THURSDAY, NOVEMBER 29, 1883

SCIENTIFIC WORTHIES

XXIII.—SIR CHARLES WILLIAM SIEMENS,[1] BORN APRIL 4, 1823; DIED NOVEMBER 19, 1883

THE death of Sir William Siemens, coming as it did so suddenly and unexpectedly, has been felt as a severe blow and grief through a far wider circle than that of his personal friends. His work for the last five or six years has interested the general public to a degree that has perhaps never before been the lot of any man devoted to science as he has been. Not only the people of his adopted country, England, but the larger public of the whole civilised world, have been deeply interested in the electric lighting, the electric transmission of power, the electric railways, the regenerative gas furnaces, and the conversion of fuel into gas to feed them, and the prospect of smoke abatement by this mode of dealing with coal, and the improvements it has helped to make in the manufacture of steel, in all of which they have recognised Sir William Siemens as an originator, a devoted worker, and a friend. The Portrush and Bushmills electric tramway in the north of Ireland, one of the most splendid and interesting of his achievements, now carries passengers on a six and a half miles line of steep gradients and sharp curves, at a good ten miles an hour, solely by water power of the River Bush, driving, through turbines, a 250 volt Siemens dynamo at a distance of seven and a half miles from the Portrush end of the line. Just two months before his death he was present, and the writer of this article had the great pleasure of being present with him, at the formal opening to the public by the Lord-Lieutenant of Ireland, Earl Spencer, of this transcendent gift of science to mankind. His death is mourned as an irreparable loss, and the thought that advances in so many lines of beneficent progress, carried on by his untiring activity and his splendid zeal, are so suddenly stopped has caused most grievous disappointment.

William Siemens had the great characteristic common to all men who have left their mark on the world, the *perfervidum ingenium*, in which thought leads to instant action. When he was only twenty years old he came to England with his brother Werner, to realise an invention for electro-gilding; and, persevering through the complication of difficulties naturally met with by young men in a strange land, with little knowledge of its language, they succeeded in proving the usefulness of their invention, and getting it carried into practical effect through the wise and kindly appreciation of Mr. Elkington. Encouraged by this success, William Siemens returned a year later with his chronometric governor, an invention of remarkable beauty and ingenuity, in which, by the motion of a pivoted framework carrying an idle wheel geared to bevel wheels on two shafts in line, or geared to the outer and inner circumferences of concentric wheels, rotating in opposite directions on coaxial shafts, the movement of one wheel is caused to keep time with that of the other. We believe that although the invention was not a commercial success, and is not generally known in this country as practically realised except in its application to regulate the motions of chronoscopic instruments in the Royal Observatory of Greenwich, it may yet be destined to have large practical applications in engineering.

One of William Siemens's early inventions was his water-meter, which exactly met an important practical requirement, and has had a splendid thirty years' success. It realised curiously subtle hydraulic principles, which, even irrespectively of the practical value of the instrument, may interest readers of NATURE. Imagine a Barker's mill running absolutely unresisted. The discharged water must have approximately zero absolute velocity on leaving the nozzles; in other words, its velocity relatively to the nozzles must be approximately equal to the contrary absolute velocity of the nozzles. Hence the machine will rotate in simple proportion to the quantity of water passing through it. By an extension of similar considerations it is easy to prove that if the wheel, instead of being unresisted, is resisted by a force exactly proportional to the square of its angular velocity, its velocity must still be proportional to the quantity of water passing through it per unit of time. Thus, provided this law of resistance is maintained, the whole angle turned through by the wheel measures the whole quantity of water that has passed. Now think of the difficulties which Siemens had to overçome to realise this principle. What we have roughly called a Barker's mill must be completely inclosed in the supply water-pipes, its nozzles discharging into water, not into air. It must be of very small dimensions to be convenient for practice, and its bearings must be kept oiled to secure, not only that it may not be injured by the wear of running for years, but also that the constant frictional force of solid rubbing on solid may be as nothing compared to the resistance, proportional to the square of the velocity, exerted by the circumambient liquid upon a wheel with sharp edged vanes rotating in it. After a few years of trials, difficulty after difficulty was overcome, and the instrument did its work with the accuracy and convenience which met practical requirements. It was we believe the protection offered by the British Patent Law, which, in the case of this very instrument, allowed Siemens to work it out in England, and so helped him eventually to find his home among us, and to give us primarily the benefit of his great inventiveness in all directions; while the want of similar protection under German law at that time rendered it practically impossible for him to work out so difficult an invention in his own country.

In electric invention William Siemens has been associated with his brother Werner, and the world has profited largely by this brotherly cooperation of genius. More than a quarter of a century ago, they brought out what is now known as the Siemens armature. The writer well remembers admiring it greatly when he first saw it (he believes at the London Exhibition of 1862), mounted between the poles of a multiple steel horseshoe magnet and serving for the transmitter in an electric telegraph. That was what we may now call the one-coil Siemens armature. It suggested inevitably the mounting of two or more coils on the same iron core, in meridional planes at equal angles round the axis, and as nearly equal and similar in all respects as is allowed by the exigencies of

[1] The Steel Engraving, which was put in hand some time ago while the life which has now passed away was rich in promise as well as achievement, is not yet finished. It will be issued with a future number.—ED.

completing the circuits with the different portions of wire laid over one another, and bent to one side or the other, to avoid passing through the space occupied by the bearing shaft. The principle of electro-magnetic augmentation and maintenance of a current without the aid of steel or other permanent magnets, invented by Werner Siemens, and also independently by Wheatstone and S. A. Varley, was communicated to the Royal Society by William Siemens on February 14, 1867, in his celebrated paper "On the conversion of dynamical into electric force without the aid of permanent magnets." This paper is peculiarly interesting, as being the first scientific enunciation of that wonderful electro-magnetic principle, on which are founded the dynamo-electric machines of the present day. Soon after came the Paccinotti-Gramme ring, from which followed naturally the suggestion of the mode of connection between the coils of a multiple-coil Siemens armature, described in the Siemens-Alteneck patent of 1873, and made the foundation of the Siemens dynamo as we now have it, whether as given from the Siemens firm, or with the modifications of details and proportions, valuable for many practical purposes, which have been contributed by Edison and Hopkinson. The evolution of the Siemens armature, as we now have it, in this splendid machine, from the rudimentary type which the writer saw a quarter of a century ago, is one of the most beautiful products of inventive genius, and is more like to the growth of a flower than to almost anything else in the way of mechanism made by man.

Space prevents us from more than mentioning the works of William Siemens and his brothers, Werner and Carl, in land and sea telegraphic engineering, and their great achievements in Atlantic cable-laying. The *Faraday* bore particularly the impress of William Siemens's practical genius. It is remarkable that a ship capable of doing what no other ship afloat can do in the way of manœuvre, as has been proved by her success in the difficult and delicate operations of laying and lifting cables in depths of 2500 fathoms, and of cable repairing in all seasons and all weathers, should have been the work of a landsman, born in the middle of Europe, who early made himself a sailor in cable-laying expeditions in the Mediterranean and the Black Sea, but whose life has been chiefly devoted to land engineering and science.

