, it is supposed to be sensible at only very small distances. That this is true, in general, for molecular forces, is shown by such facts as the following:—When a solid, as a piece of marble, is reduced to powder, no amount of pressure will make the powder again cohere into a solid mass. Two *clean* surfaces of lead may be made to cohere, but not if there is the slightest film of oxide. There are a number of other facts of the same kind. The height to which the fluid rises, or is depressed, in a capillary tube is independent of the thickness of the tube. Also, to take the case of water—if the thinnest film of grease be present in the tube, the water is depressed instead of elevated, showing that the sphere of action of the molecular forces of the glass on the water is less than the thickness of the thinnest film of grease. The strength of a wire, also, is dependent only on its *section*. Also, if we take a crystal of Iceland spar, and reduce it by cleavage, or otherwise, to as small dimensions as possible, it is found that the crystals successively obtained are in every respect similar in their optical properties to the original crystal. The portions of the crystals, therefore, removed by cleavage, have no effect on the optical properties of the minute crystal ultimately obtained; and as crystals of quartz and other substances have been obtained of almost microscopic dimensions, but still possessing all the properties of large crystals of these substances, we see that the motion of the ether at any point of a crystal is only affected by the material molecules which are within extremely minute distances of that point.

Again, there is no dispersion of light *in vacuo*, or in space. In order that this may be the case, that is, in order that rays of all wave lengths may be propagated with the same velocity, it can be shown that the action exerted by the parts of the ether on each other can only be sensible at very small distances.

In obtaining the equations of motion, it is supposed that the motion constituting light is transversal to the direction of propagation, which is equivalent to supposing that the ether is incompressible with respect to the forces called into action in the propagation of light, or that the motion of the ether takes place without change of density.

The arguments in support of the hypothesis of transversal vibrations, to which Fresnel was led by physical considerations, founded on the non-interference of rays polarised in planes at right angles to each other, are so well known, that it is not necessary to enter into their discussion. Suffice it to say, that "if the simplicity of a theory which conducts us through a multitude of curious and complicated phenomena, like a thread through a labyrinth, be considered to carry the stamp of truth, the claims of the theory of transverse vibrations seem but little short of those of the theory of universal gravitation" (Stokes "On the Dynamical Theory of Diffraction," *Cam. Phil. Trans.*, vol. ix. p. 2). As in other theories, the squares of the displacements of the elements of ether from their positions of equilibrium are neglected.

The following Gentlemen were balloted for and admitted Fellows of the Society:—

Adam Black, Esq.
Alexander Macduff, Esq. of Bonhard.
Thomas Constable, Esq.
Dr James Dunsmure, Pres. R.C.S.
Dr Arthur Mitchell.

The following Donations to the Library were announced:—

Journal of the Scottish Meteorological Society. New Series, No. 9. Edinburgh, 1866. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society of London. Vol. I. No. 1. 1866. 8vo.—*From the Society.*

Journal of the Linnean Society of London. Vol. IX. No. 36. (Botany). 8vo.—*From the Society.*

Eighth Detailed Annual Report of the Registrar-General of Births, Deaths, and Marriages in Scotland. Edinburgh, 1866. 8vo. —*From the Registrar-General.*

Monthly Return of the Births, Deaths, and Marriages registered in the eight principal towns in Scotland. January 1866. 8vo.—*From the Registrar-General.*

Rendiconto delle Tornate e dei Lavori dell' Accademia di Scienze Morali e Politiche. Anno 4. 1865. 8vo.—*From the Royal Society of Napoli.*

Entstehung und Begriff der naturhistorischen Art, von Dr Carl Nägeli. Zweite Auflage. München, 1865. 8vo.—*From the Author.*

Induction und Deduction, von Justus von Liebig. München, 1865. 8vo.—*From the Author.*

Rede gehalten in der öffentlichen Sitzung der K. Akademie der Wissenschaften, am 25 Juli 1864, zur vorfeier des allerhöchsten Geburts und Namens-Festes Sr. Majestät des Königs Ludwig II. von Bayern. Von Dr Georg Martin Thomas. München, 1864. 4to.—*From the Author.*

Chinesische Texte zu Dr Johann Heinrich Plath's Abhandlung. München, 1864. 4to.—*From the Author.*

Magnetical and Meteorological Observations, made at the Government Observatory, Bombay, in the year 1863. Bombay, 1864. 4to.—*From the Observatory.*

La Repubblica di Venezia e la Persia, per Guelielmo Berchet. Torino, 1865. 8vo.—*From the Italian Government.*

Relazione della direzione tecnica alla direzione generale delle strade ferrate dello state. Torino, 1863. 4to.—*From the Italian Government.*

Monday, 5th March 1866.

In the absence, from illness, of Sir David Brewster, the chair was taken, *pro tem.*, by Professor Tait, on the motion of Professor Balfour.

In delivering the Keith Medal to Principal Forbes, Professor Tait said—" The suddenness of this summons, and my consequent total want of preparation, may well excuse me if I fall short of what is due to the Society or to Principal Forbes on this occasion. Nothing, however, could be more agreeable to myself than to perform such a duty to him who was my earliest instructor in the science I now profess. Principal Forbes has already obtained this prize, and has, during a long and active career of investigation, over and over again merited it. As one of his unrewarded works which may be taken as a type of their value, I may merely mention his Theory of Glacier motion, which, in spite of ignorant and invidious criticism, still remains the true statement of the observed phenomena—all it pretended to be.

" Happily, with reference to the paper which has won the honour I have to confer, I am provided with the opinion of perhaps the greatest living authority on the subject of Heat, Professor W. Thomson of Glasgow. As one of your secretaries, I had obtained it from him, with the view of its being incorporated in the address which ill health has prevented our President from delivering on the present occasion. The reading of this is all that is necessary to prove to you how justly the medal has been merited.

" Principal Forbes' experimental investigation of the thermal conductivity of iron has enlarged our knowledge of the properties of matter with information, which is not only of extreme interest and importance in the deeper speculations of natural philosophy, but of very great practical value. Other experimenters had given tolerable approximations to the *relative* conductivities of different metals, but had either not attempted, or had most notably failed, to measure the conductivity of any one metal. The problem which had thus proved so difficult has been first solved by Forbes. The absolute value which he has found for the conductivity of iron is well guaranteed for accuracy by the full and satisfactory statement of the principle and details of his investigation, which has been published in the 'Transactions.' Its close agreement with Ångström's subsequent determination, by a very different method, also trustworthy, proves the agreement in the conductive quality of the specimens of iron used by the two experimenters; but is not required to confirm the results of either.

"The method by which Forbes analyses the circumstances concerned in the transmission of heat along a bar of which one end is maintained at a high temperature, is remarkable, no less for the ingenuity shown in its invention than for the thorough and vigorous working out of the laborious processes of experiment and of reduction, both graphic and by calculation, which it involves. The manner in which, from that analysis, Forbes discovered the *variation* of conductivity, due to variation of temperature, along the bar, is very striking. The final deduction of the varying value, through a wide range of temperature, of the absolute measure of the thermal conductivity of iron, constitutes a very important contribution to physical science."

After the delivery of the Medal, Principal Forbes took the Chair as senior Vice-President.

The following Communications were read:—

1. On Some Capillary Phenomena. By Professor Tait.

This communication was intended to illustrate by experiments with the solution of glycerine and oleate of soda, devised by Plateau, the mode in which a soap-bubble is detached as a closed shell from the mouth of a funnel; the mode in which two bubbles unite; and the process of cutting one into two or more.

A statical investigation of the form of an unclosed film, blown with coal gas, was given (the kinetic problem presenting very grave difficulties), and the results were shown to be in accordance with observation, so far as the eye can follow the rapid change which takes place in the neck of the film just before the closed bubble is detached.

Professor Tait called attention to the exquisite manner in which the molecular motions in the film may be exhibited by employing the posterior surface of a large bubble as a concave mirror to form a small bright point from a beam of parallel rays, and receiving on a screen the light diverging from this point after it has passed through portions of the anterior surface.

He also noticed that the spectrum of the reflected light shows very effectively the phenomena of interference, supposed by Von Wrede to account for the dark lines in the solar spectrum.

2. On Functions with Recurring Derivatives. By Edward Sang, Esq.

In a previous paper, it was pointed out that the characteristic problem of the third branch of the higher calculus, is to discover the relation between the primary variable and its function, when the relation subsisting between the function and its derivative is known. The present paper treats of the solution of the simplest case of this general problem, that in which the function is equal or proportional to its derivative.

The proposition in hand is naturally divided into cases, according to the order of derivation: The first two of these can, by well-known artifices, be brought under the dominion of the integral calculus, and their relations can therefore present nothing new. But for the sake of the continuity of the treatment, and of certain relationships which otherwise could not have been so well explained, they have been discussed in the paper. When we inquire into the nature of the function which is equal to its own first derivative, we arrive at the exponential function, and at the basis of Neperian Logarithms of this function e^t, the development is

$$1+\frac{t}{1}+\frac{t^2}{1\cdot 2}+\frac{t^3}{1\cdot 2\cdot 3}+\frac{t^4}{1\cdot 2\cdot 3\cdot 4}+\&c.$$

and it is shown that the fundamental recurring functions of any higher order, as the n^{th}, are obtained by taking each n^{th} term of this development.

When each alternate term of the series for e^t is taken, we obtain a function which is equal to its own second derivative; of this function there are two varieties, according as the terms contain the even or the odd powers of the primary. If the value of the primary be represented by abscissæ, and the corresponding values of the function be indicated by ordinates, we obtain two curved lines, one of which is the catenary, and the other, a line which may be called the companion to the catenary; these two lines do not meet each other.

If we take each third term of the development of e^t, we obtain recurring functions of the third order; of these there are three varieties, according to the term with which we begin. When the values of these three functions are represented by ordinates, there result three curved lines which intersect each other, and it is shown that their intersections take place on ordinates at equal distances from each other, the lines being, as it were, plaited upon each other. As the value of the primary is augmented, the interval between the curves, as measured on an ordinate, generally diminishes, and the three lines soon become so close as to be undistinguishable in a drawing of ordinary size. For negative values of the abscissæ, the curves separate more and more from each other. The distance between the ordinates, on which these intersections take place, is an important feature of the ternary functions; it bears a certain relation to the circumference of a circle of which the radius is equal to the linear unit, and is susceptible of very easy computation.

A very remarkable property of the lines representing these ternary functions is this, that if an equilateral triangle be placed in a plane perpendicular to the plane of the paper, and passing through one of the ordinates in such a way as that the three corners of the trigon may have the points of the three curves for their projections; and if the ordinate be supposed to be displaced along the line of abscissæ at a uniform rate, the trigon will turn round also with a uniform velocity, and its side decreases or increases in continued proportion, according as the direction of the motion of the ordinate is toward the + or − side of the absciss.

When each fourth term of the series for e^t is taken, we obtain recurring functions of the fourth order; of these there are four varieties, distinguishable into two groups according as they involve odd or even powers of the primary. The curved lines representing the functions of the even powers accompany each other, crossing and recrossing on ordinates at equal intervals, the middle line between them being a modification of the catenary. The lines representing the functions with odd powers also accompany each other on ordinates midway between those of the previous pair. The distance between these ordinates corresponds to the value of π, the ratio of the circumference to the diameter of a circle; and as the computation of this value is easily made, we have a new determination of π, independent of the theory of the circle. The intersections of the curves of even with those of odd powers, are not on ordinates at equal distances.

The quaternary functions are notable on this account, that by addition, they gave the catenarian—by subtraction, the circular functions.

When we proceed to the fundamental recurring functions of higher orders, we find that the interruptions of the representative curves no longer occur on equidistant ordinates, although certain compounds of them present the plaited appearance of the ternary lines; and it is noteworthy, that then the loops widen as we proceed towards the + end of the line of abscissæ.

3. The World as Governed by Law, Teleologically considered. By R. S. Wyld.

Mr Wyld stated that he considered the philosophic treatment of this subject important, as there existed a great amount of loose, ill-digested opinion in the public mind regarding it, and possibly also in the minds of many men of science.

The first object of the paper is to direct attention to the fact of the existence of general laws, alike in the physical and in the moral world; to consider these as designed for the benefit of the human race; and to enforce the duty of reviewing them as the appointed paths to human happiness and progress.

Mr Wyld showed that the doctrine is not only not necessarily connected with what is called infidel opinions, but, on the contrary, is far more naturally allied with the belief in a supreme Ruling Intelligence.

In the prosecution of the subject, he first directed attention to physical law, showing, in particular, in what manner he believed the law of attraction to have operated in bringing about the present structure of the earth, and to be operating in a similar way in the case of some of the planets.

Regarding the mental or moral world, the writer showed that the entire social system was compacted, and kept in life and energy, by virtue of the various appetites, desires, emotions, and passions by which man is influenced.

The conclusion to which the writer is led, in considering this part of the subject is, that it is unwise and in vain to talk of repressing the instinct which leads man to expect special instances of Divine favour. The instinct is a strong and universal one implanted in us, doubtless for wise and useful ends. It would seem the part of wisdom, then, rather to regulate than to extinguish it; and this can only be done safely, by showing that the *laws of nature* are the *special, just,* and *wise methods appointed by the Ruler of the world for dealing with man*, and as such, that they are to be reverenced, submitted to, and obeyed.

4. Description of *Pygopterus Greenockii* (Agassiz); with Notes on the Structural Relations of the genera *Pygopterus*, *Amblypterus* and *Eurynotus*. By Ramsay H. Traquair, M.D., Demonstrator of Anatomy in the University of Edinburgh. Communicated by W. Turner, M.B.

In this paper a detailed description is given of a species of Pygopterus (*P. Greenockii*) from the carboniferous shales of Wardie, Mid-Lothian, which was named by Agassiz, but without any figure or description, beyond the mention of the fact that the scales of the anterior part of the trunk are higher than broad, a circumstance distinguishing it from all the other species of this genus.

According to specimens exhibited by the author, the scales are of different forms on different parts of the body, being very minute, and nearly equilateral along the belly; the fins are large, and the dorsal is placed so far back as to be nearly opposite the anal; the interspinous bones of the azygos fins are well developed, and there are traces of vertebral apophyses, but none of vertebral bodies. On the top of the head are shown the parietal, mastoid, frontal, post-frontal, and prefrontal bones, with a single nasal forming a projection above the mouth. On the side of the head, the operculum, suboperculum, superior maxillary bone and lower jaw are distinctly recognisable, with a large triangular plate, covering the cheek above the upper jaw bone, and smaller ossicles around the orbit, which is placed very far forwards. The broad superior maxillary bone is beveled off for the orbit in front, to a narrow point which comes in contact with a small intermaxillary situated below the nasal and prefrontal bones. The teeth are conical and of two sizes, large ones alternating with small. The branchiostegal apparatus consists of numerous narrow flattened plates, and the shoulder girdle shows the supra-scapular, scapular, and coracoid bones, with a triangular plate in front of the lower end of the coracoid, analogous to a similar plate in the recent Polypterus.

A comparison was made between the osteology of the head in Pygopterus and in Amblypterus, showing the very intimate correspondence in the form and arrangement of the bones in those two genera; and the appearances in both were then compared with the structure of the skull in the recent Lepidosteus and Polypterus.

The general structure of Eurynotus was then noticed, and several of its facial bones described, together with the peculiar rounded teeth with which the jaws and palate are furnished. The opercular apparatus and superior maxillary bone differ considerably in form from those in Amblypterus, and still more marked is the difference in the shape of the teeth; but the two genera agree in the form and arrangement of the branchiostegal plates and in the general structure of the fins and scales. A specimen in the St Andrews Museum, shows distinctly that there were two rows of fulcral scales along the anterior edge of the dorsal fin, at least of Eurynotus.

In regard to classification, it was shown that Pygopterus and Amblypterus must be placed close together in the same family of "Palæoniscidæ," as already done by Vogt (*Zool. Briefe* II. Band s. 133), a family including the so-called "Lepidoidei Heterocerci," with the addition of *Pygopterus*, *Acrolepis*, and their allies, formerly classed as "Sauroidei;" the distinction between Lepidoids and Sauroids having been long ago shown to be artificial. (Müller—*Ganoiden*—Abhandl. Berl. Acad. der Wissenschaften, 1844.) As to the position of Eurynotus, and whether it should remain with Amblypterus and Palæoniscus, or be transferred to the same family with Platysomus and the Pycnodonts, as has been recently done by Dr Young (*Proc. Geol. Soc.* London, Feb. 1866), the author is of opinion that for the present it should remain in the former family, although considered as a member of the group of Palæoniscidæ, it is certainly a very aberrant form.