On the 19th of this November the writer of the present article was accosted in a manner of which most persons occupied with science have not infrequent experience:—"Can you scientific people not save us from those black and yellow city fogs?" The instant answer was—"Sir William Siemens is going to do it; and I hope if we live a few years longer we shall have seen almost the last of them." How little we thought that we were that very evening to lose the valuable life from which we were promising ourselves such great benefits. May we not hope that, after all, the promise was not vain, and that, although Sir William Siemens is gone from among us, the great movement for smoke abatement, in which he has so earnestly laboured during the last three years of his life, may have full effect.

Just nine days previously, the writer had received a letter from Sir William Siemens, saying nothing of illness, but full of plans for the immediate future: chiefly an address to the Society of Arts, and the realisation at Sherwood of his method for the smokeless supply of heat to a steam boiler, by the combustion of hydrogen, carburetted hydrogen, and carbonic oxide, obtained from the conversion into these gases of the whole combustible material of the coal, together with some hydrogen and oxygen from water, and oxygen from air, in his gas-producing kiln. "The producer will be in full operation at Sherwood by that time" were almost the last words received by the writer from his friend, kindly inviting him to come and see the new method in operation at the end of the present month. A short time before, in travelling home from Vienna, where they had been associated in the British Commission for the Electrical Exhibition, Sir William Siemens had told the writer that without waiting for a perfected gas-engine to use the products of combustion as direct motive agent, and so give the very highest attainable economy, he expected by using the gas from his producer as fuel for the fire of a steam-boiler, even on a comparatively small scale, like that of his appliances at Sherwood for electric lighting and the electric transmission of power, to be able to obtain better economy of coal for motive power than by burning the coal directly in the usual manner in a furnace under the boiler. And further, what is specially interesting to persons planning isolated installations for electric light, he believed that the labour of tending the producer and boiler and steam-engine would be on the whole considerably less than that which is required on the ordinary plan, with its incessant stoking of coal into the furnace under the boiler, as long as steam is to be kept up. There is something inexpressibly sad, even in respect to a comparatively small matter like this, to see the active prosecution of an experiment so full of interest and so near to a practical solution, suddenly cut short by death. But the great things done by Siemens with gas produced in the manner referred to above, first in the gas glass furnace, described with glowing admiration by Faraday on Friday evening, June 20, 1862, in his last Royal Institution lecture, and more recently in connection with another great and exceedingly valuable invention, the Siemens process for making steel, by using the oxygen of iron ore to burn out part of the carbon from cast iron, and still more recently in the heating of the retorts for the production of ordinary lighting gas, by which a large increase has been obtained in the yield of gas per ton of coal used, are achieved results which live after the inventor has gone, and which, it is to be hoped, will give encouragement to push farther and farther on in practical realisation of the benefits to the world from the legacy of his great inventions.

A most interesting article on the life and work of Sir William Siemens in the *Times* of November 21 concludes with the following words, in which we fully sympathise:—"Those who knew him may mourn the kindly heart, the generous noble nature, so tolerant of imperfect knowledge, so impatient only at charlatanism and dishonesty; the nation at large has lost a faithful servant, chief among those who live only to better the life of their fellow-men by subduing the forces of nature to their use. Looking back along the line of England's scientific worthies, there are few who have served the people better than this her adopted son, few, if any, whose life's record will show so long a list of useful labours."

In private life Sir William Siemens, with his lively bright intelligence always present and eager to give pleasure and benefit to those around him, was a most lovable man, singularly unselfish and full of kind thought and care for others. The writer of the present article has for nearly a quarter of a century had the happiness of personal friendship with him. The occasions of meeting him, more frequent of late years, and more and more frequent to the very end, are among the happiest of recollections. The thought that they can now live only in memory is too full of grief to find expression in words.

WILLIAM THOMSON

In addition to the above notice by a master-hand we give the following details of Sir William Siemens's life and of the sad and solemn closing scene.

CHARLES WILLIAM SIEMENS was born at Lenthe, in Hanover, on April 4, 1823; he was educated at Lübeck, the Polytechnic School of Magdeburg, and had the advantage of sitting for a couple of sessions under Professors Wöhler and Himly at the Univerity of Göttingen, finishing his academical career at the age of nineteen. He stayed one year at the engine works of Count Stolberg, and when twenty years of age landed in England to introduce a new process of electro deposition, and, as stated above, was so successful that he made England his home. Another early invention of the two brothers was one which Faraday lectured upon at the Royal Institution one Friday evening under the title of the "Anastatic Printing Process of the Brothers Siemens."

Between his twentieth and thirtieth years he was mainly engaged in problems connected with mechanical engineering, improving the chronometric governor, bringing out a double-cylinder air-pump and a simple water-meter which has been extensively used both in this country and on the Continent. When twenty-four years of age he constructed a four horse-power steam-engine, with regenerative condensers, in the factory of Mr. John Hicks, of Bolton, and the Society of Arts acknowledged the value of the principle by giving him their gold medal in 1850. At this time also he made a modification of Grove's secondary battery, to which he referred two years ago at the Jubilee Meeting of the British Association. When just over thirty years of age he received the Telford prize and premium of the Institution of Mechanical Engineers for his paper "On the Conversion of Heat into Mechanical Effect," in which he defined a perfect engine as one in which all the heat applied to the elastic medium was consumed in its expansion behind a working piston, leaving no portion to be thrown into a condenser or into the atmosphere, and advised that expansion should be carried to the utmost possible limit. In taking up the question of heat he adopted the dynamical theory as the result of a study of the works of Joule, Mayer, and others, and we find him when thirty-two years of age exhibiting two steam-engines with regenerative condensers, the one of twenty and the other of seven horse-power at the Paris Exhibition of 1855.

Between his thirtieth and fortieth years he read several papers before the Institution of Civil Engineers on electrical subjects, and before the Institution of Mechanical Engineers upon the various inventions which he had already brought out. During this period also was established the firm of Siemens Brothers, which has become so famous for their machines, and submarine and land lines, four Transatlantic cables, the Indo-European line, the North China cable, the Platino-Braziliera cable, and others. In 1860, when engaged in superintending the electrical examination of the Malta and Alexandria telegraph cable, he thought of using the increased resistance of metallic conductors due to rise of temperature as a means for measuring temperature, and brought out next year a pyrometer based upon this principle.

He was now also engaged with his brother, Mr. Frederick Siemens, upon that invention with which his name has since been mainly connected—the regenerative gas furnace. By means of this furnace, which is now used all over the world, two evils which formerly appertained to heat furnaces are cured, viz. the discharge of the products of combustion at a very high temperature and in an incompletely combined state. Another advantage of this furnace is the very high temperature that could be attained by its use, and from the very first its author looked upon it as capable of accomplishing what Reaumur, and after him Heath, had proposed, namely, to produce steel on the open hearth. It was in 1862 that Mr. Charles Atwood made the first attempt to produce steel in this manner at Tow Law under a license from Mr. Siemens; but, though partially successful, it was afterwards abandoned; after one or two other disappointments, Mr. Siemens had to take the matter into his own hands, and having matured the process at his experimental works at Birmingham, he laid the foundation of an industry which now employs thousands of workmen at the works of the Landore Company, Vickers and Co. of Sheffield, the Steel Company of Scotland, and others, about half a million tons of mild steel having been produced last year in Great Britain alone. This steel is now used almost exclusively in Her Majesty's dockyards in the construction of the boilers and hulls of ships, and its use in private yards is extending rapidly.

On February 14, 1867, he brought before the Royal Society the paper on the conversion of dynamical into electrical force referred to by Sir William Thomson.

Not only to these large applications of electricity did Sir William Siemens direct his attention but to electro-metallurgy and horticulture. Those who were present at his lecture to the Royal Institution on March 12, 1880, will remember the stream of light which poured forth from his electric furnace when the lid was taken off the crucible to pour the fused steel into the mould, and the result of his experiments on the influence of electric light upon plant growth in the exhibition of peas, roses, lilies, and strawberries at this early season with the fruit partially developed. But the space at our disposal will only allow us to remind our readers of others of his inventions, his bathometer for measuring the depth of the sea, and his attraction meter (*Phil. Trans.*, 1876); the selenium eye, which was sensitive to variation of colour; the regenerative gas burner, and regenerative gas and coke stove; the hypothesis of the conservation of solar energy; all of which have appeared from time to time in these columns. The last time Sir William Siemens lectured in public in this country was at the Institution of Civil Engineers on March 13 last, on "The Electrical Transmission and Storage of Power," the evening the attempt was made to blow up the offices of the Local Government Board by dynamite, when, although a portion of the glass was shattered in the theatre of the Institution, the lecturer resumed the thread of the discourse after a moment's pause as though nothing had occurred.

Sir William was a member of nearly all the scientific societies of Great Britain; he was the senior member of council of the Institution of Civil Engineers; he was elected a member of the Royal Society in 1862, and had twice served on the council of that body. He has been President of the Institution of Mechanical Engineers, twice of the Society of Telegraph Engineers, of the Iron and Steel Institute, and last year, at Southampton, of the British Association; whilst at the time of his death he was Chairman of the Council of the Society of Arts. He was made a D.C.L. of Oxford *honoris causâ* in 1870, an LL.D. of Glasgow in 1880, of Dublin in 1882, in which year the University of Würtzburg also bestowed on him its honorary Ph.D. He was elected with Sir Henry Bessemer, the first honorary members of the Gewerbe-Verein of Berlin, besides being a corresponding or ordinary member of several learned societies in Europe and America.

He received prize medals at the Exhibitions of 1851 and 1862, and a *Grand Prix* at the French Exhibition of 1867 for his regenerative gas furnace and steel processes. In 1874 he was presented with the "Royal Albert Medal," and in 1875 with the "Bessemer Medal" on account of his scientific researches and his inventions relating to heat and metallurgy, whilst only last week the Council of the Institution of Civil Engineers awarded him the Howard Quinquennial Prize for the advances he had made in the manufacture of iron and steel. He has received recognition of his services to pure and applied science from the Emperor of Brazil, the Shah of Persia, and from France both under the Empire and the Republic, whilst in March last Her Majesty was graciously pleased to confer upon him the honour of knighthood.

It was whilst returning from the monthly meeting of the Managers of the Royal Institution on November 5 that he met with the accident that accelerated his death, which took place on Monday, the 19th inst.

In accordance with the desire of the whole community, the public ceremonial performance of the last sad rites took place in Westminster Abbey on Monday last before the remains were conveyed to their resting-place in the cemetery at Kensal Green. The Prince of Wales placed his name at the head of the requisition submitted to the Dean of Westminster, asking that a public funeral might mark the recognition of Sir William Siemens's claims to be held in remembrance as a public benefactor, while few were more deeply affected at the graveside than the men who came to show their respect to a kindly master.

At the Abbey, according to the *Times* report, the distinguished public personages and representatives of scientific bodies assembled in the Jerusalem Chamber or in the Abbey, members of societies not attending in official capacities having places assigned them in the sacrarium or transepts, the choir and seats under the tower being reserved for presidents, vice-presidents, members of council, and officers of the societies invited to be present. The ancient tapestried chamber which has of late years been the scene of several such sad gatherings was filled—indeed, crowded—with the many warm friends and admirers of the deceased. His Royal Highness the Prince of Wales was represented by one of his grooms-in-waiting, Mr. Andrew Cockerell. The German Ambassador, Count Münster; the Chancellor of the Exchequer, Mr. Childers; the First Commissioner of Works, Mr. Shaw-Lefevre; Lord Bramwell, and Lord Claud Hamilton were also present; together with Mr. F. R. Pickersgill, Keeper of the Royal Academy, representing the President, Sir F. Leighton; Sir Douglas Forsyth, Sir Theodore Martin, Sir J. M'Garel Hogg, M.P., Sir Henry Tyler, M.P., Major-General Sir Andrew Clarke, General Crofton, Major-General Pasley; Mr. Fung Yee, secretary to the Chinese Legation, and others.

Taking the scientific Societies and their representatives in the order in which they were marshalled to join the procession, there were as pall-bearers—Prof. Huxley, President of the Royal Society; Sir Frederick Bramwell, predecessor of Sir William Siemens in the office of Chairman of Council of the Society of Arts; Mr. Brunlees, President of the Institution of Civil Engineers; Mr. Percy Westmacott, President of the Institution of Mechanical Engineers; Prof. Sir W. Thomson, for the British Association; Prof. Tyndall (Royal Institution); Mr. Willoughby Smith, President of the Society of Telegraph Engineers and Electricians (a society of which Sir William was the first president); and Sir James Ramsden (in the unavoidable absence of Mr. B. Samuelson, M.P.), representing the Iron and Steel Institute. The Royal Society was further represented by the treasurer, Dr. John Evans, and the secretaries, Prof. G. G. Stokes and Prof. Michael Foster; and among other well known members of this, the oldest of the learned and scientific societies, were Sir Joseph Hooker, Sir Frederick John Evans, K.C.B., Mr. Norman Lockyer, Mr. Warrington Smyth, Dr. Hopkinson, Prof. W. G. Adams, Prof. Bartholomew Price, Prof. Chandler Roberts, Prof. R. B. Clifton, Prof. Carey Foster, and Mr. R. W. Mylne. The Society of Arts was represented by the following Members of Council:—Sir Frederick Abel, C.B., F.R.S., Mr. A. Carpmael, Mr. Andrew Cassels, Lord Alfred S. Churchill, Sir Philip Cunliffe-Owen, Mr. B. F. Cobb, Mr. H. Doulton, Capt. Douglas Galton, C.B., F.R.S., Admiral Sir Edward Inglefield, C.B., F.R.S., Mr. T. V. Lister, Mr. Owen Roberts, Lord Sudeley, and by Mr. H. Trueman Wood, secretary, Mr. H. B. Wheatley, assistant secretary, Mr. Howard Room, and other officers. Of the Institution of Civil Engineers there were past presidents—Sir John Hawkshaw, F.R.S., Sir Charles Hutton Gregory, K.C.M.G., Mr. Hawksley, Mr. Bateman, Mr. Barlow, Mr. Abernethy; vice-presidents—Mr. Edward Woods, Mr. G. B. Bruce; Mr. Charles Manby, honorary secretary; Sir John Coode, Mr. Berkley, Dr. Pole, Mr. Hayter, Sir Robert