The following Gentleman was balloted for and elected a Fellow of the Society:—

Dr Patrick Heron Watson.

The following Donations to the Library were announced:—

Pinetum Britannicum. Parts XIV. XV., fol.—*From Charles Lawson, Esq.*

Proceedings of the Royal Geographical Society of London. Vol. X. No. 2. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XV. No. 81. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society of London. Vol. I. (New Series). No. 2. 8vo.—*From the Society.*

Geology of the North of Scotland. By James Nicol, F.R.S.E., &c., Edinburgh, 1866. 8vo.—*From the Author.*

Sketch of the Romantic History of Parallels. By Matthew Ryan, Washington, 1866. 8vo.—*From the Author.*

Proceedings of the Royal Medical and Chirurgical Society of London. Vol. V. No. 3. 8vo.—*From the Society.*

Transactions of the Royal Society of Literature, London. Vol. VIII. Part II. 8vo.—*From the Society.*

Nachrichten von der K. Gesellschaft der Wissenschaften und der

Georg-Augusts-Universitat aus dem Jahre 1865., Göttingen, 1865.—*From the University.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. T. XXI., St. 2., T. XXII., St. 1–2., T. XXIII. 4to.—*From the Society.*

Monday, 19th March 1866.

Sir DAVID BREWSTER, President, in the Chair.

The following Communications were read :—

1. Observations on the Marine Zoology of North Uist, Outer Hebrides,—(Cœlenterata, Mollusca, Echinodermata, Gephyrea, and Pisces).* By W. C. M'Intosh, M.D., F.L.S. Communicated by Professor Allman.

The surface of the island is less richly supplied with animal life than the ocean, and, indeed, with vegetable likewise. The grass is coarse and stunted, and even the hill tops are boggy; while the sea border has rich crops of Fuci, Laminariæ, and other sea-weeds, and harbours hosts of animals, both vertebrate and invertebrate. The inhabitants seem to take certain of the circumstances in which they are placed to the best advantage. Kelp is manufactured from the sea-weeds; the drift-wood makes the framework of their hovel roofs, and is applied, besides, to many other useful purposes; while fishing is universal. The soil, again, on the eastern side, with a single exception, is cultivated with neither vigour nor profit, the islanders having a tendency to be a pastoral and fishing, rather than an agricultural race.

There are few or no rock pools on the eastern side, but at Paible, on the western, they are common, their rich vegetation affording shelter to Cotti, Wrasses, Shannies, and Mysidæ—animals almost totally absent between tide-marks on the eastern side. On the other hand, the laminarian blades at Paible, beyond low-water mark, do not seem to be so prolific in simple or compound Ascidians—probably because the water is purer and more boisterous. At Loch-

* Every specimen hereafter mentioned was seen by the author.

maddy the blades of this sea-weed are covered with a flocculent, muddy deposit, that appears to be favourable to Ascidian existence; while at Paible they are fresh and clean, there being naught, indeed, but pure sand to deposit on them.

The occurrence of inland seas affords an interesting variety in examining marine life. The most abundant animal species in these is *Littorina tenebrosa*, which clothes the branches of the fuci with its myriad examples, and abounds under stones; while swarms of the young of *Rissoa striata* and *R. ulvæ* speckle the green Cladophora. The common mussel clings by its byssus to the fuci and stones; but no large example was seen in such localities, either living or dead. The hand-net showed that *Mysis chamœleon* and *Idotea tricuspdata* found amongst the sea-weed thickets both food and shelter; and the ubiquitous *Gammarus locusta*, and other sessile-eyed crustaceans, lurked under the stones in thousands, as well as sported in the water. *Carcinus mœnas*, as fierce and wary as when in purer water, was common. Under the stones were numerous groups of the little *Planaria ulvæ*. The sole representative of the swimming jellies was a small medusa, with four lilac loops, like *M. aurita*. Of fishes there were grilse, trout, young gobies, and rough-tailed sticklebacks. It was strange to find, within forty yards of such an inland sea, a true boggy, fresh-water lake, where we had the bold contrast of the white water-lily, cardamine, sparganium, horse-tails, and confervæ, holding the place of the neighbouring fuci, and marine algæ. Instead of the marine fauna before-mentioned, glistening beetles skimmed the surface, water-boatmen, dytisci and cyprides the depths, pond snails, cyclades, and leeches, climbed the water plants, and annelids and larvæ crawled in the brown peaty mud at the bottom.

Of the Cœlenterata, nine were got within tide-marks, the most abundant being *Sertularia pumila*. *Caryophyllia Smithii* swarms at the verge of low water on the eastern side of the island, being attached to rather muddy stones that lie piled over each other, so as to form small caverns, in which the corals hang, grow upright, or project horizontally; they feed voraciously on the salpæ. Amongst the anemones *Anthea cereus* attracts most notice from its curious arborescent habits on the fuci and laminariæ of the creeks at low water.

The only Sertularian found in profusion on laminarian blades from deep water was *S. operculata*, which seemed to thrive best on the west coast of the island. Adhering to a mass of *Tubularia indivisa* from the Minch was a creeping stem, having a series of horny, ringed polyp cells, of a somewhat fusiform aspect, with a short, smooth peduncle, the whole having the appearance of a *Campanularia* (fig. 1). They were only observed after immersion in spirit, so that the tentacles of the polyps could not be counted. *Pavonaria quadrangularis* is not uncommon in the Minch, but I only got a single mutilated specimen. *Lucernaria auriculata* was dredged at Paible. In all, thirteen Cœlenterata were procured from deep water.

Fig. 1.

List of Zoophytes.

Clava multicornis.	Campanularia verticillata.
Hydractinia echinata.	dumosa.
Tubularia indivisa.	fig. 1.
gracilis.	Pavonaria quadrangularis.
Halecium halecinum.	Alcyon. digitatum.
Sertularia rugosa.	Caryophyllia Smithii.
pumila.	Actinia mesembryanthemum.
operculata.	coriacea.
Plumularia catharina.	crassicornis.
Laomedea geniculata.	troglodytes.
gelatinosa.	Anthea cereus.
Campanularia integra.	Lucernaria auriculata.

Thirteen Polyzoa were procured between tide-marks; and it is curious to find that here *Crisia eburnea* forms the pigmy forests under stones, in place of the *Sertularia pumila* of the east coast of Scotland. A very abundant Lepralia in the same region is *L. verrucosa*.

From beyond low-water mark there were thirty-six Polyzoa. In one instance, no less than three cups of *Tubulipora patina* grew one above another. *Crisidia setacea* was very abundant on laminarian roots, forming dense, snowy tufts. More than a third (seventeen) of the total number were Lepraliæ. One of the richest fields for these and other marine productions not destroyed by drying was the collection of Laminariæ, chiefly from the Monich region, formed at the kelp factory. On a tuft of *Tubularia indivisa* from the deep water of the Minch, two specimens of *Retepora Beaniana* occurred. One of these adhered to the test of an Ascidian in a position which prevented the coralline from following its usual law of having the cells only on the concave side, since, to accommodate itself to circumstances, the Retepora had its cells on the convex side. The latter, however, may be regarded only as a contorted inner or concave side. A small independent Retepora on the same mass presented a peculiarity in having its inner or cellular surface hispid with rather stout, simple spines. The apertures of the cells were round, with a raised tooth on one edge, like the cells of *R. Beaniana.* The outer or smooth side in the various specimens is marked by delicate white lines, which at first sight look like cracks.

List of Polyzoa.

Tubulipora patina.
hispida.
flabellaris.
serpens.
hyalina.
Alecto granulata, *var.*
Crisia eburnea.
denticulata.
geniculata.
Crisidia cornuta.
setacea.
Hippothoa divaricata.
Cellepora pumicosa.
ramulosa.
Lepralia hyalina.
tenuis
Hassallii.
linearis.
granifera.
auriculata.
punctata.
annulata.
biforis.
Peachii.
pediostoma.
Lepralia verrucosa.
variolosa.
nitida.
unicornis.
Ballii.
ciliata.
spinifera.
immersa.
violacea.
bispinosa.
Membranipora pilosa.
membranacea.
Cellularia ciliata.
scruposa.
reptans.
Flustra membranacea.
Retepora Beaniana.
Salicornaria farciminoides.
Alcyonidium gelatinosum.
hirsutum.
parasiticum.
Flustra hispida.
Bowerbankia imbricata.
Pedicellina echinata.

The island is peculiarly rich in Ascidians, thus affording a marked contrast to the eastern shores of Scotland, where the compound species, and a few solitary ones under stones, are the only representatives generally met with between tide-marks. *Aplidium fallax* occurs occasionally in masses fully an inch across. On touching living specimens, the large aperture in the common test leading into the internal cavity was sharply contracted. A group of curious animals (*Amouroucium?*), elevated on long, clavate, hyaline peduncles, and arranged round a common centre, were also got under a stone. The truncated tips of the masses were caruncnlated, and the polyps of a bright orange hue during life. Numerous specimens of several species of bright orange and reddish orange *Leptoclini* abounded on the stones and fuci; and both *Botryllus* and *Botrylloides* were well represented, many having tadpoles in their masses. A curious thin, greyish-brown species, and a bright ochre-yellow one, occurred at the extreme verge of low water, both having glistening (as if varnished) surfaces, covered with soft spiniform papillæ. A *Clavelina* (fig. 2) was got between tide-marks, of a clavated outline, and

Fig. 2.

with a hyaline test. At the upper part of the animal a dull greyish, muddy mass capped the viscera; below this was a somewhat fusiform, flesh-coloured thorax, irregularly streaked with yellow lines; a swollen bright reddish orange stomach succeeded, marked by regular yellow bands, which on both sides presented a similar appearance, viz., two lateral lines corresponding with the curve of the region, and a central one, the whole having the shape of the inverted Greek letter ω, and resembling a crown. The visceral region dwindled to a streak before reaching the radiciform prolongations at the base.

The simple Ascidians were represented by *A. intestinalis*, *A. canina*, *A. mentula*, *A. scabra*, and *A. aspersa*. Accompanying the latter were one or two hard, reddish species, that apparently could be classed with neither. From the deep water of the Minch came several Ascidians, slightly adhering to each other by the extraordinary *debris* of shells, mud, and corallines, that surrounded them, yet otherwise solitary and distinct, like *Molgula oculata*. Their orifices were situated on separate fleshy papillæ, the anal having eight streaks of crimson, with intermediate pale lines; the branchial somewhat larger and more prominent, but similarly tinted. *Molgula tubulosa* was occasionally met with on muddy ground (six fathoms) in Lochmaddy. The papillæ were greyish-brown; and when placed in spirit, it speedily cast off its coating of mud and minute shell fragments.

Cynthia rustica and *C. grossularia* are frequent between tide-marks, but not at the extreme verge, for that seems rather occupied by sponges and zoophytes. If a stone having its under surface covered with the former is turned over, death and discoloration of the Ascidians soon take place, although they remain in the same spot as regards the tide. *C. ampulla* (?) was dredged in twelve fathoms on hard ground; it had a tunic covered with sandy hairs, with a clear space on which the two long pinkish apertures were situated. A small specimen allied to *C. tesselata* was also dredged. On the test of a large *A. mentula* from the Minch were several examples of *Cynthia Uistiæ*, new sp. (fig. 3). The largest were about a a quarter of an inch in diameter, globose, and hisped with branched bristles springing from papillæ on a tough greenish tunic. It differs from the Ascidia echinata of Professor Forbes in having four divisions to its branchial orifice, in having no regularity in the arrangement of the bristles, and in their want of radiation.

The countless multitudes of *Salpa spinosa* and *S. runcinata*, in both solitary and aggregate forms, is also a noteworthy fact.

One of the most striking features in the distribution of the mollusca (proper) of the island is the abundance of wood-borers, and the comparative absence of rock-miners.* The sole examples of the latter lurked between stones that had been fixed together by a laminarian root, in the interstices of the latter, on rocks, in peat, never in an independent tunnel. The drift-wood, again, is almost universally perforated by the Teredo, and many logs are so honeycombed, that they are only fit for firewood, or the cabinet of the naturalist. *Teredo norvagica* and *T. megotara* were the two species observed. The total number of mollusca (proper) recognised was 145; of which sixty-three were Lamellibranchiate, eighty-one Cephalophorous, and one Cephalopodous.

Fig. 3.

Between tide-marks the prevalence of *Trochus zizyphinus* was characteristic. The women and children still gather *Littorina littorea* for sale. The inherent apathy of the islander prevents him taking due advantage of the occurrence of *Mytilus edulis* in the creeks; and he is to be seen fishing with a scrap of limpet or cockle, rather than trouble himself to procure the former for bait. The somewhat rare *Tapes decussata* is met with in the sand at low water. *Fisurella reticulata* and *Emarginula reticulata* are abundant under stones in the same region. *Doris proxima* is common on the floating blades of fuci at low water; and most of the Nudibranchs (17

* The rocks are for the most part composed of *gneiss*.

in number) are in a new field,—one being a new species, viz., *Eolis Lochmaddii* :—*Body*, rather more than a quarter of an inch in length, pale, translucent, and faintly pinkish on dorsum from viscera. *Tail*, stretching a little beyond the sloped branchiæ, pale. *Oral tentacles*, pale, rather short. *Dorsal tentacles*, generally carried erect, thick, coarsely crenulate, barred with pink, and white at tips. *Eyes*, distinct. *Branchiæ*, at first small and club-shaped, then becoming long and slightly fusiform; processes bent inwards over the dorsum, and tapered towards the tips. *Colour*, pale pink, grained with red; tips with white grains and a few red, capped by a translucent point. It is an active and hardy nudibranch, swimming on the surface, elongating its foot, and throwing it into a goove. It deposited* pale pink ova, as a simple band in transparent mucus.

In the loch, the hard and muddy ground abounded in small cockles, *Venus ovata*, *Crenella decussata*, *Corbula nucleus*, and occasionally the rare *Lima subauriculata*. The most common univalves brought in by the dredge (from four to fifteen fathoms) were Trochi, Lacunæ, Rissoæ, and the curious species resembling *Akera bullata*, but possessing two distinct eyes; the latter animal preferring a hard bottom, not far from mud. *Thracia distorta* and dead valves of *Thracia convexa* were got in company with *Tellina donacina*, *Venus casina*, and *Artemis exoleta* in the same region. The valves of the *Pecten maximus*, cast on shore by winter storms, are still used by the natives for skimming milk and scooping butter. On the western shores of the island the pretty *Phasianella pullus* is common. *Sepiola atlantica* was dredged also at Paible, on sandy ground. A purplish-brown variety of *Elysia viridis*, with many pink and blue specks, was frequently got at Lochmaddy.

List of Mollusca.

Teredo norvagica, *d.*†
megotara.
Saxicava artica.
rugosa.
Mya truncata.
arenaria.
Corbula nucleus
Thracia convexa, *d. v.*†
distorta.
Cochlodesma prætenue, *d. v.*
Solen siliqua.
ensis.
pellucidus.
Tellina donacina, *d. v.*
solidula.
Syndosmya alba.
intermedia.
Scrobicularia piperata.

* August 1865.

† Dead.

Mactra elliptica.
subtruncata.
Tapes decussata.
pullastra.
Venus casina.
striatula.
fasciata, *d. v.*
ovata.
Artemis exoleta.
lincta.
Lucinopsis undata, *d v.*
Cyprina Islandica.
Circe minima.
Astarte sulcata, *d. v.*
compressa.
triangularis.
Cardium echinatum.
edule.
nodosum.
fasciatum.
pygmæum.
suecicum.
Lucina borealis.
spinifera. *d. v.*
Montacuta ferruginosa.
bidentata.
Kellia suborbicularis.
rubra.
Mytilus edulis.
Crenella discors, in nests and in H. panicea.
marmorata.
decussata.
Nucula nucleus, *d. v.*
nitida.
decussata.
tenuis.
Arca tetragona, *d. v.*
Lima subauriculata.
Pecten niveus, *d. v.*
pusio.
tigrinus.
similis.
maximus.
opercularis.
Ostrea edulis.
Anomia ephippium.
patelliformis.
striata.
Spiralis ?