Rawlinson, C.B., Mr. E. A. Cowper, Mr. Rendel, Mr. B Baker, Sir James N. Douglass, and Mr. J. W. Barry, members of Council; and Mr. James Forrest, secretary, and Mr. H. E. Eaton, assistant secretary. The Institution of Mechanical Engineers sent—Mr. Ramsbottom, a past president, for long mechanical engineer to the London and North-Western Railway Company: Mr. Rennie and Mr. T. R. Crampton, vice-presidents; Mr. W. Anderson, Mr. Kitson, Mr. Peacock, Mr. Richardson, Mr. J. Tomlinson, jun., Mr. Tweddell, and Mr. Price Williams, members of Council; Mr. W. R. Browne, secretary, and Mr. A. Bache, assistant secretary. Prof. Bonney's name may be given as one of many connected with the British Association; and as members of the London Institution those of Mr. Warren De La Rue, F.R.S., Mr. W. Bowman, F.R.S., its honorary secretary; and Dr. Gladstone, F.R.S. From the Society of Telegraph Engineers there were—Mr. Latimer Clark, Lieut.-Col. Webber, R.E., C.B., past presidents; Mr. Spagnoletti, Prof. D. E. Hughes, F.R.S., and Sir Charles Bright, vice-presidents; Mr. Stroh and Mr. H. C. Forde, of the Council; and Mr. F. H. Webb, secretary. The Iron and Steel Institute, of which Sir W. Siemens was a past president, was also represented by Mr. W. Whitwell, Mr. G. J. Snelus, Mr. Edward Williams, Mr. T. E. Horton, Mr. Daniel Adamson, Mr. E. Windsor Richards, and Mr. J. S. Jeans (secretary). The Royal Astronomical Society had a fitting representative in the Astronomer Royal, Mr. W. H. M. Christie, a vice-president. Mr. Horace Jones, president, and Mr. Mac Vicar Anderson, honorary secretary, of the Royal Institution of British Architects, and Dr. W. H. Perkin, F.R.S., President of the Chemical Society, represented those bodies. For the Royal Meteorological Society, there were the President, Prof. J. K. Laughton; Mr. G. J. Symons, F.R.S., the honorary secretary; the Hon. Rollo Russell, Mr. R. J. Lecky, and Dr. J. H. Gilbert. From the Institute of Naval Architects there were two vice-presidents—Mr. N. Barnaby, C.B., Director of Naval Construction; Mr. James Wright, C.B., Engineer-in-Chief at the Admiralty; and Mr. George Holmes, secretary to the Institute. The Society of Engineers was represented by the President, Mr. Jabez Church, Mr. Nursey, of the Council, and Mr. Bartholomew Reed, secretary. There were also present representatives of the Geological Society, the Chemical Society, the Physical Society, and the Society of Chemical Industry. The German Athenæum in London was represented by a deputation, headed by Count Victor Gleichen, its honorary president, and including Mr. Alma Tadema, R.A., Mr. Carl Haag, Dr. Hess, Mr. F. Rosing, Mr. E. Meyerstein, honorary secretary, and Mr. C. Sevin.

Sir Henry Bessemer wrote to the secretary of the Iron and Steel Institute expressing his deep regret that an attack of bronchitis prevented him from being present.

Forming a long procession, the occupants of the Jerusalem Chamber filed past the Westminster Schoolroom, and, meeting the family mourners at the entrance from Dean's Yard, took their appointed places, and followed the coffin through the cloister to the Canons' door, in the south aisle of the Abbey. The coffin was covered with wreaths sent from nearly every country in Europe.

A great part of the large assemblage joined the procession formed after the Abbey service and accompanied the remains to Kensal Green. At the cemetery there were also present very many of the workmen from the telegraph works at Woolwich. A bank of grass and flowers breast high encircled the head of the grave, and the sides of the interior were hidden by fern-fronds and flowers.

The inscription on the coffin was simply—

C. William Siemens,
Died 19th Nov., 1883.
Aged 60 years.

THE FOREST LANDS OF FINLAND

Finland: its Forests and Forest Management. Compiled by J. C. Brown, LL.D. (London: Simpkin, Marshall, and Co., and William Rider and Son, 1883.)

AT a time when renewed effort is being made in our own country to stir up interest in the subject of forestry, it is instructive to notice what progress is being made in woodcraft in other lands. Sir Richard Temple brought before the Social Science Congress at its recent meeting the condition of our home and colonial forestry; next year an international forestry exhibition is to be held in Edinburgh; and Sir John Lubbock has given notice of a motion affecting forestry for next session in the House of Commons.

Dr. Brown divides his book into three parts, dealing respectively with the lakes and rivers of Finland, its forest economy, and its physical geography, including geology. The first part, though decidedly interesting, savours rather too much of the guide-book style, and is interspersed with adventures and scriptural quotations. Water occupies two-fifths of the area of Finland, which is called by its inhabitants "The Land of a Thousand Lakes," and most of the internal communications of the country are effected along its lakes and streams. Another poetical designation, "The Last-born Daughter of the Sea," refers to the recent upheaval of the Finnish area, a rising which is still in progress, as is proved by the continuous shallowing of the waters on the Baltic coast-line. The country abounds in interesting glacial phenomena, but we must confess to a feeling of disappointment with the geological as well as with the first portion of the work. Moreover, ordinary care has scarcely been exercised, otherwise we should not read of "palatal mansions," of boulders "marled or variagated" by lichens, of "moluscs," "mamifers," and "carnivori," nor yet of "the old Taurentian formation," to say nothing of the excessively vague notion conveyed by such an expression as "pre-Adamic times."

The second part, dealing with forest economy, occupies rather more than half the book, and constitutes presumably the *raison d'être* of the whole. Forest products form more than half the total value of exports from Finland, and it is estimated that 64 per cent. of the entire surface of the land is covered with forests, which up to quite recent times were subjected to the most reckless waste. Finland is the only country in Europe in which *sartage*, that is, the practice of setting fire to the trees in order to clear the ground, is still carried on extensively. The clearing away of the woods is to prepare the ground for agriculture, but as much or more by the preparation of the soil as by obtaining space for the cultivation contemplated, and this is the peculiarity of the usage. The trees growing on the spot selected are burned, and the seed is sown on the soil thus manured with the ashes of the trees. The effects of *sartage* in other European countries, in India, and in North America, are brought under notice and discussed at some length. In France it is a practice recognised both in forest science and in forest management, but whereas it was formerly resorted to largely it is now adopted only in special circumstances. It is there found that the oak, particularly a hardy variety known as the *rouvre*, of all forest trees sustains best the treatment of *sartage*. In the Ardennes the coppice woods of *rouvre*, which are so treated, yield excellent firewood and charcoal. The burning is carried out in August and September, and, at the proper time for sowing cereals, rye or buckwheat is scattered over the ground and covered with a light hoe. After the crop is reaped the young tree-shoots begin to grow rapidly, but it is often necessary in order to insure perpetuity of good growths to plant out seedlings, and this is especially the case with the oak.