Chiton discrepans.
Hanleyi.
ruber.
cinereus.
asellus.
Patella vulgata.
athletica.
pellucida.
Acmœa testudinalis.
virginea.
Dentalium entalis.
Fissurella reticulata
Emarginula reticulata.
Trochus zizyphinus.
granulatus, *d.*
Montagui.
tumidus.
cinerarius.
umbilicatus.
majus.
Phasianella pullus.
Littorina littorea.
littoralis.
rudis.
tenebrosa.
Lacuna pallidula.
vincta.
Rissoa Beanii.
punctura.
costata, *d.*
striata and *var.*
parva.
labiosa.
cingillus.
soluta.
ulvæ.
Skenea planorbis.
Turitella communis.
Aporrhais pes-pelicani.
Eulima distorta.
Odostomia eulimoides ?
Natica nitida.
pusilla.
Lamellaria perspicua.
Purpura lapillus.
Nassa reticulata.
incrassata.
Fusus ? young.
Buccinum undatum.
Trophon muricatus.

Mangelia turricula.
Cypræa Europœa.
Cylichna cylindracea.
truncata.
obtusa.
Tornatella ? young.
Akera bullata ? with eyes.
Philine scabra, *d.*
punctata.
Doris tuberculata.
repanda.
aspera.
proxima.
bilamellata.
Doris pilosa.
Goniodoris nodosa.
Ægirus punctilucens.
Polycera quadrilineata.
ocellata.
Doto coronata.
Eolis lochmaddii, *n. s.*
gracilis.
olivacea.
aurantiaca.
cingulata.
Farrani.
Elysia viridis, *var.*
Sepiola atlantica.

Thirteen Echinoderms were dredged or procured between tide-marks, besides a new species of Astrophyton, and a new Synapta. With regard to the *Astrophyton Elizabethœ*,* new sp., fig. 4, it

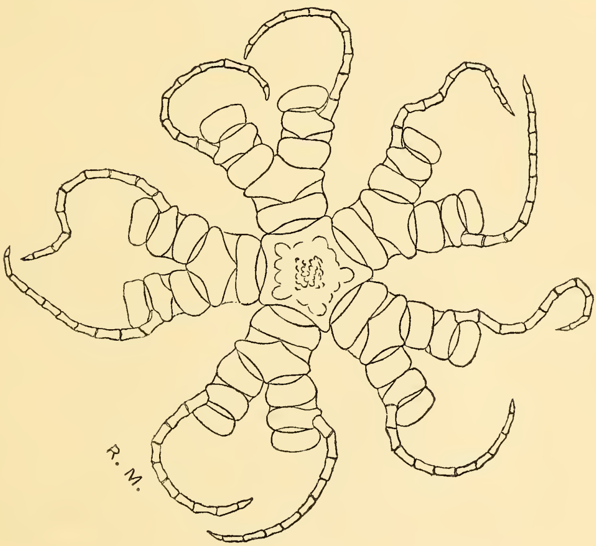


Fig. 4.

is curious that no example of the genus has been found in Britain since the publication of Professor Forbes's work.† It was

* Named after a zoological benefactress.

† Rev. A. Norman, *An. Nat. Hist.*, Feb. 1865. Professor Duns, however, intimated that a specimen of *A. scutatum* had been procured from Shetland since the above-mentioned period by the late Dr Fleming, and was now in the Free Church College Museum.

dredged in six fathoms, on mud and shell gravel. *Body*, somewhat pentagonal, of a pale-flesh colour, here and there slightly grained with red; having regular markings, roughly granulated, and with the margins modified so as to fit the bases of the five rays. The first joint of each of the latter is nearly plano-concave, minutely grained and frosted (in spirit). Between this and the body is a biconvex, ligamentous connection. The next joint is somewhat lozenge-shaped, presenting a central projection, and two slightly curved articular surfaces to the first joint, and a longer process and two more extensive articular surfaces (also curved) on the distal side, each of the latter articulating with a division of the bifid arm beyond. Viewed dorsally, it has thus no less than four articular ligaments. The limbs usually separated at the joint between this and the first segment. A transverse section of an arm at its base showed aborally an arched outline, orally a flattened, so that it was somewhat D-shaped, with a perforation in the centre. Two symmetrical muscular bundles were placed over each of the larger joints inferiorly. The first joint of the secondary arm is of an irregular rhomboidal shape, being widest towards its outer edge, and with the deepest curve on its proximal side; the second, of an irregular lozenge-shape, pointed on both proximal and distal edges, especially the latter, the distal apex being on the outer side of the middle line, the short outer curve thus formed giving rise to the long, jointed limb. The last joint presents a somewhat plano-concave outline on its dorsal surface, the concavity being proximal, and articulating by means of a biconvex ligament with the preceding segment. From the outer side and shorter curve of the second last segment springs, as before mentioned, a long, delicate, jointed arm of ten gradually diminishing pieces, like the skeleton of a vertebrate tail. The segments of these are (in spirit) finely grained, and frosted (after the manner of several Lepraliæ), like the larger segments, and have also microscopic spikes near the junctions, directed distally. Along the ventral surface of these slender armlets, after preservation in spirit (which blanched the rest), were numerous dull, reddish, minute tubercles, apparently imbedded in the tough membrane that was present on this surface. All the arms and their branches were coloured, during life, of a beautiful purple lake, a slightly paler portion being in the centre dorsally.

The hard parts of the animal were densely calcareous, and the disc seemed quite solid. On the under surface was a bulky, soft mass, of a reddish-brown hue, which covered the central disc, and extended outwards over the bases of the arms. Microscopically this consisted of a rich cellulo-granular structure, that might have been the *debris* of ova. The mass readily separated from the under surface of the body and arms, but left a membranous coating which adhered very closely to the edges of the limbs, so that it seemed a fixed process. In this tough, translucent membrane were many minute calcareous scales, with a concentric structure, like those of a cycloid fish. The oral surface, after removal of the soft mass, had a wide circular opening, with several tooth-like processes projecting inwards from the circumference.

Imbedded in the soft mass last mentioned, and partly projecting outwards, was a curious crustacean parasite, of a mottled crimson colour, when fresh (fig. 5).

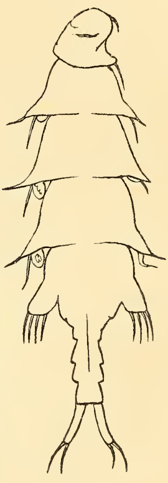


Fig. 5.

The occurrence of *Synapta Galliennii* (Herapath),* a species hitherto only procured from Guernsey, is interesting, and shows how cautiously deductions as to the distribution of marine animals ought to be made. Some of the specimens, though imperfect, measured between 2 and 3 inches, of a pale pinkish or flesh colour, clouded by the dark intestine. Interspersed amongst the spicula were numerous circular, papilliform, grained rings of a brownish-red colour. The specimens agreed in most respects with Dr Herapath's description, but the anchors and anchor plates seem to be more than "serrated," since both are studded over with groups of microscopic spikes and granules, which impart to them a rough, corroded aspect, very characteristic when compared with the succeeding species or *S. digitata*.

Synapta Buskii,† new sp.—Two, about an inch in length, were dredged (nine to ten fathoms) on a bottom of muddy clay in Loch-

* Quart. Jour. Micros. Soc., January 1865.

† Named after Professor G. Busk, London.

maddy. It is a most translucent species, of a pale flesh colour, with the plates and anchors visible as distinct glistening points under a lens, and having five longitudinal muscular bands. One adhered to the cover of a table during life, and could not be taken off without serious mutilation. The intestine is dull yellowish. Both had eleven tentacles, each of which apparently had five divisions, though I am not certain of these figures, since they were minutely examined after immersion in spirit, and then only the terminal and two adjoining divisions of the arms were distinct. The plates and anchors were identical throughout in both examples, and very characteristic (fig. 6). The plates have a somewhat hexagonal out-

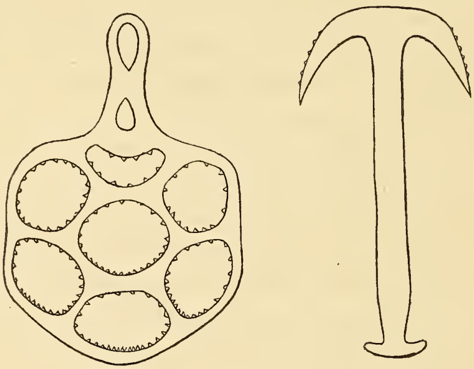


Fig. 6.

line, with a long process, like a handle, and are perforated by a central and six surrounding apertures, with serrated edges. There are two small openings in the "handle." The anchors, about the same length as the plates, are articulated to the end of the last-mentioned process, and present slight serrations on the flukes.

List of Echinodermata.

Ophiura albida.
Ophiocoma brachiata.
 filiformis.
 bellis.
 granulata
 rosula.
Astrophyton Elizabethæ, *n. s.*
Uraster glacialis.
Uraster rubens.
Cribella oculata.
Solaster papposa.
Echinus sphæra.
Ocnus brunneus.
Synapta Galliennii.
 Buskii, *n. s.*

Gephyrea.—*Priapulus caudatus* was met with in great abundance in the sandy mud of a creek at low water; some of the specimens, independently of the long tail, measuring 6 inches in length. A great change will require to be made in the descriptions of Professor E. Forbes, for he does not notice the presence of the horny teeth of the proboscis, with their curved central and three lateral fangs, or the occurrence of papillæ in rows on the same organ, or on the body and processes of the tail.

Besides the common *Sipunculus Bernhardus* and *S. Johnstoni*, a new Syrinx (Forbes), Dendrostomum (Quatrefages), was found. *Dendrostomum Huxleyii*,* new sp.; from under a stone lying on muddy sand. It stretched itself when living to the length of 7 inches, both extremities being tapered. Body of a uniform dull brownish hue, elongated, vermiform, and with the proboscis abruptly separated anteriorly by a well-marked shoulder; instead of having a smooth body, as in *S. Harveii* (Forbes), to which it seems most nearly allied, this is everywhere marked by fine transverse lines, closely studded with small papillæ, just visible to the naked eye. The shoulder and base of the proboscis present the most conspicuous carunculæ, those at the tapering, downy, posterior extremity being somewhat less marked, from the absence of rugæ. The proboscis is about an inch and a quarter in length, very rugose at the base, more finely papillated towards the extremity, near which the papillæ sharp like spikes, and towards the buccal cirri marked as minute black dots.

List of Gephyrea.

Priapulus caudatus.	Sipunculus Bernhardus.
Dendrostomum Huxleyii.	Johnstoni.

Fishes.—The most conspicuous character in the class of fishes (of which thirty-three species were observed) was the abundance of the *Wrasses* that swam in shoals at the margin of the rocks, or lurked under the sea-weeds of rock pools. Numerous examples of *Lepidogaster bimaculatus* and *Siphonostomus Typhle* were caught in the laminarian region around the little islands.

* Named after Professor Huxley, London.

Salmon and trout were everywhere plentiful. Attached by a long, slender, central appendage (like that of a *Chalimus*) to the pectoral region of a *Motella glauca*, that swam amongst the salpæ, was a remarkable crustacean parasite (fig. 7). A malformed young *Turbot** was also caught as it disported itself amongst the salpæ, having both *sides* of its body coloured, and with an eye on each; opercular bones on both sides armed with prickles. The dorsal fin commences rather behind the posterior border of the orbit, leaving a distinct crown of the head in front. The ventral line was flattened, had a prominent spinous process at the posterior termination of the lower jaw, in a line with the posterior part of the orbit, and a deep notch behind the rudimentary ventral fins. The directions of the axes of the eyes were different. The anal fin commenced behind the ventral notch. There was little abnormality in either pectoral or caudal fin, save that the latter was directed somewhat downwards (ventrally).

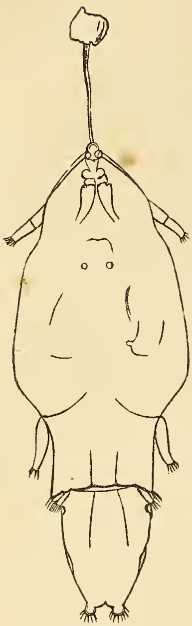


Fig. 7.

List of Fishes.

Anguilla latirostris.
Conger vulgaris.
Ammodytes lancea.
Clupea harengus.
Salmo salar.
Fario argenteus.
Labrus maculatus.
Ctenolabrus rupestris.
Crenilabrus pusillus.
Gadus morrhua.
œglefinus.
Merlangus carbonarius.
Lota molva.
Motella quinquecirrata.
glauca.
Psetta maxima.
rhombus.
Platessa flesus.
limanda.
Acanthocottus scorpius.
Gasterosteus trachurus.
spinachia.
Gobius bipunctatus.
minutus.
Lepidogaster bimaculatus.
Cyclopterus lumpus, young.
Liparis vulgaris.
Blennius pholis.
Muræenoides guttata.
Lophius piscatorius.
Siphonostomus Typhle.
Acanthias vulgaris.
Raia batis.

* In my diagnosis of this animal I was aided by Dr R. H. Traquair, who has recently published many valuable observations on the Pleuronectidæ, *Linn. Trans.*

2. On the Natural History of Lewis. By Professor Duns, D.D., F.R.S.E.

Comparatively little attention has been given to the natural history of Lewis. Stray notices of the geology, botany, and zoology of the Outer Hebrides are to be met with, but, with one or two exceptions, these are not of much value. Martin's "Description of the Western Islands (1703)," is chiefly interesting for its full account of the industrial and moral condition of the people. Little, however, can be made of his incidental references to the natural history of the islands. Two volumes on the "Economical History of the Hebrides," by Rev. Dr Walker, Professor of Natural History in the University of Edinburgh, were published in 1808, after Dr Walker's death. This work contains a good deal of information on indigenous plants, but almost none on zoology. Dr Maculloch's "Description of the Western Islands of Scotland (3 vols., 1819)," is in every way an abler and better work than either of the two now named. Its notices of the geology and mineralogy of the Outer Hebrides are even still valuable. The only other work calling for notice here is the late Mr James Wilson's "Voyage Round the Coast of Scotland and the Isles (2 vols. 1842)." Mr Wilson spent a short time at Stornoway, but the work contains only one brief reference to the zoology of the district. He names starlings, redbreasts, larks, thrushes, and sand-martens as the only land birds seen by him near that town.

In addition to these works there are several separate papers on the natural history of the Long Island, which should be named. Two were published by the late Professor Macgillivray, in the second volume of the "Edinburgh Journal of Natural and Geographical Science (1819)," and another by Mr John Macgillivray, on the "Zoology of the Hebrides," in the "Annals of Natural History (vol. viii. 1840)." These papers are chiefly devoted to the zoology of Harris, and are very imperfect. In the "Transactions of the Botanical Society of Edinburgh (1841)," Dr Balfour published a very complete list of the plants of the "Outer Hebrides and Skye." Captain Thomas's interesting paper on "The Geologic Age of the Pagan Monuments of the Outer Hebrides (*Proc. Royal Phys. Soc.* 1862)," contains valuable particulars as to the supposed rate of growth of peat, changes in the surface deposits of the localities referred to, &c.

I visited Lewis last summer, chiefly with the view of looking at its zoology and surface geology. In the present paper, attention is limited to the mammals, birds, reptiles, and land mollusca.

MAMMALIA.

VESPERTILIONIDÆ,	Common Bat, . . .	*Vespertilio pipistrellus.*
MUSTELIDÆ, .	Otter, ...	*Lutra vulgaris.*
	Common Martin, . . .	*Martes foina.*
PHOCIDÆ. . .	Common Seal, . . .	*Phoca vitulina.*
	Grey Seal, ...	*Halichærus gryphus.*
MURIDÆ, . .	Common Mouse, . . .	*Mus musculus.*
	Norway Rat, . . .	*Mus decumanus.*
LEPORIDÆ, .	Common Hare, . . .	*Lepus timidus.*
	Alpine Hare, . . .	*Lepus variabilis.*
CERVIDÆ, . .	Red Deer, ...	*Cervus elaphus.*
DELPHINIDÆ, .	Common Porpoise, . .	*Delphina phocœna.*
	Grampus, ...	*D. orca.*
	Round-headed Porpoise, .	*Phocœna Melas.*

AVES.

FALCONIDÆ, .	Ring-legged Buzzard, . .	*Buteo lagopus.*
	Common Buzzard, . .	*B. vulgaris.*
	Golden Eagle, . . .	*Aquila chrysaëtus.*
	White-tailed Sea Eagle, .	*Haliaëtus albicilla.*
	Fishing Osprey or Fish Hawk,	*Pandion haliaëtus.*
	Iceland or Jer-Falcon, . .	*Falco gyrfalco.*
	Peregrine Falcon, . .	*F. peregrinus.*
	Merlin, ...	*F. æsalon.*
	Kestrel, ...	*F. tennunculus.*
	Sparrow Hawk, . . .	*Accipiter nisus.*
STRIGIDÆ, . .	Snowy Owl, . . .	*Syrnea nyctea.*
	Common Owl, . . .	*Strix aluco.*
	Barn Owl, ...	*S. flammea.*
	Bare-Toed Day Owl (?),	*Noctua nudipes,* Gould, (?).
HIRUNDINIDÆ, .	Chimney Swallow, . .	*Hirundo rustica.*
	Sand Martin, . . .	*H. reparia.*
CAPRIMULGIDÆ,	Goatsucker, ...	*Caprimulgus Europæus.*

CUCULIDÆ, .	Cuckoo, ...	*Cuculus canorus.*
CORVIDÆ, . .	Raven, ...	*Corvus corax.*
	Hooded or Grey-backed Crow,	*C. cornix.*
	Rook, ...	*C. frugilegus.*
STURNIDÆ, .	Starling, ...	*Sturnus vulgaris.*
TURDIDÆ, . .	Dipper, ...	*Cinclus Europœus.*
	Blackbird, ...	*Turdus merula.*
	Ring Ousel, ...	*T. torquatus.*
	Fieldfare, ...	*T. pilaris.*
	Song Thrush, . . .	*T. musicus.*
	Redwing, ...	*T. iliacus.*
	(*Sylvinœ*).	
SYLVIIDÆ, . .	Garden Warbler, . . .	*Sylvia hortensis.*
	Willow Woodwren, . .	*S. trochilus.*
	Gold Crest, ...	*Regulus auricapillus.*
	Common Wren, . . .	*Troglodytes vulgaris.*
	(*Erythacinœ*).	
	Redbreast, ...	*Erythacus rubecula.*
	White-rumped Stone Chat, .	*Saxicola œnanthe.*
	Whin Chat, ...	*Fruticicola rubetra.*
	(*Parinœ*).	
	Blue Tit, ...	*Parus cœruleus.*
	(*Motacillinœ*).	
	Pied Wagtail, . . .	*Motacilla Yarrelli.*
	(*Fringillinœ*).	
FRINGILLIDÆ, .	Chaffinch, ...	*Fringilla cœlebs.*
	Mountain Finch, . . .	*F. montifringilla.*
	Grey Linnet, . . .	*F. cannabina.*
	Twite, ...	*F. montium.*
	Greenfinch, ...	*F. chloris.*
	House Sparrow, . . .	*Passer domesticus.*
	(*Emberizinœ*).	
	Common Bunting, . .	*Emberiza miliaria.*
	Yellow Hammer, . . .	*E. citrinella.*
	Reed Sparrow, . . .	*E. schœniclus.*
	Snowflake, ...	*Plectrophanes nivalis.*
	(*Alaudinœ*).	
	Meadow Pipit, . . .	*Anthus pratensis.*
	Shore Pipit, . . .	*A. obscurus.*
	Sky Lark, ...	*Alauda arvensis.*

COLUMBIDÆ,	Wood Pigeon,	*Columba palumbus.*
	Rock Dove,	*C. livia.*
	Turtle Dove (?),	*C. turtur.*
PHASIANIDÆ,	Common Pheasant,	*Phasianus Colchicus.*
PERDICIDÆ,	Common Partridge,	*Perdix cinerea.*
TETRAONIDÆ,	Black Grouse,	*Tetrao tetrix.*
	Red Grouse,	*T. Scoticus.*
	Ptarmigan,	*Lagopus cinereus.*
GRUIDÆ,	Grey Crane,	*Grus cinerea.*
PLURIOLIDÆ,	Golden Plover,	*Charadrius pluvialis.*
	Dotterel,	*Pluvialis morinellus.*
	Ring Plover,	*Charadrius hiaticula.*
	Lapwing,	*Vanellus crestatus.*
	Turnstone,	*Strepsilas interpres.*
	Oyster Catcher,	*Hœmatopus ostralegus.*
	Grey Sandpiper,	*Tringa canutus.*
	Purple Sandpiper,	*T. maritima.*
	Dunlin,	*T. cinclus.*
	Sanderling,	*Calidris arenarea.*
	Curlew,	*Numenius arqueta.*
	Whimbrel,	*N. phœopus.*
TOTANIDÆ,	Redshank,	*Totanus calidris.*
SCOLOPACIDÆ,	Common Snipe,	*Scolopax gallinago.*
	Jack Snipe,	*S. gallinula.*
	Woodcock,	*S. rusticola.*
ARDEIDÆ,	Common Heron,	*Ardea cinerea.*
RALLIDÆ,	Water Rail,	*Rallus aquaticus.*
	Land Rail,	*Crex pratensis.*
	Water Hen,	*Gallinula chloropus.*
	Coot,	*Fulica atra.*
ANATIDÆ,	Grey Lag Goose,	*Anser ferus.*
	Wild Goose,	*Anas anser.*
	Short-billed Goose,	*Anser brachyrhyncus.*
	White-fronted Goose,	*A. albifrons.*
	White-faced Bernicle Goose,	*Bernicla leucopsis.*
	Swan,	*Cygnus musicus.*
	Shieldrake,	*Anas tadorna.*
	Mallard,	*A. boschas.*
	Teal,	*A. crecca.*
	Pintail Teal,	*A. acuta.*

ANATIDÆ	Wigeon	*A. Penelope.*
	Broad-billed Scaup Duck	*A. marila.*
	Tufted Pochard	*A. fuligula.*
	Velvet Scoter	*A. fusca.*
	Black Scoter	*A. nigra.*
	Eider Duck	*A. mollisima.*
	Golden Eye	*A. clangula.*
	Gooseander	*Mergus merganser.*
	Red-breasted Gooseander	*M. serrator.*
COLYMBIDÆ	Little Grebe	*Podiceps minor.*
	Great Northern Diver	*Colymbus glacialis.*
COLYMBIDÆ	Black-throated Diver	*C. arcticus.*
	Red-throated Diver	*C. septentrionalis.*
ALCIDÆ	Common Guillemot	*Uria troile.*
	Black Guillemot	*U. grylle.*
	Little Auk	*Alca alle.*
	Razor Bill	*A. torda.*
	Puffin	*A. arctica.*
PELICANIDÆ	Cormorant	*Pelecanus carbo.*
	Shag	*P. graculus.*
	Gannet	*P. bossanus.*
PROCELLARIDÆ	Fulmar	*Procellaria glacialis.*
	Manx Shearwater	*Puffinus Anglorum.*
	Stormy Petrel	*Procellaria pelagica.*
LARIDÆ	Richardson's Skua	*Lestris Richardsonii.*
	Kittiwake	*Larus rissa.*
	Great Black-backed Gull	*L. marinus.*
	Lesser Black-backed Gull	*L. fuscus.*
	Herring Gull	*L. argentatus.*
	Common Gull	*L. canus.*
	Brown-hooded Mew	*L. ridibundus.*
	Common Tern	*Sterna hirundo.*
	Arctic Tern	*S. arctica.*

REPTILIA.

Stone Worm	*Anguis fragilis.*
Common Adder	*Vipera berus* (?)

MOLLUSCA (LAND).

Limax agrestis, Zonites cellareus, Z. nitidus, Helex aspera, H. nemoralis, H. rotundata, Zua lubrica.

These lists are not a little suggestive, when regarded from the point of view of the geographical distribution of animals. Taking into account the climatal condition of Lewis, its relation to the mainland and to the islands of the Outer Hebrides group, it will be seen that its fauna contains forms which could scarcely have been looked for there, and that others are absent which we might have expected to find. Its climate is comparatively mild, and not so humid as many believe. The mean annual temperature is 46°·5′, and the average annual rain-fall is not more than 30·2 inches. The greatest cold is seldom more than 35°, and the greatest heat 65°.

In the list of mammalia the *Mustelidæ* are represented by two genera, *Lutra* and *Martes*. It is, however, remarkable that neither the common weasel, the stoat, nor the polecat, should be met with in a locality which still shelters one of the least common Scottish forms of this family—the rapidly decreasing *Martes foina*. This animal, whose skin still sells at a price varying from 14s. to 20s., occurs in Sir James Matheson's deer forest, Mhorsgail. Under the family *Phocidæ*, the common seal and the grey seal are named as known to breed on the west coast of Lewis. When Martin visited the district more than 160 years ago, he wrote—"Seals are eaten by the vulgar, who find them to be as nourishing as beef and mutton." Two species of *Muridæ* occur—the common mouse and the Norway rat. In almost all other districts these species are found associated with the shrews, the voles, and the field mouse, none of which are met with in Lewis. It is curious, too, that while the common and Alpine hares abound, there are no rabbits. Several attempts to introduce them have failed. The fox, hedgehog, mole, and badger, are also absent, yet these, I believe, all occur in Skye. The number of species of Mammalia which fall to be associated with Lewis is thirteen. In the same way, the number of species of birds is 110. Many of these, however, are occasional visitors. The number of reptiles is one, and of land mollusca seven. A careful examination may add some forms to the last; but I do not anticipate that the list of birds will have many names added.

Many of the birds came under my own observation. Others are named from a collection preserved at the gamekeeper's lodge, near

Stornoway Castle. Several of the rarest forms are among these. For the names of others I am indebted to Mr Liddle, farmer, Gress, an intelligent and trustworthy observer.

Not fewer than ten species of *Falconidæ* occur in Lewis, or in some of the islands on the east and west coast. The golden eagle is seen throughout the year; in winter singly, in summer often in pairs. The belief is common among the people that this species takes salmon, as well as hares, moorfowl, &c. The white-tailed eagle, in its turn, poaches on the territory of the golden one. It has been often known to take lambs as well as salmon, and is said to have killed a fawn in Mhorsgail Deer Forest. The fishing osprey is more common than either of these. It nests in the Shiant Islands, and may not unfrequently be seen on the Uig coast. The jer-falcon is only an occasional visitor. It is more frequently seen in the Flannen Isles, on the west coast of Lewis. The peregrine falcon is observed throughout the year. It is noted as a bold hunter, and very destructive to young grouse. When pressed by hunger it will attack the old also. Its favourite prey is the rock pigeons, which abound on the west coast especially. The merlin was once abundant, but is now comparatively rare. The sparrow-hawk is common. The kestrel is not so. Two snowy owls were shot at the Butt in 1855, and one at Uig in 1859. The common and barn owls are comparatively rare. A good observer described to the author a species which he had once seen, as small, bare on the toes, brown above and yellowish below. The description suggested *Noctua nudipes* of Gould; but this is of very rare occurrence in Britain, and even on the Continent it is seldom met with north of lat. 55°.

The cuckoo frequently appears in the end of April, but its usual time seems to be from the 10th to the 15th of May. Writing of Rona, Martin makes the following note:—"The inhabitants of this little island say that the cuckow is never seen or heard here, but after the death of the Earl of Seaforth or the minister!"

Among the *Corvidæ*, the raven and grey-backed crow are common. Both of these birds are very bold, and destructive to grouse. The former not unfrequently attacks diseased sheep, and picks their eyes out before the animals are dead. Several of the latter have been seen to attack the female grouse, when covering her young, drive her away, and fly off with a young bird each. Both build in the wild cliffs overhanging the sea, but they are often met with in the moors. The rook is rarely seen in Lewis. It is noticed only as an occasional visitor in winter, and, when disturbed, takes flight in the direction of the mainland; yet there is abundance of food for it. Not only does the earthworm abound, but many hurtful grubs also. Cultivated patches were pointed out to me as having been destroyed by mildew, but on pulling up the plants by the roots, numerous wire worms of *Tipula* and *Elator* were seen.

The jackdaw is absent, but the starling, which in many of its habits resembles this bird, is very abundant. The starling builds in the holes of rocks, and seems to be much more particular about its nest than it is in the south. In Lewis it uses moss and wool as a lining, and is often seen on the sheep's back, not feeding on the ticks, which it sometimes does, but quietly pulling out the wool for nest-lining.

Six species of the family *Turdidæ* occur. Of these the dipper is the least common. The ring ousel is met with in summer. An interesting illustration of what might be called the adaptive power of instinct came under my notice in the little island named Pabba, near the Uig shore. On the 15th of June 1865, when examining the rocks of the island, I met with a nest of the common thrush, containing four eggs. In placing it at the top of a sand-covered rock, over the edge of which long stalks of lyme grass drooped, the bird had availed itself of these for a kind of cradle for the nest. Indeed, some of the leaves were woven into the outer covering of the nest, which was thus hung out over the bank. In the Lowlands the favourite nesting-place of the thrush is a tree or a bush; but as these are of rare occurrence indeed in Lewis, the bird yields to circumstances, and places its nest in the hollows of the rocks, or on the top of sand-banks near the shore. In this case it had managed to place it where it would swing in the breeze. The nesting-time of the thrush in the south is in April and the beginning of May. These birds occur in great numbers all over Lewis. The missel-thrush and redwing appear in winter. In the south the former is most common, in the north the latter.

The family *Sylviidæ* is well represented. Some members occur in Lewis, which we could not have expected to find. I met with the garden-warbler, the willow wood-wren, and the pretty little gold-crest, in the plantation around Stornoway Castle. The age of the trees and bushes there is not great. These birds must thus have found their way thither after the plantation was made. It would be interesting enough if we could trace the path of their progress north, especially as they arrive only a few days later than those which frequent the neighbourhood of Edinburgh. The presence of the blue tit is as curious. Of related forms the pied wagtail and yellowhammer, whinchat and redbreast, may be mentioned as not common.

The lark may be named the bird of Lewis. On every moor, in every cultivated spot, inland or along the shore, wherever there is a bit of turf, you meet this bird. Some have thought that the increase of starlings in the Lowlands has thinned the number of larks. In Lewis both are very abundant.

Among the *Fringillidæ*, perhaps the least common is the house-sparrow. "A pair of sparrows," says James Wilson, in the work referred to above, "built in Stornoway in 1833, but we did not see their descendants in 1841." I believe that the date of the introduction of the sparrow into Lewis is correct. They are now spread all over the country; but in few localities, except in Stornoway, do they breed in the eaves and thatch of houses. Even the sparrow turns away from the wretched huts in which the majority of the people dwell. Here, again, we have an illustration of the influence of habit on instinct. Were a sparrow to build a nest in the thatch of one of these wretched hovels, it would be almost sure to be destroyed when the eggs were dropped. To prevent the escape of smoke almost all the huts are built without a chimney. Windows occur in very few of them, and the doors are smaller than those of cottages in the Lowlands. The object of this is to direct the peat smoke into the loose thatch, in which the soot may lodge. In spring this part of the covering is taken off, and spread over the "lazy beds," in which barley and green crops are to be raised. Thus manured, they yield abundant crops. The sparrow has been taught the uncertainty of tenure in such roofs, and builds its nest in the holes of rocks instead of the habitations of man.

The *Columbidæ* are represented by the rock-pigeon and the wood-pigeon. The former is very abundant; the latter is only seen occasionally in spring or in autumn. Some years ago one of Sir James Matheson's keepers shot a specimen of the turtle dove. This, I believe, is the only instance in which this bird has been met with so far north.

When the pheasant was first introduced, it roosted habitually on the trees near Stornoway Castle. This it seldom does now. Has it, too, learned something by experience? It has nothing to dread from fox, or polecat, or ermine; and the marten, which would be destructive to it, frequents a distant locality. Efforts have been made to introduce the black grouse, but they have not as yet been successful. Walker seems to have met with it on the occasion of his visit to these islands. He says, "The stomach of the black-cock is often found stuffed in spring with the *Polypodium vulgare;*" and adds, "This is the only certain instance that has occurred of any animal living upon a plant of the fern kind in this country." Ptarmigan are very common, especially on the Lewis slopes of the Harris hills. The red grouse is not fit for shooting till about September.

One species of *Gruidæ*, the grey crane, has several times been shot in severe winter weather. Of the *Pluvialidæ*, the golden plover is very abundant in the moors during summer. In winter it retires to the shore. The dotterel is seen in June and July, and the ring-plover is very abundant throughout the year. Mr Macgillivray says that the lapwing is of extremely rare occurrence in the Hebrides. This is a mistake; I saw it frequently. Its habits as to change of place are similar to those of the golden plover. The turnstone is met with during winter. The oyster-catcher is abundant. I found several nests on a shelving rock near Gallan Head, with eggs in them, on the 14th of June. In some the shell was beginning to break, and the "peep-peep" of the chick could be heard. In the Fern Islands the young of this bird appear a fortnight earlier. The nesting-place was a hollow in the large rock, without lining of any kind.