At the present time there are in Finland districts in which *sartage* is now prohibited, others in which it is carried on under restrictions, and others in which it is tolerated and apparently freely practised. Should the cleared ground not be retained permanently under agriculture, it is likely to become covered again with a crop of self-sown trees, of the same kind as those destroyed, or of a kind of higher pecuniary value. On the banks of the Saima See, for example, fir trees have been replaced either by firs or by birch. The fir or pine may be of more value for building purposes, but the birch supplies a better firewood, and for this there is and probably will long continue an ever-increasing demand in St. Petersburg, to which it can be sent from most places in Finland by water.

When a crop of trees after destruction is not replaced by another crop, the proximate effect upon the climate is generally considered to be beneficial to agriculture. But in Sweden in many districts in which the forests have been cleared away it is remarked that spring now begins a fortnight later than it did in the last century, and this is attributed to protracted frost due to diminished humidity of the atmosphere.

The improved forest economy of France dates from the issue of the celebrated Forest Ordinance of 1669, if not from a much earlier period. But in Finland all improvements in forest economy have been effected since 1809, and particularly during the last twenty-five years. Though formerly an independent country, Finland was for a long time a province of Sweden, and in 1809 it was annexed to the dominions of Russia as a Grand Duchy, with the enjoyment of pre-existing privileges and of government under its own laws issued in accordance with its Constitution. In 1848 were sent out Imperial Instructions relative to the management of the Crown forests, along with regulations respecting projected surveys, and in 1858 new arrangements for the management of these forests were made.

The forest administration of Finland is now in the hands of well-trained officers, and much of the lavish waste of former days has ceased. By giving more attention to considerate thinning, by more skilful conservation and more scientific exploitation, it was felt that the "produce and the products of the forests might be equalised approximately, if not perfectly," and one object aimed at in the inspection of forests is to prevent the removal of trees being effected more rapidly than the re-growth. As has been remarked, Finland has a constant market for firewood and timber in St. Petersburg, where firewood is now more expensive than coal brought from Britain.

It is to its School of Forestry at Evois that Finland looks for its supply of trained forest conservators. This school was opened in 1859, and intending students were required to produce before admission a university diploma, or a first class certificate of the completion of the course of study at a gymnasium. Closed after a time from lack of students, it was reorganised and reopened in 1874. The course of study occupies two years, and the subjects are forest science, surveying, engineering, rural economy, legal economy, and drawing. In July and August the pupils are required, for the sake of practice, to measure fields and woods, and to estimate the quantities of standing timber. We observe that under forest science is included "the science of hunting," whereat many an English youth would no doubt be inclined to say "Happy Finlanders!" Officered by men trained in this school, the Finnish forest administration is now in a position to attain objects identical with those of the advanced forest economy of Europe: first, to secure a sustained production from the forests; secondly, to secure along with this an amelioration of their condition; and thirdly, a reproduction of them by self-sown seed when felled.

Readers who are interested in forest conservancy will find much valuable information in the middle section of Dr. Brown's work. The subject is one which must ere long force itself on the attention of political economists. The reckless clearances that have been effected in our Canadian territories are approaching a limit; the most cautious estimates do not allow a longer period than fifteen years for the exhaustion of our Canadian timber lands at the present rate of consumption, and one very trustworthy and experienced authority limits it to seven years.

W. FREAM

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Optical Phenomena

THE phenomenon described as "Cloud-Glow" by your correspondent, Mr. F. A. R. Russell, in NATURE of the 15th inst. (p. 55), and by Mr. J. J. Walker in your last issue (p. 77), was observed here by me; as, however, the time my observation commenced (5 p.m.) was three-quarters of an hour later than the time given by Mr. Russell (4.18 p.m.) it is probable that many of the features described by him had faded before the phenomenon came under my notice. As seen by me, the appearance consisted of an arc-like mass of glowing vapour of a ruddy hue, but of a tint not familiar to me, in the western horizon, extending from the north-west to a point near the South Pole. The centre of the mass was about due west, and was there some 25° above the horizon. There was no wind; there were no cirri. The sky was clear and the air transparent, and I could not associate the appearance with anything like a "cloud-glow." It seemed to me like the blaze of a great conflagration seen through a smoky medium, and I expected every moment to see the fire-engines rush past me. At dark (6 p.m.) there were long pallid streaks of polar auroral light, proceeding from a centre in the north-west. These presented no signs of the flickering activity usually accompanying auroral manifestations. Soon after 7 p.m. all traces of polar aurora vanished. It may be mentioned that, while instances of aurora have been common here throughout the autumn, on one occasion only have flashing rays and beams been present.

Every sunset since the 9th, when the condition of the weather permitted—somewhat rarely—the remarkable glow under notice has been visible in the west, sometimes marked and prominent, as on the 17th inst., at others somewhat indistinct, according as the state of the atmosphere served.

Here to-day, after the storms of yesterday, blue sky prevailed, and the afternoon proved favourable for observation. The sky was clear; the air, washed by frequent rains, was transparent; wind south-west and tranquil; barometer low; thermometer at 2 p.m. 48°. At 4 p.m. a great arc-like bank of dusky coloured vapour, extending as before from north-west to south, was discernible. On the sun declining behind the mass, it was suddenly shorn of its beams, and looked like the moon when rising. In a few minutes the vaporous bank assumed the peculiar vivid ruddy hue distinctive of the phenomenon; the blue colour of the sky changed to green. The green was speedily replaced by the ruddy tint before described, which presently suffused the whole hemisphere, tinged the entire landscape, and presented an appearance of which I have never seen the like. The colour was deeper round the horizon than at the zenith. The colour gradually faded as the vaporous glowing mass sank in the western horizon, and at 5.30 had left no trace.

Worcester, November 26 J. LL. BOZWARD

P.S.—The atmospheric effect described as cloud-glow was visible here to-night. There was a cloud canopy, but at 4.30 the ruddy light was visible under the canopy over the whole hemisphere. The ruddy light was manifest in a marked manner at sunrise on the 24th, and was discernible this morning. Probably the phenomenon is attributable to the aqueous vapour in suspension in the atmosphere. J. LL. BOZWARD

Worcester, November 27

THE remarkable cloud-glow after sunset on November 9 was seen by me at Sudbury on the southern border of Suffolk. I was struck by the softness and uniformity as well as brightness of the glow, and by its contrast with the pale greenish hue of the clear sky around, from which it was separated by a frame of nearer clouds in shade. When I first noticed it the (upper) margin was about 15° above the horizon (estimated from memory). Presently the glow diminished in brightness and increased in extent upward to about 40° above the horizon; and at the highest (nearest) part the delicate structure of the cirrus was visible.

Was it noticed at any place further north than Sudbury?