Of the *Tringidæ*, the grey sandpiper arrives in small flocks in September, the purple sandpiper appears for a few weeks in spring, the dunlin is abundant on the Uig coast in June, the sanderling arrives early in September, and departs in March, the curlew is abundant, and the whimbrel is seen in May for a short time. It does not seem to breed in Lewis.

The *Totanidæ* are represented by the redshank, which is not common, and is seen only in summer. Three species of *Scolopacidæ* are met with. The common snipe is abundant throughout the year. The jack-snipe is not common in winter. The woodcock arrives, but not in great numbers, in October. In no case have they been known to remain during summer.

The common heron is often observed in winter; very seldom at any other season. The water-rail is not common. It is found throughout the year. The land-rail arrives between the middle and end of May; but a curious fact was brought under my notice in regard to it: its cry is frequently heard in Bernera, Uig, ten days or a week earlier than in the Long Island itself.

No fewer than nineteen species of *Anatidæ* have been met with in Lewis. Among these, the grey lag and bean goose are seen occasionally in winter; the pink-footed or short-billed goose breeds in the Flannen Islands; the white-fronted goose, the swan, shieldrake, velvet and black scoters, appear in winter; the pintail teal is rare. The wigeon has frequently been shot in Lewis, though Mr Macgillivray says, "In the north of Scotland they are uncommon; on its north-west coast scarcely ever seen; in the Outer Hebrides, I believe, never." The broad-billed scaup duck is a rare winter visitant. The eider duck breeds in the Flannen Isles. I saw a pair which had been brought to Bernera two days before my visit. I observed a pair of the golden eye on a small lake in Uig in June. I watched them with a field-glass for about an hour. One of Sir James Matheson's keepers was with me, but they never came within gun-shot. The gooseander breeds occasionally in the district.

All the other forms named in the list of birds are abundant, with the exception of the little grebe, which is not very common.

Under *Reptilia* I have set down the common adder; but its occurrence in Lewis is apocryphal, though assured by several that they had seen what must have been an adder. The only reptile is the slow worm, of which the people have a great and superstitious dread, though it is perfectly harmless. The frog, the toad, and the newt are absent. On this account, the people call Lewis a blessed country, in being so free from the evil creatures that abound in the south!

3. On M. Mége Mouriés' Process of Preparing Wheat Flour. By Professor Wilson.

Some twelve years ago M. Mége Mouriés had his attention directed to the composition of the grain of wheat, and to the processes of grinding and panification. The object of that gentleman's investigations was to show the defective knowledge and waste of material in the ordinary practices of the trade; but although these were fully proved by the results, there appeared to have been trade and other difficulties in the way of its general adoption. Having last year acted as juror on "Food Substances" at the Dublin Exhibition, I had my attention recalled to the subject by an article which was submitted to the jury under the name of "Cerealina," purporting to be a preparation of wheat flour by the process indicated by M. Mége Mouriés, and which, on examination, confirmed the opinions which had been previously formed of its food value. On further inquiry, it was found that a simple mechanical process had been devised in the United States, where the flour had been prepared, for effecting the most difficult part of M. Mége Mouriés' process—that of decorticating the grain. This rendered the operation of preparation so easy and so inexpensive as to make it desirable that attention should again be called to the process. In examining the composition of the grain of wheat, M. Mége Mouriés found that it was a far more complicated structure than was commonly supposed—that it consisted of (1) an outer covering or epidermis, (2) epicarp, (3) endocarp, and that these three layers consisted chiefly of ligneous tissue, and formed the exterior covering of the grain or true bran, and had no food value. Together, they averaged from two to three per cent. of the weight of the wheat. Beneath these came (4) the testa or seed-coat proper, which was a distinct cellular tissue of a dark colour—yellow or orange, according to the description of the grain; and (5), the embryo membrane, directly connected with the germ, which, indeed, it supplied as soon as the vital principles of growth were excited. These two coats or layers contained nitrogenous matters in large proportions, and enveloped the mass of starch-cells which formed the body of the grain. Ordinary flour was composed entirely of these interior starch-cells—the remaining portions of the grain being separated in the shape of bran, and carrying away with them, at the same time, a proportion, generally five or six per cent., of the flour also. M. Mége Mouriés found that the gluten contained in the grain was very unequally divided; that while in the epidermis or the true bran it was least, it existed in larger quantity in the two next layers than it did in the starch-cells or flour of the interior. He therefore recommended that the grain should be merely decorticated previous to grinding, and that the layers of cells, so rich in gluten as the testa and embryo membrane, should be ground up with the starch cells, and form part of the flour used for bread or other food purposes. From an analysis which has been made by Dr Lyon Playfair, I found that by this process the true bran contains only 4·571 per cent. of gluten instead of 15·019 by the ordinary process. The flour made by M. Mége Mouriés' process contains 15·672 per cent. of gluten, as compared with 9·795 in the ordinary flour. By merely taking off the outer covering of the grain, which is perfectly valueless as an article of food, instead of following the ordinary process, which takes off at least 14 per cent. of bran, fully 10 per cent. is added to the food portion of wheat, while the nutritive value of flour is increased by about 60 per cent. This, upon the wheat consumption of the kingdom,—say 20,000,000 of quarters,—is a matter of considerable importance. Another important advantage is secured by M. Mége Mouriés' process in regard to the storage and preservation of wheat. It appears that the outer covering—the epidermis—absorbs moisture far more readily than the regular cellular tissue of the inner layers, and thus renders the grain more or less liable to mould and other injuries by keeping, unless great care be taken by occasionally shifting, &c. By the process of decortication this is entirely removed, and a hard, smooth surface given to the grain, from which every particle of deteriorating matter, in the shape of dirt, smut, &c., has been removed, diminishing its bulk, and leaving it ready for the miller whenever it may be required. The following is the method adopted for the preparation of the grain by M. Mége Mouriés' process:—

"Wheat is carried up to the topmost floor, then, passing through a screen or riddle, it falls through a hopper into a long narrow trough which contains water, and is traversed through its length by an Archimedian screw. This carries the wheat slowly along the trough to the discharge end, where it now, in a moistened state, falls down a tube to the unbranning or decorticating cylinders. These are formed of cylinders of cast-iron, ridged on their interior diameters, and with closed ends. A screw shaft traverses the centre of them, carrying broad arms or floats set at an angle, diagonal, or 'aslant' to the face of the cylinder, and with a diameter so much less than that as to cause friction, but to allow the grain to pass without crushing. A rapid rotation is given to this central shaft, and, owing to the angle at which the floats are set, a slight progressive motion is given to the grain. The friction causes a large proportion of the true bran—epidermis, epicarp, &c. —to be separated; and this is removed, as it is separated, by a blast driven through the cylinder in a direction contrary to the motion of the shaft, which also has the effect of drying the excess of moisture of the grain. It then passes along a spout into a second cylinder, where it undergoes the same process; and, finally, is carried into the drying-chambers, composed of a series of iron troughs, along which the grain is propelled by screw shafts, a current of dry warm air being driven along them in an opposite direction. It then, quite dry, receives its last friction in the polishing cylinders, where the friction is limited to that of the grains themselves, and leaves it in a dry, smooth, rounded form. As this generates a considerable elevation of temperature, it requires to undergo a cooling process before storing or using. This is effected by carrying it up to the upper floor, and allowing it to fall down inclined planes through a flat shoot, up which a blast of cold air is driven."

4. Observations on Meat (Butchers'-meat), in relation to the Changes to which it is liable under different circumstances. By John Davy, M.D., F.R.SS., London and Edinburgh, &c.

Animal food is of so much importance, in relation to our wants as to diet, that I have been induced to make some experiments on it, with the hope of obtaining useful results. These I now submit to the Society, imperfect as they are, trusting that they may not prove altogether useless, and that they may lead to further inquiry.

1. *Of Degree of Temperature as modifying Change.*

It is well known how rapidly meat undergoes the putrefactive change in the height of summer, and in tropical climates at all seasons; and, on the contrary, how long it may be kept free from putridity during our winter, and more especially at the freezing temperature, and degrees of temperature approaching the freezing,— in this, as in the preceding instance, fully exposed to the air of ordinary atmospheric humidity.

In the comparative trials I have made in each season, for the sake of precision, the meat used has been divided into two portions,— one, suspended by a thread, has been fully exposed to the air of the room; the other has been suspended in a receiver over a little water,—the receiver, so covered as to admit air, and yet prevent rapid desiccation by evaporation.

In one experiment on portions of lamb, made at a temperature varying from 60° to 65° of Fahr., between the 11th and 12th of August, the results were strikingly different. The portion fully exposed to the air lost weight rapidly, and soon became dry and hard, without acquiring any putrid taint; whilst the other, on the contrary, softened, and for most part actually liquified, at the same time becoming extremely putrid.* I have mentioned these results in a note, in a paper published in the last volume of the Society's Transactions,† and in the same note have adverted to the fact of the perfect preservation of the meat during the like time and temperature over water in vacuo.

In a second trial made in winter, a portion weighing 141·1 grs., exposed freely to the air, became dry and hard in twenty-three days, viz., from the 27th of October to the 19th of November, the thermometer in the room averaging about 55°. During this time

* The droppings from the putrifying meat have had some resemblance to chyme, being found to consist of a fluid coagulable by heat, in which were suspended, as seen with a high magnifying power, innumerable granules, some fibres, and some minute crystals.

† Transactions, vol. xxiv. p. 137.

it lost by evaporation 95·6 grs., or 67·7 per cent.; and it lost no more from further exposure.

Another portion of the same meat, weighing 74·5 grs., suspended over water lightly covered, retained during the same time much of its humidity, and shortly became covered with a delicate, white filamentous growth of the mucednous kind, not unlike very fine hair.* It emitted the peculiar smell of mould, and the water beneath had a taint of the same. On the 15th of December it was reduced to 26·6 grs., or had lost 65·2 per cent. The delicate white fibres were somewhat shrunken; the upper moiety had become darker; cut into, the mouldiness was found to be superficial; the interior, of a darkened colour, was of increased translucency; its muscular fasiculi were distinct; their structure so little altered, that when moistened with dilute acetic acid their striæ were seen well defined. Underneath, in the water, there was a little white sediment, which was found to consist chiefly of cells (spores) thrown off from the mildewed surface. Evaporated to dryness, the residue weighed only ·4 gr. Replaced over fresh water, this water, in three days, had become slightly turbid from spores suspended in it, and had acquired the peculiar smell of mould.† The portion of meat was now freely exposed to the air; it soon shrunk and became hard; and when it sustained no further loss from evaporation it was reduced to 21 grs., a loss of 71·6 per cent.—a part of which loss, it may be presumed, was owing to the vegetable growth.

In the paper already referred to, I have mentioned that dried meat does not attract the flesh-fly, only the putrid in progress of deliquescence, when it affords a fit nidus for the larvæ of this fly, and for their nutriment. I may further remark that the temperature at which the flesh-fly loses its activity, and is no longer seen

* This may help to account for what is stated of a body long buried, which, after forty-three years, was found as reported almost entirely covered with hair. According to the narrative: " The cover of the coffin having been removed, the whole corpse appeared perfectly resembling the human shape, exhibiting the eyes, nose, mouth, ears, and all the other parts, but from the very crown of the head to the sole of the feet covered over with hair, long and much curled." A specimen of this hair-like substance was considered worthy of a place in the repository of Gresham College. (See *Phil. Trans.* abridged, vol. ii. p. 490.)

† Spores were found also on the inner surface of the glass covers. When thrown off, it may be inferred that they are readily diffused in currents of air.

(one of about 50°), is also that at which the deliquescent process of putrefaction ceases and the mould-growth takes its place.

2. *Of a Moist or Vaporous state of Atmosphere as modifying Change.*

The influence of warmth and moisture of atmosphere in promoting the putrid decomposition of animal matter is an established fact. It is well known that within the tropics, especially in littoral regions where the thermometer ranges between 78° and 83° or 84°, and the atmosphere is commonly damp, the difference between the moistened and dry bulb seldom exceeding 5° or 6°, putrefaction is so rapid that meat cannot be kept more than a few hours without acquiring a putrid taint. When, however, the air is very dry, as in Nubia and the African deserts, then the putrefactive process is very much arrested, though the temperature may be high. At Malta a wind occasionally prevails,—a south-west wind, coming from Africa,—which, in the summer season, I have known as high as 105°, and so dry that the difference between the moistened and dry-bulb thermometer has been as much as 30°. The atmosphere of Nubia is somewhat of the same character; and its quality, as to the checking of the putrefactive change, is well shown by a passage in a very charming book by a lady,—Lady Duff Gordon's "Letters from Egypt," 1863–65; writing from that country, Nubia, she remarks: "Fancy that meat kept ten and fourteen days under a sun which I was forced to cover my head before! In Cairo you must cook your meat in two days; in Alexandria as soon as killed, and the sun is nothing there. But in Nubia I walked till I wore out my shoes and roasted my feet: and I was as dry as a chip in Nubia and as low down as Kiné, below Thebes some way; after, it altered, and, though cold, I perspired again." I may mention another striking example. In the early spring of 1826 I visited the Greek island of Ipsara, a little more than two years after it had been invaded and devastated by a merciless Turkish force.* We found it a desert, the town in ruins, only one of the inhabitants remaining, who served as our guide, all the rest, excepting those who escaped in their ships, or were captured and enslaved, having been massacred. On one side of the island, exposed to the south-east wind, the moist sirocco,

* This was in June 1824, about midsummer.

on a spot where the carnage had been greatest, only bleached bones were to be seen ; whilst on the other and opposite side, exposed to the north, to the dry Etesian wind, at a battery called Fetellio, which had been heroically defended, we found two or three hundred bodies still remaining, lying as they fell, and so little were they changed that our companion was able, though their faces were blackened and shrunk, to recognise each individual by his features. They had become, as it were, natural mummies; their clothes—for they were all clad—had apparently suffered little decay; and their hair, except that it was a little bleached, showed its natural colour.

Whether such a checking of putrefaction is owing to a rapid desiccation of the surface and a retardation of the entrance and penetration of oxygen, or to other less obvious causes, may be a question. I am disposed to consider it owing to the former, inasmuch as putrefaction always begins at the surface,* and from the circumstance that desiccating substances, such as quicklime, prevent putrefaction.†

3. *Of Cooking as modifying Change.*

That the boiling or roasting of meat thoroughly enables it to be kept longer, even at a temperature and moist state of atmosphere

* It is well known to cooks, that whilst the outer surface of meat, such as venison, may be offensively tainted, the inner portion may be comparatively sweet and fit for use, especially if the deer, as soon as shot, has, according to the practice of the skilled forester, been well blooded. It need hardly be remarked, that if the blood is allowed to remain, it is itself a source of putrefaction, owing to the oxygen which it retains. The butcher, guided by experience, is most careful in expelling as much blood as possible without delay from his slaughtered animals.

† I may refer, in proof of the above, to the results of experiments given in vol. ii. of my Researches, published in 1838, confirmed by others in a later vol., that of 1863. In the former I have quoted an instance from the "Philosophical Transactions, Abridged," vol. ix., of the futility of burying the carcasses of diseased cattle with quicklime. Yet quicklime is still ordered to be used in the interment of such carcasses, but with the addition of some disinfectant. Such a procedure, no doubt, will vastly delay the decomposition of the bodies, and prevent the formation of offensive gases. Carbolic acid, one of the disinfectants recommended, has the advantage, I find, of being repulsive to dogs. A portion of meat moistened with this acid was refused by three hungry dogs.

most favourable to putrefaction, is well known to the housewife. From the few trials I have made, the process appears to arrest the putrefactive change, and to favour other changes with the production of mould or mildew.

The following is an instance:—On the 11th of July 1864, a portion of well-boiled mutton was suspended in a receiver, and covered with a plate of glass not air-tight. It weighed 82·2 grs. On the 20th of the same month it was reduced in weight to 74·3 grs., and on the 7th of August to 65·6 grs. It now had a slight smell, not agreeable, not putrid. It seemed drier, and was covered with mould of various colours, mostly white. Cut into, its interior had the smell of decaying cheese. The muscular fasciculi were distinct; and, with the aid of dilute acetic acid, their striated structure was seen. It was near, and only near, the surface, that the vegetable growth was visible. Four months later, it weighed 49·4 grs. It was drier, and had become very much darker; its colour was a very dark brown. Examined in the following December, *i.e.*, after seventeen months, some mildew was found on its surface. It had an ammoniacal and disagreeable smell, like that of rotten cheese, and it cut like such cheese. When broken, not cut, it was found friable. The muscular fasciculi still retained their form, and, with dilute acetic acid, showed the striated marking, with an increase of translucency. From another experiment of the same kind on boiled mutton, begun on the 13th of August 1864, and continued to the 11th December of the present year, like results were obtained

Blood, too, I find, after having been subjected to the boiling temperature, has its tendency to putrefy, arrested, like muscle, and that from keeping it undergoes somewhat similar changes. I may mention one instance:—On the 6th of September 1864, a portion of fowl's blood, just after it had coagulated, was boiled for several hours. The vial holding it, on its cooling, was corked, but not so tightly as to prevent the admission of air. It was placed in a room where there was no fire in winter, and, with the exception of being under cover, the temperature to which it was exposed differed but little from that of the open air. Examined on the 14th of December 1865, it was found moderately dry, for most part of a brick-red colour, partially whitish. It had an ammoniacal odour, no putrid odour. Under the microscope, it was seen to consist chiefly of amorphous matter, of cells like the spores of mucedo, and of blood corpuscles,—these, except in form and size, but little altered;—no crystals were visible. It imparted to water only a very faint, just perceptible, brownish hue, as seen after filtration and separation of suspended particles. The water had a strong alkaline reaction, but was almost tasteless.

A clot of blood—to mention another instance—which had been boiled only ten minutes, kept the same time, offered nearly the same results. It escaped the putrefactive change; mould formed on it, which, after more than a year, was of various colours, bright red, white, and black—changes of colour, it may be conjectured, owing to the different states of the vegetation.

Is the change which meat and blood undergo after exposure to a boiling temperature, as described, in any way analogous to that which vegetables experience when converted into peat?—a conversion which appears to take place only at a comparatively low temperature—below that favouring rapid decomposition; for I am not aware of any peat-formation having ever yet been discovered in progress within the tropics or in any locality the mean annual temperature of which is above 60° of Fahr.

4. *On the Influence of Sulphurous Acid and Acetic Acid in arresting Putrefaction.*

From time to time I have made some other experiments on meats chiefly with a view to their preservation. The first instituted were with sulphurous acid, of which I have given an account in a volume of "Researches," published in 1839. The second were on vinegar, the results of which are there also described.* The sulphurous acid had previously been employed in arresting the fermentation of the more delicate white wines. I found it to arrest the putrefaction equally well of animal and vegetable substances, and so preserving them as to render them not unfit for use as human food. Trials with vinegar and dilute acetic acid gave somewhat similar results, so far as the immediate arrest of putrefaction was concerned; but it did not, like the sulphurous acid, so alter the character of the

* Researches Anatom. and Physiol. vol. i.

animal or vegetable matter as to prevent ulterior change on the removal of the acid by washing with water.*

If the subject under consideration, that of the preservation of meat, is always, from an economical point of view, deserving of attention, is it not especially so at a time such as the present, when, owing to the cattle plague, there is a danger of a stinted supply, at a greatly enhanced price?

5. The Buried Forests and Peat Mosses of Scotland. By James Geikie, Esq. Communicated by Archibald Geikie, Esq.

This communication is an attempt to eliminate the geological history of our Scottish peat mosses, which appear to contain the record of certain changes of climate, that have not hitherto fully engaged attention. The phenomena revealed by our peat mosses are threefold—First, the buried trees, and the condition of this country at the period of their growth; second, the causes which led to the destruction of these trees; and, third, the present aspect of the peat mosses. Under the first head is to be considered the continental period of Great Britain, to which the buried trees in the older peat bogs of the country belong. Under the second head, the causes of the destruction of these trees are chiefly assigned to the upward growth of wet mosses, the chilling effects of which caused the overthrow of the trees. This points to a change of climate;

* Since the experiments above referred to were made, others have been tried, the results, too, of which I may briefly describe.

On the 9th of September, a fresh parr, laid open and eviscerated, was suspended by a thread in a bottle in which was a little vinegar, the parr not in contact with the acid. Another parr, similarly prepared, was moistened with vinegar and wrapped in blotting-paper, also moistened with the acid. Thus enclosed, it was placed in an ale-glass and covered with a tumbler. After eight days the suspended parr was found well preserved; it had not the slightest unpleasant smell; its surface was not distinctly acid to the taste, and its teeth retained their sharpness. The other parr was also free from any unpleasant smell, but was softening in places; the bones were quite soft. After ten days the body of the first parr was found detached from softening, and had fallen into the acid, the head remaining suspended, and it was still free from any unpleasant smell, as was also the softened body. The parr in paper was little changed; it showed no marks of putridity.

the country was no longer characterised by an excessive or continental climate, but by an insular and more moist one. In regard to the third head—the present aspect of the peat mosses—a glance at these will convince any geologist that the peat moss formation has not only ceased to spread, but is in most cases rapidly disappearing. The moisture, which in former times afforded it nourishment and support, has now become its chief enemy. Every shower of rain, every frost, gives fresh impetus to the decay; and leaving altogether out of account the operations of agriculture, there can be no doubt that natural causes alone will in time suffice to strip the last vestige of black peat from hill and valley. The peat mosses of Scotland are only a wreck of what they have once been. The growth of the peat has ceased to be general: here and there mosses continue to increase in sufficient abundance to form that substance, but this increase is far exceeded by the general rate of decay. The peaty covering invariably shows an upper or surface stratum of heath and grasses, and is almost everywhere full of holes and winding channels. These, and other appearances, convince the writer that the climate has now become less humid—agricultural operations alone not being entirely sufficient to account for the change. The change of climate indicated by the wasted aspect of peat moss appears to have shown itself first along the southern limits of that formation in Europe. It then slowly extended its influence in a northward direction, meeting in its course with many modifications, such as must arise from local circumstances. Chief among these was the configuration of the land—the peat of low-lying districts dying out more quickly than the mosses of higher levels, where any diminution of moisture is last to be appreciated. In the same manner, the track of the rainy winds on the west and south-west coasts have also marked out a region where we now meet with less waste among the mosses than in other districts. But as the effect of such a cosmical change must be so blended with the results brought about by the progress of cultivation, the geologist can do little more than suggest the extreme probability of its existence. As it can be shown that the destruction of our ancient forests is not primarily due to man, although in the later stages of the process he certainly played an important part, so we may expect that the change from a humid to a drier climate has also been effected by natural causes; but man, eagerly following nature, has outstripped her in her work, and so identified this with his own, that it now becomes scarcely possible to distinguish the one from the other.

The following Donations to the Library were announced:—

Transactions of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge. Vol. XIII. Part 2. Philadelphia, 1865. 4to.—*From the Society.*

Proceedings of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge. Vol. X. No. 74. 8vo.—*From the Society.*

Transactions of the Highland and Agricultural Society of Scotland. Vol. I. No. 1. 1866. 8vo.—*From the Society.*

Journal of the Royal Dublin Society. No. 34. Dublin, 1865. 8vo. —*From the Society.*

Journal of the Chemical Society. Vol. IV. Nos. 37, 38. London, 1866. 8vo.—*From the Society.*

Proceedings of the British Meteorological Society, London. Vol. III. Nos. 21, 22. 8vo.—*From the Society.*

The American Journal of Science and Arts. Vol. XLI. Nos. 120, 121. New Haven, 1866. 8vo.—*From the Editors.*

Quarterly Return (with Supplement) of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. No. XLIV. 8vo.—*From the Registrar-General.*

Monthly Return of the Births, Deaths, and Marriages registered in the Eight Principal Towns of Scotland. February, 1866. 8vo. —*From the Registrar-General.*

Catalogue of the Specimens of Entozoa in the Museum of the Royal College of Surgeons of England. London, 1866. 8vo. —*From the College.*

Abhandlungen der Mathematisch-Physischen classe der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Band VII. No. 2, 3, 4, Philologisch-historischen classe. B. IV. No. 5, 6. B. V. No. 1. 8vo.—*From the Society.*

Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Philologisch-historische classe, 1864. No. 2, 3. Math.-Phys. cl. 1864. 8vo.—*From the Society.*

Schriften der Königlichen Physikalisch-Okonomischen Gesellschaft zu Königsberg. No. 1, 2. 1864. 4to.—*From the Society.*

Jahresbericht über die Fortschritte der Chemie und verwandter Theile, anderer Wissenschaften fur 1864. Giessen, 1865. 8vo. —*From the Editors.*

Observations Météorologiques faites à Nijne-Tagnilsk (Monts Ourals, Gouvernement de Perm) Année 1864. 8vo.—*From the Russian Government.*

Om Östersjon af S. Lovén. 8vo.—*From the Author.*

Monday, 2d *April* 1866.

Sir DAVID BREWSTER, President, in the Chair.

The President, in delivering the Neill Medal to Professor A. C. Ramsay, LL.D., F.R.S., &c., made the following remarks:—

In adjudicating the Neill Prize for the triennial period from 1862 to 1865, the Council of the Royal Society could not overlook the high claims of our eminent countryman, Mr Andrew Ramsay, Professor of Geology in the Government School of Mines, and local Director of the Geological Survey of Great Britain.

Mr Ramsay's geological studies commenced with a survey of the Island of Arran. After investigating the structure and the relations of the rocks of that interesting island, he embodied the results of his researches in a beautifully executed model, which we had the pleasure of seeing at the meeting of the British Association at Glasgow in 1840. This model, which was afterwards published on the scale of *two* inches to the mile, attracted the particular attention of Sir Henry De La Beche, the Director-General of the Geological Survey; and in the following year Mr Ramsay was appointed one of the surveyors who were then at work in the county of Pembroke.

In 1845, when the Survey was remodelled, the important office of local Director for Great Britain was conferred upon Mr Ramsay, and he has to the present day discharged its duties with credit to himself and advantage to the Survey. He has thus not only mapped large areas with his own hand, but has had the general superintendence of the geological researches carried on under Sir Henry De La Beche, and afterwards under our distinguished countryman, Sir Roderick Murchison.

In 1847 Mr Ramsay was appointed to the Chair of Geology in the University College, London, an office which he held till 1851, when he was chosen Lecturer on Geology in the Royal School of Mines in Jermyn Street.

In the midst of these various official duties, Mr Ramsay found leisure for pursuing several interesting branches of geological research. In 1846 he published, in the *Memoirs of the Geological Survey*, a paper on the "Denudation of South Wales," which led the way to those measured details by which this branch of geology has been so greatly advanced.

In 1855 Mr Ramsay published his remarkable paper on the "Permian Breccias of Shropshire," in which he made it highly probable that there were glaciers in our latitudes during the Permian era; and he at the same time suggested, that some of the thick conglomerates of the Scottish Old Red Sandstone might, in like manner, be the representatives of an ancient glacial drift.

Mr Ramsay has distinguished himself by the energy and ability with which he has elucidated the history of the glacial period in the British islands, and by the ingenious theory in which he refers the frequent occurrence of rock-basin lakes, in the northern hemisphere, to glacier erosion during the glacial period.

No British geologist, in our day, has done more than Mr Ramsay to extend our knowledge of the causes to which the present outlines of the surface of our country is due.

In his annual addresses, as President of the Geological Society, in 1863 and 1864, he has skilfully applied his extensive and minute stratigraphical knowledge to those higher branches of philosophical geology which deal with the succession of life in time, and with the relation between the appearance of living beings on the surface of the earth and the physical changes which that surface has undergone.

For these varied and important labours, the Council of the Royal Society considered Mr Ramsay well entitled to the honour of receiving the Neill Medal. The President, addressing Mr Ramsay, then said,

Mr Ramsay, I have much pleasure in delivering to you the Neill Medal, and in congratulating you on an honour which you have so well deserved.

At the request of the Council, Professor Piazzi Smyth, Astronomer-Royal for Scotland, gave "an account of recent measures at the Great Pyramid, and the deductions flowing therefrom."

This address, which was illustrated by specimens, models, drawings, and stereoscopic photographs, referred chiefly to the four months' labour of the author in the winter and spring of 1864 and 1865 at the Great Pyramid; where he went with the approval of, and also, he thankfully acknowledges, a considerable amount of assistance from, His Highness the Viceroy of Egypt. The observations then made, comprised measures of length, angle, and heat; and are enough to fill several MS. books, which are being prepared for publication. The author, indeed, had hoped to put all these foundational facts into the hands of the public before venturing to announce any of the conclusions, but was overruled by respect for the appeal made to him by the Council of the Society on this occasion. He trusts however, still, that no one will prejudge the pyramid question on hearsay, but wait until they have all the instrumental particulars before them.

The following Gentlemen were duly elected Fellows of the Society:—

Dr John Smith.
James Falshaw, Esq., C.E.

The following Donations to the Library were announced:—

Useful Information for Engineeers. First Series. Fourth Edition. By William Fairbairn, LL.D., F.R.S., F.G.S. London, 1864. 8vo.—*From the Author.*

Useful Information for Engineers. Second Series. By William Fairbairn, LL.D., F.R.S., F.G.S. London, 1860. 8vo.—*From the Author.*

Treatise on Mills and Millwork. By William Fairbairn, C.E., LL.D. In two vols. Second Edition. London, 1864. 8vo.—*From the Author.*

Iron, its History, Properties, and Processes of Manufacture. By William Fairbairn, C.E., LL.D. Edinburgh, 1865. 8vo.—*From the Author.*

Treatise on Iron Ship-Building, its History and Progress. By William Fairbairn, C.E., LL.D. London, 1865. 8vo.—*From the Author.*

On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn, C.E., F.R.S. Third Edition. London, 1864. 8vo.—*From the Author.*

Remarks on Canal Navigation, illustrative of the Advantage of the Use of Steam as a Moving Power on Canals; with an Appendix. By William Fairbairn, Engineer. London, 1831. 8vo.—*From the Author.*

Experiments to determine the Effect of Impact Vibratory Action and long-continued Changes of Load on Wrought-Iron Girders. By William Fairbairn, LL.D., F.R.S. 4to.—*From the Author.*

On the Law of Expansion of Superheated Steam. By William Fairbairn, LL.D., F.R.S., and Thomas Tate, Esq. 4to.—*From the Authors.*

Experimental Researches to determine the Density of Steam of different Temperatures, and to determine the Law of Expansion of Superheated Steam. By William Fairbairn, F.R.S., and Thomas Tate, Esq. 4to.—*From the Authors.*

Journal of the Royal Horticultural Society of London. Vol. I. Part 2. 8vo.—*From the Society.*

Proceedings of the Royal Horticultural Society of London. Vol. I. No. 3. (New Series.) 8vo.—*From the Society.*

Journal of the Chemical Society of London. Vol. IV. No. 39. 8vo. —*From the Society.*

Quarterly Journal of the Geological Society of London. Vol. XXII. Part 1. 8vo.—*From the Society.*

List of the Geological Society of London. December 31, 1865. 8vo. —*From the Society.*

Observations on the arrested Twin Development of Jean Battista

Dos Santos. By P. D. Handyside, M.D. Edinburgh, 1866. 8vo.—*From the Author.*

Dublin International Exhibition, 1865—Kingdom of Italy—Official Catalogue, illustrated with Engravings. Published by order of the Royal Italian Commission. Second Edition. Turin, 1865. 8vo.—*From the Commission.*

Bulletin de la Société de Géographie. Tome X. Paris, 1865. 8vo. —*From the Society.*

Bulletin de la Société de Géographie. Jan. Fev. Mars 1866. 8vo.—*From the Society.*

Nova Acta Regiæ Societatis Scientatis Scientiarum Upsaliensis. Vol. V. Fasc. 2. Upsala, 1865. 4to.—*From the Society.*

Memoir of the Geographical Survey of Great Britain, and of the Museum of Practical Geology. The Geology of North Wales by A. C. Ramsay, F.R.S., Local Director of the Geological Survey of Great Britain. With an Appendix on the Fossils, with Plates, by J. W. Salter, A.L.S., F.G.S. 8vo. London, 1866.—*From Professor Ramsay, LL.D.*

Relationen einestheils zwischen Summen und Differenzen und Andherntheils zwischen integralen und differentralen. Von P. A. Hansen. 8vo. 1864.—*From the Author.*

Monday, 16th April 1866.