Woodbridge, November 25 HUBERT AIRY

IN travelling up from Leeds on Monday afternoon I was able to watch the whole progress of the remarkable sunset sky on that afternoon. The sun went down quite clear, and the sky was all but cloudless. Shortly after sunset a crimson arch appeared stretching from south-east to north-east, with a very clear greenish blue sky beneath it in the east. This crimson arch gradually proceeded westwards over the sky, and at about 4.20 was stretching from south-west to north-west. At this time it developed a number of well-defined, pointed rays or streamers radiating from the point where the sun was below the horizon. Between the arch and the western horizon was a sky of a bright silver-white colour, which was so brilliant that it gave us quite a second daylight. The crimson arch continued to sink towards the western horizon, the streamers still retaining the same relative positions. At about 4.40 it formed simply a bright crimson band along the western horizon, and the streamers still pointing out from it gave the appearance of some large forest on fire in the west. Finally, at 4.50, when we were some twelve miles north-west of Nottingham the crimson arch had entirely vanished below the horizon. At one time, when the arch was at its brightest, with the silver-white sky beneath it, it had exactly the appearance of the aurora, except that the streamers remained fixed in relative position. In the silver-white sky there seemed to be a very thin cloud layer. A. TARN

31, Mornington Road, N.W., November 27

OPTICAL phenomena of a peculiar nature appeared here on the 25th and 26th inst. On the 25th, shortly before sunset, the atmosphere, which was exceedingly clear except in the west, was suffused with a brilliant tint of lake. Over and to the left of the sun, which appeared to shine with a remarkably white light, there was a heavy cumulus, the edges of which were tinted with a strange, olive-green colour. After sunset the sky in the east became gradually of a more brilliant rose tint, which continued a long time after the sun's rays ceased to be reflected from a long, curled streak of cirro-filum, at an altitude of 2600 feet. The sky nearer the zenith at 5 p.m. appeared to be of a sea-green tint. A little later, the most brilliant rose-coloured glow covered the western and south-western sky, which continued up to about 5.45 p.m., and might easily have been mistaken for a red aurora.

On the 26th a similar phenomenon took place upon a grander and more unusual scale. At 3 p.m., when the sky was totally devoid of higher cloud, the sun, which was shining with a remarkably white light like the electric light, was surrounded by a very broad halo of a uniform *pale pink* colour, whose exterior margin was very ill-defined. This halo was of about 22° radius and was totally devoid of the usual prismatic tints. A little before sunset the sky, which was clear except in the distant south-west, where there was a thin bank of cirriform cloud, became of a bright salmon colour. At 4.35 there was a beautiful display of *rayons du crépuscule* in the east-north-east, there being six larger and some smaller lake-coloured belts. But the most splendid phenomenon was yet to come. From 5.5 to 5.15 p.m. a brilliant arc of red light having the position of the sun for its centre, and having an altitude of about 25°, illuminated the western heavens. This light was bright enough to cast a vivid red glare on all objects seen in the opposite direction. From this arc throughout the whole of its extent arose bright rays of red light, divergent from the sun's position, the perpendicular one in the centre extending nearest to the zenith. The arc gradually sank towards the horizon, following the sun's westward declining course.

The barometer at the time was very low, the temperature high, and there was marked "visibility." To-night (27th) there is again a red glow, seen feebly through a thick sheet of cirriform cloud.

Is it possible that particles of ice-dust carried upwards to a great altitude in the extensive cyclonic disturbances now prevalent may have produced these phenomena? In any case it seems clear that the reflecting matter was in the first case very equally diffused, having no tendency to arrange itself in strips or cloudlets; in the second place of considerable vertical thickness; and thirdly, that its greatest altitude was upwards of thirteen English miles.

I hope that some of the readers of NATURE who have witnessed these phenomena may be able to explain them, and not least of all the pink halo. ANNIE LEY

Ashby Parva, Leicestershire, November 27

IN connection with different singular atmospheric phenomena noticed lately in India, Ceylon, and even in our own country, I think an extract from a letter received by the last Cape mail may prove of interest to some of your readers. I may premise that my correspondent resides upon an open Karoo plain, where the atmosphere is always clear; such a "phenomenon" as a *fog* being unknown, and where the sunsets generally are of a beauty that I have not seen surpassed even in the tropics, a beauty, however, very evanescent, for it will be remembered that in those latitudes there is little or no twilight.

The letter is from about thirty-five miles south of Graaff Reinet, and is dated October 21. "Many of us out here are much interested in a very peculiar light visible in the west nearly every evening about an hour after sunset. It lasts until quite dusk, and throws a sort of lurid glare over everything, and the sky is angrily red; I have not seen anything about it in the papers, but the people were very full of it in Graaff Reinet. It is now about a month since we first noticed it."

M. CAREY-HOBSON

Pons' Comet and Meteors.—The Quadrantids

I SEE in Greg's list of possible cometary radiant points there is one given for Pons' Comet, the date December 6, radiant point R.A. 200°, N.D. 68°·5. The radius-vector of the comet at its descending node is 0·77, so that the likelihood of a shower of meteors seems very small; but it might be worth while to look out for one on the 6th of next month.

Pons' comet was just visible to my naked eye on the evening of the 19th—visible only by rare glimpses. On the 20th it was easily visible with the naked eye, almost steadily, so that it would be about of the 7th magnitude. Its tail is still very faint with a 4¼-inch refractor, and grows very slowly.

I would call the attention of observers of meteors to the favourable circumstances attending the next shower of quadrantids, as regards absence of moonlight and the convenient time at which the maximum will be reached. On the other hand, the radiant point will be low at that time, thus diminishing the number of meteors visible. I have examined my observations of this shower in 1859, and from 1872 to 1883, and find that the maximum takes place when the sun's longitude is nearly 282°. This will correspond at the next apparition to the middle of the night of January 2. The duration of the activity of this shower is short compared with that of some other periodical showers, and I am making a more minute calculation of it, the result of which I purpose sending to the *Astronomical Register*.

Sunderland, November 27 THOS. WM. BACKHOUSE

Meteor

A REMARKABLE meteor appeared in the eastern sky this evening at about 8.30. Coming out of *Cetus* it travelled slowly towards *Orion*, being visible for five or six seconds. The head was rounded in front, about one-eighth of a degree wide, tapering backwards to the length of half a degree, distinctly bluish in colour, and leaving an indistinct trail of about twice its own length behind it. It was so bright and seemed so near that I took it at first for a firework of some kind. But it was undoubtedly a meteor. It died out silently, and without breaking up, at about 15° from the horizon. F. T. MOTT

Birstal Hill, Leicester, November 20

Some Habits of Bees and Humble-bees

HAVE any of your readers noticed, or can any account for, a curious practice which I observed on several fine days this autumn among the humble-bees that frequented a bed of blue salvia, viz. that in piercing the calyx and upper end of the tube within it, they would invariably attack it on its *right-hand side, i.e.* the right side of the flower as it looks straight out from the stem. After having several times counted fifty or sixty such attacks in succession, I gathered a number of flowers at random and, carrying them indoors, requested my brother to lay each on its side, so as to show the hole uppermost; twenty-five out of twenty-six were without hesitation placed with the *right* side exposed, the remaining one was considered doubtful. The apparent rule of proceeding was this:—The bee alights on the under midrib or keel of the calyx, with her head towards the stem, then turning her head and fore feet slightly round to the right, inserts her proboscis just clear of the rib, the process being visible only to a person standing on that side of the flower. Whether the flower was on the north or south side of the bed, in shade or sunshine, made no difference, nor did it matter in which direction the bee was making her circuit round the bed. Where two flowers hung so close together as to touch, after piercing the right-hand one on its outer side, and satisfying herself that she could not conveniently push her way in between the two, she would fly off to another, losing the honey rather than attempt to reach it through the left side of the flower. This occurred repeatedly.