Dr CHRISTISON in the Chair.

The following Communications were read :—

1. Some Observations on Incubation. By John Davy, M.D., F.R.S., Lond. and Edin.

In this paper its author describes the results of experiments made with two intents—one, to endeavour to ascertain whether there can be a complete arrest of vital action without the death of the egg; the other to ascertain the changes which take place in those instances in which, during incubation, the egg proves unproductive.

The eggs used were chiefly those of the common fowl. The trials to which they were subjected were of three kinds—the air-pump, the ice-house, and immersion in lime-water.

Though the results obtained were not entirely negative, yet, when reasoned on, and all the circumstances of the experiments taken into account, they have not appeared so decisive as to allow of the inference, in regard to arrested action, that that was absolute; or as regards the changes, that these, so many and different, which take place in unproductive eggs, admit of any satisfactory explanation.

2. On the Absorption of Substances from Solutions by Carbonaceous Matters, and the Growth thereby of Coal-Seams. By William Skey, Analyst to the Geological Survey of New Zealand. Communicated by James Hector, M.D., F.R.S.E., Director of the Geological Survey of New Zealand.

Some time since, during the performance of a series of analyses of the Brown Coals of Otago, my attention was directed to the very large quantity of sulphur which several of them contained, even where the most careful examination failed to detect more than traces of sulphates or sulphides in the composition of the coal, a singular fact which has been before commented upon by Dr Percy in his work on Metallurgy.

After several unsuccessful efforts to discover the form in which the excess of sulphur was present, it occurred to me, that possibly the sulphur might be retained to the coal in combination with hydrogen, by a similar absorptive power to that which charcoal exercises over that gas. I therefore tried whether brown coals had the property of absorbing sulphuretted hydrogen. Finding that brown coals did possess this power, the experiments were extended over a variety of other substances in solution, and the fact was established that, with certain modifications hereafter to be described, all mineralized carbons, such as lignites, coal, and graphite, possess the power of absorbing the same substances as charcoal, especially those soluble organic matters that occur in natural waters.

The circumstance that these minerals are thus able to arrest and retain organic substances, was so suggestive in relation to the origin and physical characters of coal, that I was led to make this property of coal a special object of study, and as the course the investigation took rendered it very desirable to test the solubility of coal, this subject was also carefully examined by me, and as the results of these investigations appeared to have some degree of interest, I submitted them to the attention of Dr Hector, and with his advice and assistance, I now endeavour to state them in a concise form.

In communicating a detailed account of the various experiments employed in these investigations, the results arrived at, and the inferences they appear to justify, I have divided the whole subject into three parts, the first of which is—

I. *On Absorption as a Property of Lignite, Coal, and Graphite, in common with Charcoal.*

a. Absorption of Acids.
b. Absorption of Basic Substances.
c. Absorption of certain neutral Organic Substances.
d. Absorption of certain decomposed Organic Substances.
e. Combining quantities of bodies probably observed in their absorption.
f. Substitution effected in certain cases.

Summary.

Sufficient has been adduced by the experiments conducted by me to prove the existence of an absorptive power in lignite, coal, or graphite for many organic and inorganic substances. There is no doubt the list of such might have been almost indefinitely extended if it had been necessary; but I desired rather to establish the general fact of absorption, and to ascertain the principles which regulate it.

So far as these results enable us to judge, it would appear that generally when any substance has but a feeble solubility in water, or when it has its affinities for this liquid lowered or overpowered by other agents, such substance will be withdrawn from solution by contact with any of the foregoing bodies, lignite, coal, graphite, or charcoal. Those substances which possess basic or acid properties especially, are subject to absorption, providing such properties are not too well defined. The substances of this class can generally be abstracted from the absorbing body by the application of a suitable acid or base, as the case may be.

The fact of the absorption of acids being often facilitated by the presence of stronger acids, and that of bases by the presence of stronger bases, the application of these being indeed often absolutely necessary to produce absorption, may perhaps be accounted for by the greater affinity these stronger chemicals have for water.

Thus the solvent powers of this liquid for the body we wish to determine to the coal, &c., is reduced, or altogether removed, and that state most favourable for absorption obtains. If this is so, we can perceive why sulphuric acid and the caustic alkalies are not capable of being retained by coal or charcoal; their affinity for water being so intense that it cannot be overcome by absorptive power alone, and we are not in the possession of means to remove or lower the affinity of these substances, as we have in the case of others.

But it is particularly at this stage, in the investigation of *assisted* absorption, that, as I have before observed, we are enabled to trace differences in the intensity of the absorptive power of charcoal and coal; the former body being able to absorb many acids from solution without that assistance from stronger acids required so frequently by coals, the absorbing power of the charcoal being superior to the affinity subsisting between the acid and the water, while that of coal is generally inferior. However, there is this to consider, that when we have determined the absorption of any acid to coal by the assistance of a stronger, we can remove the latter without effecting the solution of the former to any considerable extent.

General Remarks.

It is worthy of remark, as indicating a practical application of these observations, that the absorption of arsenious acid by carbonaceous substances would allow of its separation from solution for analytical purposes if desirable; arsenic acid, too, would no doubt be also absorbed, being isomorphous with one which is so, that is, phosphoric acid.

In reference to the property of phosphoric acid, of being absorbed by charcoal, &c., it is not improbable that the low decolorising power of animal charcoal, when separated from the phosphate of lime by means of hydrochloric acid, to what it should be theoretically, may be partly due to the presence of this acid; for if animal charcoal, which has been submitted to three days' digesting in ordinary hydrochloric acid, be washed in water till nothing further is removed, and be then placed in contact with ammonia for a short time, a slight but decided crystalline precipitate, soluble in acetic acid, is obtained by adding chloride of ammonium, and sulphate of magnesia in excess of ammonia; while, if water or weak hydrochloric acid was substituted for the ammonia, and suffered to remain in contact with the charcoal for many hours, not the least indication of phosphoric acid was obtained by the application of the above test. It may be mentioned, the water employed contained a minute quantity of carbonic acid, which would probably substitute itself for a portion of the phosphoric acid absorbed to the charcoal, and thus render its detection more difficult.

The absortion of hydriodic acid by coal from acidulated solutions renders it very probable that, wherever any coal-bed is acid from the presence of the stronger acid, and has a flow of water through it, such bed will be charged with hydriodic acid in those parts which first receive the underground flow; and there, also, we may reasonably expect to find an unusual proportion of other acids, such as phosphoric, arsenic, hydrosulphuric, and hydroarsenic acids.

The property of brown coals, &c., to absorb sulphuretted hydrogen, affords a probable solution, as before shown, of the difficult problem, In what form does the sulphur exist in those highly sulphurized coals, which are comparatively free from either iron pyrites, sulphuric acid, or sulphates? That it does exist, in combination with hydrogen, to form sulphuretted hydrogen, received confirmation from further experiments, which went to prove that such coals evolved considerable quantities of this gas when subjected to temperatures ranging from 212° to 300° Fahr.

In regard to the action of decomposing organic matters upon sulphates furnishing the gas, we have only to take into consideration the general absorptive power of coal to explain the frequent association of sulphuretted hydrogen with it.

It may be stated that many of the older coals, as also samples of graphite from England, and from the province of Nelson, New Zealand, gave indications of the presence of sulphuretted hydrogen in the vapour evolved from them by the application of a heat not exceeding 300° Fahr.

In reference to the absorption of gas, it would appear that at least carbonic acid does not owe its absorption to the porous nature of the coal alone; for substances quite as porous, such as clay, brick, blotting-paper, and wood, when dried at 212° Fahr., and placed in carbonic acid gas, did not exhibit any power of absorption. A piece of well-washed hydrate of alumina, however, was found to be capable of absorbing ten volumes of this gas when dried at 212° Fahr., and nearly as much when exposed to a red heat; but as this substance in solution has decided basic properties, it is probable the absorption in this instance is due to the exercise of these.

II. *Partial Solubility a Property possessed by Coal.*

a. Partial Solubility of Brown Coal.

b. Partial Solubility of Bituminous Coal.

Summary of Results.

From the experiments conducted under this department, it was found that a lignite of good average quality, compact and lustrous, is soluble in *pure* water to a considerable extent,—about 1-20th per cent. being thus soluble,—and that even in the case of a hard, compact bituminous coal of excellent quality, belonging to the carboniferous formation, this also has a small but very appreciable solubility in the same liquid. Allowing this last to be an exceptional case however, it might be argued (if, indeed, lignites are in a transitional state between dead vegetable matter and mineral coal) that the solubility of the lignite will be continued far into the coal proper; but the degree of it will gradually diminish until scarcely any method of testing would discover it, or until it be finally and completely lost in those members of the coal series farthest removed from the commencement.

III. *On the Influence which the Absorptive Power and Solubility of Carbonaceous Deposits exercises upon the Growth of Coal Seams.*

(1). Recapitulation of those facts already stated affecting the question at issue.

(2). Application of these phenomena.

In applying these various phenomena to explain how certain of the properties of the coal have been attained, the subject will be treated in the following manner. The first of the division is—

a. Absorption applied to increase the Compactness of Coal-Seams.

b. Absorption applied to increase their thickness. Two objections answered.

c. Absorption applied to convert Carbonaceous Clays into Bituminous Shale or impure Coal.

d. The lustre, hardness, and coherence of Coal possibly due to the exercise of its absorptive power and its partial solubility in water.

e. The absorptive power and solubility of Coal applied to increase the structural and chemical differences of adjoining parts.

Summary of Facts.

In summing up the several parts we find the absorptive power of the coal enables it to arrest those organic matters contained in common water, and a continual supply of such being kept up by the flow of the water down to the level of the sea, carrying the necessary material, we may have the compactness of the same largely augmented; all losses entailed by decomposition made good by interior absorption, or by a surface absorption, and thus these matters may be applied to build up the seam to a greater thickness. In the one case we require no miraculous interposition of pressure to remove the vesicularity which decomposition entails in the indurated mass; and in the other, in surface absorption, we reduce the difficulty we have in accounting for the remarkable thickness which has been attained by certain coal-seams.

These additions would be singularly free from earthy impurities of any kind, and therefore, no matter how great a thickness the seam ultimately attained by this means may be, we should find it comparatively pure and uniform in composition. The whole roof of superincumbent material, however great its thickness might be, would be lifted up in detail, scarcely a particle would be left behind to attest the act.

In part (*c*) we find how this absorptive power may be applied with some degree of probability to account for the production of certain bituminous shales and impure coals, characterised by their homogeneity, and their poverty in vegetable structures. The whole process is nearly a repetition of what is supposed to occur in the case of coal itself, the only difference being, that in one case the absorbing substance is thinly dispersed through a quantity of earthy matters, while in the other it is in a concrete form.

In part (*d*) I have attempted to show in what manner the partial solubility of coal, together with its absorptive power, may have affected its physical character.

It has been supposed that the whole seam has been repeatedly turned over by these means, and each time reduced by the separation of portions of it, principally in the form of oxygenated compounds: the losses so incurred, however, being abundantly made up by introduced substances. It is, in fact, a continual re-solution and re-deposit.

Now, all these processes going on at an exceedingly slow rate, we are quite certain, judging from analogous cases, that ultimately the product so attained will cohere in all its parts, and be possessed of the utmost hardness and the highest degree of lustre of which its constitution admits.

In the last part (*e*), I have used these properties of coal to increase the differences in adjoining parts of the seam. To assist in this, and to give a greater completeness to the work, I have gone further back in the history of coal, and traced a supposititious origin for the *commencement* of these differences, using the suggestion of Bischoff, relating to the precipitation of the organic substances from water in the first instance. Thus I had horizontal cleavage and planes of greatest change readily afforded me; and to increase the differences so started and so directed, I had only to suppose that the rates of absorption for that part most decomposed, and that part least so, are unequal.

Thus every characteristic quality which distinguishes mineral coal from ordinary decomposed vegetable substances has now been considered, and, I think, provided for in the exercise of these its newly discovered properties of absorption and solubility.

Whether a slight elevation of temperature is necessary or no to assist in educing those members of the coal series, very far removed from the primary material, it is certain it would greatly facilitate the mineralisation of these deposits, but in either case it is the presence of water which, besides initiating the commencement of the required changes, allows of them being carried to the farthest point, by bringing the particles of the solid substances within reach of each other's affinities, thus determining the production of new combinations more insoluble, more carbonaceous, and more easily absorbed; and these being deposited as they were formed *slowly*, the hardness, coherence, and compactness of the deposit are ensured.

IV. *Popular theory, explaining the Physical Properties of Coal considered.*

As I have purposely avoided all along any reference to other theories respecting the formation of coal, in order that no external influence should be brought to secure favour for the views here propounded from prematurely showing up their deficiencies, preferring rather that they should stand thus long on their own merits uncontrasted with those of others. I hope now to be allowed to state a few objections—objections so obvious and so serious that they will have frequently occurred to the mind of the inquirer.

The principal agencies hitherto supposed to be involved in the formation of coal are decomposition, pressure, and heat. In regard to decomposition, important and indeed essential as it is to the formation of coal, it is still possible to overstate its influence. Taken by itself, it is obvious it cannot increase the hardness of coal. It is the property of decay rather to reduce than to increase the hardness of minerals, the most compact of which are thus modified, and especially should this be apparent in coal where it involves a positive loss of substance. This is well exemplified in the case of wood which has suffered the "dry rot, here, from the absence of water in sufficient quantity, there has been no recomposition" of the decomposed matters; hence even the colour is unchanged, though the wood is exceedingly reduced in compactness. Nor even with the aid of pressure can we do more than increase the density; we bring their particles nearer together, but we do not affect the character of the particles themselves; if pressure could perform this, why should it not have been equally effective for the induration of clays or other soft hydrous minerals, which in certain states bear considerable resemblance to lignite, many of these having been subjected to pressure as great, or even far greater?

It is to a reconstruction of the residue from decomposition into new, more insoluble, and more permanent combination, that any great physical differences should be due, and to this only; this cannot, however, be effected while the particles of the solid vegetable matters are unable to move to each other's affinities while their position is fixed by cohesion; they must be brought into renewed chemical contact before they can enter into those combinations which give to coal qualities we have to account for.

If now we seek the assistance of an elevation of temperature sufficient to fuse or volatilize portions of the coal, so as to gain in this renewed chemical contact, so necessary for recomposition, we shall find that, although we may effect this, the results are not altogether of the kind we want.

Suppose we attempt to go no further than partial fusion, although we should certainly indurate its particles considerably, and give them some degree of lustre, and also effect favourable recomposition in the substance in regard to its chemical composition, we should certainly obliterate that laminated appearance coal often presents, and render the whole perfectly homogeneous, both in its physical character and chemical composition; and we should further most likely destroy the distinctions of those boundaries which separate the coal-seam from above or below, and also change their uniformity of direction. But, in all probability, in attempting the fusion only, we could not avoid decomposing a portion of the coal into gas, and this being mechanically retained by the semifluid mass, would render it porous throughout; and thus, although we might gain considerably in some of the properties of coal, such as those of hardness, lustre, coherence, we should lose in compactness—the vesicular appearance such a product would present would neutralise all we have gained, and give it an appearance quite foreign to that of coal. But to what extent this porosity would be modified by the application of an immense pressure during the heating process we do not know; this, however, is almost certain, that if it did succeed in preserving or giving to the coal a more mineral appearance, it could but partially reduce its vesicularity, and never so much but that it would readily be discerned—the increase of hardness supposed to follow by this process would only help to impede the effect of pressure, and preserve to the vesicules their exact shape and size.

But in order to escape this, it may be argued that the gas in these pores has since been substituted by other matters in a state of fusion, or by condensed oils, &c. If, however, such had been really the case, we should surely have been able to observe indications of it in the amygdaloidal state of the coal so found, since we could scarcely have given us the same characters to substances whose chemical composition and manner of formation are so different; this appearance would be especially manifested at the junction of those bands in the coal before alluded to; in the place of the divisional places being as now perfect, there would be innumerable interruptions from some of the geodes occupying a position in both seams. That bands of a more recent date have obliterated the amygdaloidal appearance of the coal is too improbable to need any comment.

It would therefore appear, that though the hardness of coal may be increased, even into that of coke, by heat, the coal thus obtained would be rendered proportionately lighter and more porous; and that heat could induce the laminated appearance of coal, or favour its development, when begun, is very improbable, its effect would rather be to obliterate any previous lamination, and give to the coal a homogeneous appearance.

But besides these objections against the supposition that high temperature has been concerned in the production of coal from organic matters, there are others—the non-necessity of such for the production of these chemical differences we observe between them; for that there is no absolute necessity for this may be gathered from the heterogeneous nature of most samples of coals. In the case of the Newcastle coal, the difference in the parts, great as it is, is not owing to any superior heat applied for the production of the more carbonaceous substance; for how, indeed, could superior heat be applied to these parts alone? Why, therefore, should not the bituminous coal be itself produced from brown coal without the aid of any increase of temperature over that which has obtained in its formation? there being no greater chemical difference between these than there is found to be between the bituminous coal and the fibrous anthracite.

But, besides the internal evidence afforded by coal itself that substances very rich in carbon can be eliminated at low temperatures, we have the authority of Bischoff for asserting, that for the elimination of a substance still further removed from organic matter (graphite) high temperatures are not necessary.

On the whole, it would therefore appear there is indeed no absolute necessity to provide any considerable elevation of temperature to bring about the chemical change required to convert decomposed organic matter into substances resembling anthracite; and further, it would also appear that hardness gained in such a manner would render the product porous, or, if these pores were subsequently filled, the anthracite would appear amygdaloidal.

Thus we have to rely upon the solvent powers of water as the only means by which recomposition can be effected,—as the only agency which can modify these vegetable substances in the manner we would wish, and which not only favours their decomposition, but allows of their recomposition and deposit as a hard, compact, coherent, and lustrous mineral.

In conclusion, I have to apologise for the incompleteness of these investigations; nothing but my inability to prosecute further researches for some time, owing to the removal of the laboratory to a distant part of the colony, and the consequent suspense of analytical operations, induces me to forward them in this state.

There was one part of the subject, especially, I was very anxious to examine further—that treating upon substitution—for it was apparent, if it could be ascertained whether or no gases are able to substitute each other, some further light would be shown upon the manner in which these absorptions are effected, since, in the absence of solvents, there would be fewer chemical affinities to interfere.

But it was more particularly in reference to the manner of the formation of coal as connected with its property of absorption that I was the most desirous to add to these investigations, and especially as to the precise action carbonic acid exercises during the absorption of decomposing organic matters. As to whether, in any case, these matters are able to substitute this acid when it has been previously absorbed to the coal.

If not anticipated, however, with permission, I intend communicating further upon these subjects, when the results of certain projected experiments relative to this are ascertained.

3. (1.) Description of *Erpetoichthys*, a new Genus of Ganoid Fish, from Old Calabar, Western Africa; forming an addition to the Family *Polypterini*. By John Alexander Smith, M.D., F.R.C.P.E. (Specimens of the fish were exhibited.)

In the beginning of January 1865, the author received from the Rev. Alexander Robb, Old Calabar, a package of specimens of natural history preserved in spirits. Among these were two small ganoid fish. They were, however, imperfect, having been torn across near the anal region, and their caudal extremities were wanting. The characters of the fish could not, therefore, be completely determined. The author, however, exhibited them at a meeting of the Royal Physical Society, on the 22d March 1865, and stated that they were allied to the genus *Polypterus;* but from various differences in character, to be afterwards detailed, and especially the great relative length of their bodies, and the apparently total absence of ventral fins, he would place them provisionally in a new genus, which, from their general aspect and form, he designated *Erpetoichthys*, the reptile or serpent fish; and the species, from the locality where it was found, he named *E. Calabaricus.*

Since that time the author had received perfect specimens from Old Calabar, and found that the accuracy of his previous conclusions were confirmed.

The fish is got in the fresh-water streamlets which run into the main rivers or creeks of the great Calabar river, and in the pools of the marshy lands. It is occasionally sold in the markets, and eaten by some of the natives. Its native name is *U-nyãng*, which the Rev. Mr Robb explains, by suggesting that it may be derived from a verb signifying to struggle or scuffle for the possession of a thing, and he therefore supposes it to mean the struggler, or, using a Scottish word as more appropriate, the "wambler,"—the name being probably given to it, on account of the apparent struggling, wriggling, or undulating movements of its elongated body, as it swims in the water or mud of the river.

Summary of characters of the genus *Calamoichthys*,* and its relation to the genus *Polypterus* :—

Genus Calamoichthys.—*Head*, small, depressed above, somewhat oval in shape (rounded and narrow in front, expands laterally behind orbits, and contracts again at the back part, towards neck). Suboperculum wanting. (No small plates below preoperculum.) *Body*, much elongated; anguiform (cylindrical for about half its length, then becoming gradually more compressed laterally, and tapering slightly towards its caudal extremity). *Caudal extremity*, short, tapering rapidly. *Caudal Fin*, rounded; homocercal; fin-rays, hard. (*Scales*, osseous, rhombic, sculptured.) *Fins*, small—Pectorals, obtusely lobate, fin-rays soft; Dorsal finlets, numerous, separate; Anal (with fulcrum at base anteriorly), in male large, in female small; fin-rays hard; Ventrals, wanting.

The last character is rather an important one, as this fish thus appears to be the only living ganoid yet known which has no ventral fins. Van der Hoeven, in his "Handbook of Zoology," gives the presence of ventral fins as one of the characters of his great Section III. of the Class Pisces, the *Ganolepidoti;* and older naturalists, as Cuvier, place the ganoids, for a similar reason, among the *Malacopterygii Abdominales*. The discovery of this fish will therefore necessitate a change in this character of the whole section.

In the Genus Polypterus (on the other hand), the *Head* is rela-

* Since this paper was sent to press, the author has learned that a closely corresponding name to *Erpetoichthys* had been already used in Ichthyology; and, accordingly, he now changes the designation to *Calamoichthys* (Calamos and ichthys), which still bears a relation to the cylindrical shape of the fish.

tively larger (with apparently little or no lateral expansion and subsequent contraction towards neck); its gently swelling outlines gradually expand, and run backwards into those of the body. Suboperculum present; several small plates below preoperculum. *Body*, relatively much shorter, generally tapering gradually from behind region of pectoral fins, and becoming more compressed laterally, towards its caudal extremity. *Caudal extremity*, longer. *Scales*, generally smooth(?). *Fins*, larger—Pectorals, fin-rays, osseous; Anal, apparently alike in size in male and female; Ventrals, present.

The genus *Calamoichthys* agrees, however, with *Polypterus*, in the general character of its numerous dorsal finlets; lobate pectorals; two nasal cirri; a spiracle on each side of the head above; and a large flat branchiostegous ray or jugular plate, on each side of the mesian line below; and also in the hard, osseous, rhomboidal-shaped ganoid scales, arranged in rows, running obliquely backwards; and in the tapering caudal extremity of the body.

The new genus belongs, therefore, to the same family as *Polypterus*, and would accordingly fall to be placed next to it in the Family of the *Polypterini* :—

FAMILY POLYPTERINI.

I. Genus. POLYPTERUS.

II. Genus. CALAMOICHTHYS.

1. Species. *C. Calabaricus.*

(The specimens described measured from 8 to nearly 13 inches in length.)

Habitat, Old Calabar River, and the Camaroons, West Africa.

(A female sent by Mr G. W. Mylne from the latter locality, and recently received by Dr Smith, was also exhibited.)

For the purpose of getting an anatomical description of this new fish, Dr Smith placed several specimens of the males and females in the hands of Dr Ramsay H. Traquair, who was especially qualified for the task, from having made a careful dissection and study of a species of the genus *Polypterus*. Dr Traquair has accordingly prepared a detailed account of its anatomy.

(2.) Internal Structure of *Calamoichthys Calabaricus* (J. A. Smith.) By R. H. Traquair, M.D., Demonstrator of Anatomy in the University of Edinburgh.

On dissecting those specimens of *Calamoichthys*, entrusted to the author by Dr Smith, the greatest similarity was found to exist between their internal organisation and that of *Polypterus;* the chief differences being dependent on the great elongation of the body of the former fish, while the abdominal cavity extends proportionately still further back towards the caudal extremity than is the case even in the genus last mentioned.

The vertebræ resemble in construction exactly those of *Polypterus*, but are very much increased in number, amounting, in the specimen which was used for the preparation of the skeleton, to 110, the first of which has no body, consisting merely of neurapophyses, spinous process, and a pair of ribs. These latter form the first of the series of well-developed upper ribs, which extend in the horizontal intermuscular septum, as far back as the ninety-eighth vertebra. But the lower series of ribs are very deficient in development in comparison with those in *Polypterus*, where the whole series of abdominal vertebræ, except the first, is furnished with those appendages, which posteriorly attain a considerable length. In *Calamoichthys*, on the other hand, those lower ribs are very minute, and no trace of them was found in advance of the sixtieth vertebra. The number of abdominal vertebræ is, in the specimen alluded to, 100, of caudal, 10; showing the very great proportional elongation of the abdominal and shortening of the caudal region. The vertebral column projects beyond the last caudal vertebra, as a notochordal continuation or "Urostyle," concealed among the rays of the caudal fin. The bones supporting the fins agree in their general conformation with those in *Polypterus*, —there being, however, a less ossified state of the radius, ulna, and carpus, while the pelvic bones, along with the ventral fins, are completely absent. The first dorsal finlet is placed opposite the forty-ninth vertebra.

As regards the form and arrangement of the bones of the cranium and face, the most complete correspondence is found with those of *Polypterus*, a space being found, however, below the preoperculum, which, in various species of *Polypterus*, is defended by a variable number of bony plates. The suboperculum is also completely absent. The arrangement of the mucus canals on the head is similar to that in *Polypterus.*

The arrangement of the muscular system corresponds in the two genera. In *Calamoichthys*, owing to the great increase of the number of vertebræ, the number of transverse segments of the great body muscle is also much larger. The muscular layer along the belly is very thin.

Viscera.—The œsophagus dilates into a flask-shaped stomach, which terminates behind in a *cul de sac.* From the interior part of the stomach, and close behind the entrance of the œsophagus, issues the intestine, which, passing first slightly forwards, makes almost immediately a turn on itself, and then proceeds straight back to the anus. A small cœcal appendage, with the apex directed forwards, is seen in connection with the intestine shortly after its backward flexure; and a little farther down, between this and the anus, a spiral valve of about five turns is developed in the interior. The liver was in none of the specimens examined very voluminous, but much elongated, being continued as a narrow stripe the whole length of the abdominal cavity. The gall-bladder is distinct, and opens into the intestine immediately after its flexure, and in front of the cœcum.

The heart is conformed, as in *Polypterus*, with muscular bulbus arteriosus, which is furnished internally with numerous valves of unequal size. The branchial artery gives off first a large lateral branch on each side, which divides into three for the three posterior gills; the trunk then bifurcates, giving off a branch for the anterior gill of each side. As in *Polypterus*, the posterior gill has only one row of leaflets, and the cleft behind it is wanting. No trace of a "Pseudobranchia" was found, an organ likewise absent in *Polypterus.* The spleen is very long and slender, lying closely along the great air-bladder. The air-bladders are two in number, opening by a common orifice into the lower aspect of the throat, behind the gill-clefts. That of the left side is small, being only $2\frac{5}{8}$ths inches in length on a fish of 10 inches; it is closely adherent to the side of the œsophagus and commencement of the stomach. That of the other side measures $8\frac{3}{4}$ inches on the same fish, and extends along the whole length of the abdominal cavity, lying closely along the under surface of the vertebral column.

Like the rest of the abdominal organs in general, the kidneys are very slender and elongated; each consists of a number of little lobules, which lie in the concavities on the under surfaces of the vertebral bodies. The excretory duct or ureter lies along the outer border of the organ, and passes straight backwards to unite with the genital duct, and, with its fellow of the opposite side, at the urogenital pore. The ovaries and oviducts correspond exactly with Müller's description of these organs in *Polypterus* (*Trans. Berlin Acad.* 1844). Each ovary is in the form of a flattened plate, suspended in front of the posterior part of the kidney by a mesentery, is solid, and consists of a stroma imbedding ova of all sizes, up to $\frac{1}{14}$th of an inch in diameter. The oviduct, proceeding forwards from the urogenital pore as a pretty wide tube, crosses beneath the ovarian mesentery, and opens into the peritoneal cavity, on the outer side of the gland, and closely above its lower extremity. The ovaries are not symmetrical in position, one being in advance of the other, so that also one oviduct is longer. In a female measuring $8\frac{5}{8}$ths inches, the right ovary was $1\frac{1}{2}$ inch in length, its anterior extremity being placed $4\frac{3}{8}$ths inches from the top of the snout, and the length of the oviduct $1\frac{7}{8}$ths inch, while the left measured $1\frac{5}{8}$ths inch, was situated at its anterior extremity $5\frac{3}{8}$ths inches from the tip of the snout, and having a duct of $1\frac{3}{16}$ths inch. The testes are very minute, and situated very far forwards, each being a small oval body $\frac{3}{16}$ths inch in length, in a male of 10 inches; and in the same specimen the right one was situated $2\frac{1}{2}$, and the left $2\frac{11}{16}$ths inches back from the tip of the snout. A very minute duct runs backwards parallel with and close to the ureter, which it joins near the urogenital pore.

On opening a number of specimens, it was found that all those with a large anal fin were males, while those in which that organ was small were females. The females are, however, to be distinguished from the males by another character, namely, the much larger size of the urogenital pore, which is situated immediately behind the anus.

4. Professor Archer exhibited Jones Levick's Coal-Cutting Machine, and Mr David Price's Experiments on the Restoration of Oil Paintings.

A Model of the Great Pyramid, with specimens of the stones used in the external casing of it, was presented by Professor Piazzi Smyth, and thanks were voted.

The following Gentlemen were duly elected Fellows of the Society :—

John K. Watson, Esq.
W. D. Clark, Esq.
David Chalmers, Esq.

The following Donations to the Library were announced :—

Journal of the Statistical Society of London. Vol. XXIX. Part 1, 1866. 8vo.—*From the Society.*

Proceedings of the Royal Society of London. Vol. XV. No. 82. 8vo.—*From the Society.*

American Journal of Science and Arts. Vol. XLI. No. 122. New Haven, 1866. 8vo.—*From the Editors.*

Canadian Journal of Industry, Science, and Art. New Series. No. LXI. Toronto, 1866. 8vo.—*From the Canadian Institute.*

Journal of the Chemical Society of London. Vol. IV. No. 40. 8vo.—*From the Society.*

Monthly Notices of the Royal Astronomical Society, London, for 1865–66. 8vo.—*From the Society.*

Transactions and Journal of the Proceedings of the Dumfriesshire and Galloway Natural History and Antiquarian Society, Session 1863–64. Dumfries, 1866. 8vo.—*From Sir William Jardine, Bart.*

The Geological and Natural History Repertory and Journal of Pre-Historic Archæology and Ethnology. Nos. 10–12. London, 1866. 8vo.—*From the Society.*

Bulletin de L'Académie Royale des Sciences des Lettres et des Beaux-Arts de Belgique. Nos. 2, 3. Bruxelles, 1866. 8vo. —*From the Academy.*

Sur l'État de l'Atmosphére, a Bruxelles pendant l'Année 1865. Par M. Ernest Quetelet. 8vo.—*From the Author.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, 1865–66. Paris. 4to.—*From the Academy.*

Journal of the Society of Arts and of the Institutions in Union, for 1865–66. London. 8vo.—*From the Society.*

INDEX.

PRINTED BY NEILL AND COMPANY, EDINBURGH.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1862–63.

8032

CONTENTS.

[*Turn over.*

[*For continuation of Contents, see pp.* iii *and* iv *of Cover.*

Monday, 20th April 1863.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1863–64.

CONTENTS.

Monday, 7th December 1863.

Monday, 4th January 1864.

Monday, 18th January 1864.

[*For continuation of Contents, see pp.* 3 *and* 4 *of Cover.*

PAGE

Monday, 2d May 1864.

J Henry

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1864–65.

CONTENTS.

Monday, 28th November 1864.

Monday, 19th December 1864.

Tuesday, 3d January 1865.

[*Turn over.*

Monday, 16th January 1865.

Monday, 6th February 1865.

Monday, 20th February 1865.

[*For continuation of Contents, see pp. 3 and 4 of Cover.*

Monday, 6th March 1865.

Monday, 20th March 1865.

Monday, 3d April 1865.

J Henry

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1865–66.

CONTENTS.

[*Turn over.*

[*For continuation of Contents, see pp.* 3 *and* 4 *of Cover.*