Is there anything in the structure of the calyx or in the position of the nectar that can explain this? Or is there a right and left-handedness in some families of humble-bees? Or can it be that a habit, perhaps accidentally established, may be rigidly pursued for a time, at the risk of occasional small losses, to be afterwards abandoned when the impulse is worn out, or when the results are found to be not worth the trouble of forming the habit? That small gains are sometimes neglected in obedience to a habit of quite recent formation, I had an instance a few summers ago, when watching a number of hive bees on a plant of common fuchsia. The greater part of its flowers had been pierced in the upper tube (probably by humble-bees), and my attention was drawn by the regularity and exactness with which the bees were flying straight to the tube, contrary to their usual practice of entering from below. But the flowers were not *all* pierced; and this was the curious part: when a bee had run round the tube and ascertained that there was no hole, she would give it up at once and fly to another, as though the pressure of the new habit would not permit any occasional recurrence to the good old-fashioned plan of entrance from below. Can blind obedience to an *order* given out by a superior have any place in apiary economy?

In this instance it was clear that the habit was fully formed, as regarded that particular plant: I tried to witness its commencement on another, and accordingly pierced as many flowers as I could reach on a fuchsia growing at some distance from the first. A few bees discovered my holes and made use of them, after which they showed considerable hesitation and confusion in their mode of attack, losing much time in hovering up and down as though thrown out of their usual routine; while on unpierced neighbouring plants the customary precision of aim at the lower opening of the corolla prevailed without interruption.

Reverting to the humble-bees on the blue salvias. That their piercing the flower *at all* is an occasional and not universal practice I am inclined to believe, from the totally different behaviour of a set *of apparently the same species* (though of this I cannot be certain) on the same plants during the early part of last autumn. Alighting on the lower lobe of the corolla and advancing inwards, the bee's weight forced open the throat of the flower, into which she then easily inserted her head. This plan was pursued with as much regularity as the opposite one was this autumn. On the same days it was amusing to observe the many fruitless attempts of hive bees to effect an entrance in the same manner. Their bodies being too light to weigh down the floor of the corolla, they would try in vain to force their heads in and always had to fly away disappointed, except when one more fortunate than the rest discovered a flower that had dropped from its calyx, when she would eagerly insert her proboscis into the open end of the tube.

Seeing their great anxiety to obtain salvia honey, I eventually expected to find them taking advantage, this year, of the holes ready made for them by the humble-bees, but strange to say they appeared to have quite deserted the plants, though swarming on a neighbouring bed of yellow Tagetes, an occasional wanderer only passing amongst the blue flowers, and without alighting.

ISABELLA HERSCHEL

Collingwood, Hawkhurst, November 21

Rudolphi's Rorqual

IN a communication made to the Zoological Society on the 20th inst., when describing a specimen of Rudolphi's Rorqual (*Balænoptera borealis*), lately captured in the River Crouch, Essex, I said that this was the first well authenticated example of this species taken in British waters. My friend, Mr. J. E. Harting, has kindly called my attention to a paper which had for the time escaped my memory, published by Prof. Turner in the *Journal of Anatomy and Physiology* for April, 1882, in which a specimen is described which was captured near Bo'ness in the Firth of Forth in September, 1872, and of which the skeleton is now preserved in the Anatomical Museum of the University of Edinburgh. W. H. FLOWER

November 22

Reflection of Light

AS showing how far under favourable conditions the reflection of light from a cloudy sky is visible, I may perhaps be allowed to mention that last night at nine o'clock the reflection of the London lights was remarkably strong. The sky was uniformly covered by a dense canopy of moderately high cloud, and the air very moist (humidity 95). Under such circumstances I have frequently seen at the same time the reflection of the London Brighton, Eastbourne, Hastings, and Tunbridge Wells lights, but last night this reflection in the case of London was peculiarly strong. In former years the light was of a reddish yellow, as is still the case with the lights of the other places named. But in the case of London, and less but perceptibly so in that of Brighton, the light has become of a more silvery hue, due doubtless to the extensive use of the electric light. The distance between this place (lat. 51°, long. 0) and London is about thirty-five miles in a direct line, and there is no place of any size between these points, so there can be no mistake about it; and that the reflection of light at such a distance should be visible seems worthy of notice. It would be interesting to know how far, under favourable atmospheric conditions, the reflection of the London lights can really be seen. W. J. TRENTLER

Fletching, Sussex, November 22

A Lunar Rainbow

ANY of your readers who happened to observe the heavens on Saturday night, the 17th inst., at about 11.15 to 11.30, could not fail to notice the beautiful lunar rainbow which was then visible. Though the moon had slightly passed its perigee, it was shining with such dazzling brilliance that the marbled shadows on its surface were almost effaced, and it hung in the heavens like a spotless crystal sun. The very stars seemed farther away, as though they had shrunk back, ashamed and frighted by the silver glory. Jupiter and Sirius alone stood fearless and undaunted—the former, below her to the left, as if in attendance, the latter far away in the starless south. A few featherlike clouds which the moon illumined with a splendour of her own, now and again sailed in stately silence across her path, but that portion which spread directly over her face, seemed to melt and become invisible like a snow flake on a warm hand, so that the cloud floated around her as a veil, fringing but not covering her face. It was when surrounded by one of these clouds that the rainbow became visible. I had never seen one before, so cannot say whether it was more distinct and bright than is usually the case, but I could see most vividly the red, yellow, green, and violet bands with their intermediate shades. The bow seemed formed on the cloud that shaded the moon at the time, and lay round her in a perfect, though comparatively small circle. It remained so for some nine or ten minutes, and then faded gradually away into a luminous halo of golden brown. Those of your readers who were fortunate enough to behold this beautiful phenomenon will, I am sure, agree with me that it was a sight not to be forgotten. J. C. KERNAHAN

The London Institution, November 24

Sudden Stoppage of Clocks

I HAVE four clocks in my house; one is on a wall that bears north-east and south-west, while the other three ranged nearly at right angles about north-west and south-east. The times of these clocks were not exactly together, there being from five to fifteen minutes between the times; but all of them stopped on the morning of November 18 at times as recorded by each between 3.25 a.m. and 3.40 a.m. Have any other clocks stopped on the same night? This place—Lurgybrack, Letterkenny, Co. Donegal, is in lat. 54° 56″ and W. long. 7° 41′ 52″.

Letterkenny, November 19 G. HENRY KINAHAN

Fog Bows

ON November 14, when driving about half way between Convoy and Letterkenny, Co. Donegal, I observed a very complete bow at about 1 p.m., due solely to a fog. For the most part it was quite white, but at the springing there were slight traces of prismatic colours. On November 15 at 7 a.m. at Letterkenny there was also a fog bow; this, however, had all through well developed prismatic colours. The 15th afterwards came on a heavy wet day; the 16th was fine; but since then there have been severe winds accompanied with sleet, snow, and rain. G. H. KINAHAN

Letterkenny, November 19

THE EARLY HISTORY OF THE HERRING[1]

THE Admiralty having intimated on July 31 that they were prepared to grant the use of a gunboat to enable the Board to undertake some investigations into the early history of the herring, the convener of the Committee appointed to carry on these inquiries made as complete arrangements as was possible in the limited time, and, along with Sir James R. Gibson-Maitland, proceeded to join Her Majesty's gunboat *Jackal* at Invergordon on August 6. Besides making preparations to collect material to illustrate the growth of the herring during the early stages of its development, it was thought desirable to make arrangements for the examination of the spawning grounds, in order to ascertain under what conditions the spawn was deposited. To assist in the work Mr. J. Gibson, D.Sc., of the Edinburgh University Chemical Laboratory, and Mr. J. T. Cunningham, B.A., of the Zoological Laboratory, were invited to join the expedition.

The trawls, dredges, and other appliances were taken on board on August 6, and on the following day the *Jackal* left Invergordon for the Moray Firth, and began the work of investigating the inshore spawning grounds lying between Wick and Fraserburgh. Each place examined was indicated by a number on the chart, and will be spoken of in the Report as a "station." During the month the *Jackal* was at our disposal sixty stations were made, and nearly as many by the *Vigilant* from the time she relieved the *Jackal* to her return to Granton on October 6. The plan generally adopted at the various stations consisted in (1) taking the depth and the surface and bottom temperatures; (2) collecting samples of water from the bottom, and of the mud, sand, &c., brought up by the sounding apparatus; (3) noting the nature of the surface fauna taken in the tow-net; and (4) examining and, when necessary, preserving the animal and vegetable forms brought up by the trawl, dredges, and tangles. In this way there has been collected a considerable amount of raw material, from which important results will in due time be obtained.

Not the least interesting part of the work consisted in experimenting with herring ova which were successfully artificially impregnated and developed. At first experiments were made with spawn obtained at Helmsdale on August 7, from herring which had been several hours out of the water; but the results being unsatisfactory, it was determined to obtain, if possible, the roe and milt from living fish. We, therefore, frequently remained during the night on the fishing ground, and boarded the herring boats when the nets were being hauled. The fishermen, always pleased to see us, rendered every assistance in their power. Selecting ripe fish, we expressed the roe and milt on squares of glass, which were then placed in carrying boxes specially designed for the purpose. The boxes were conveyed by the *Jackal* to a small laboratory near Geanies, which had been kindly placed at the disposal of the Committee. Once at the laboratory, the glass plates, with the developing eggs firmly adhering to them, were transferred to hatching boxes, through which a constant current of water flowed from a large tank. In from three to five days well-formed active embryos were visible through the thin transparent egg membrane, and in ten days we successfully hatched fry from the artificially impregnated ova. We soon discovered that success depended on having an abundant supply of pure sea-water at an equable temperature. Unfortunately, just as our arrangements for experimenting on a large scale were completed, the herring fishing in the Moray Firth came suddenly to an end, and it was impossible to obtain further supplies of eggs.

We next directed our attention to the nature of the surface forms, which are believed to supply the principal food for the herring fry, and when this, on account of the weather, was no longer possible, we proceeded to examine the mussel scalps in the Dornoch, Cromarty, and Inverness Firths.

As a full account of the autumn's work will be presented to the Board in time for the Annual Report, only a short statement is now given, indicating rather the

[1] Preliminary Report of the Investigation Committee of the Fishery Board for Scotland.

lines of further investigations than the results already obtained.

During our stay in the Moray Firth our attention was constantly directed to the change in the position of the spawning grounds. It was stated that, some fifteen years ago, immense shoals of herring visited the inshore ground, in order to deposit their spawn in comparatively shallow water, but that now they had deserted their former favourite haunts for banks from thirty to eighty miles at sea, lying at a depth of from thirty to fifty fathoms. This has caused great distress, as from the absence of suitable harbour accommodation, the large boats fish from distant stations, and the inshore "takes" of the smaller boats (all of which can be beached) is not now sufficient to give employment to the local population in curing. The Report of the Commissioners for British Fisheries for 1862 gives the total take at the ports especially devoted to the inshore fishing, viz. Lybster, Helmsdale, Cromarty, Findhorn, and Buckie, as 158,314 barrels, whereas in 1882 it was only 31,574. On the other hand, at Fraserburgh, a great centre for the deep-sea fishing, the take has increased from 77,124 in 1862 to 233,297 in 1882. Though these figures, and our experience during the autumn, show conclusively that herring are no longer so abundant on the inshore grounds, they do not prove that the shoals are every year spawning farther and farther from our shores, as is often alleged, or that, if we continue to disturb the offshore spawning grounds as we have the inshore, they will disappear from our waters altogether. Some who have had considerable experience believe that spawn deposited in forty fathoms water never develops, and that even if it did the herring fry would perish for want of the proper nourishment.

The disappearance of herring from inshore grounds is accounted for in many ways by the fishermen. Some believe that the offshore fishermen prevent the shoals from reaching the coast by the many miles of nets which they throw across their path; others that the inshore fishing has been destroyed by the winter sprat fishing, most of the so-called sprats being young herring. The former explanation seems to imply that the inshore and deep-sea herring are identical, whereas the latter seems to indicate that they are different. The Report of the German Commission bears that there is a difference between the autumn and spring herring of the Baltic; there may also be a difference between the deep-sea and inshore forms. When this problem is solved we may be able to account for the disappearance of the inshore herring. Should some herring have been so modified that they prefer to spawn on rocky ground in shallow brackish water rather than on deep gravel banks in the open sea, or if herring return to their birthplace to spawn, it will be possible by skilful management to restore the inshore fishing to its original productiveness.

Having examined the inshore spawning grounds, we next proceeded to investigate the banks where the deep-sea herring were believed to spawn. At the outset we felt there was no evidence that these banks had not always been used by herrings as spawning beds. We do know, however, that as the herring boats increased in size enterprising fishermen were enabled to proceed farther to sea, and as a reward they discovered great shoals of herring, the comparative density and condition of which form an interesting subject for immediate investigation. It may have been a mere coincidence that this took place about the same time as the inshore shoals began to diminish. We have no reason for supposing that what we now speak of as deep-sea herring have not been as abundant for centuries as they are at the present day. Man, it seems to your Committee, is not likely much to reduce the number of herring some fifty miles at sea, however much influence he may exert over those which frequent our territorial waters. The time at our disposal did not permit our making a thorough examination of the offshore grounds; in fact, we were only able to begin this part of the work. But there can be no doubt, from the observations already made, that spawn is deposited on these banks, and that the slight difference of the bottom temperature (some 3° C.) would only slightly retard development. Further, the fry once hatched would find an ample supply of food in the rich surface fauna.

The Committee feel that, in order to obtain satisfactory information as to the food of the herring, it will be necessary to make continuous observations for a year or more at all the principal fishing stations around our coast. This could easily be undertaken through the fishery officers.

As to the so-called migrations of the herring, the Committee has not had sufficient time to make a careful investigation, but from the observations made it seems evident that, as the spawning season approaches, the isolated herring and the small groups congregate together, and thus form dense shoals. The shoals once formed instinctively select banks free from mud and shifting sand, and provided with numerous rocks and stones, or with an abundant coating of seaweeds. Having found a convenient bank covered with water at a suitable temperature, and with the requisite specific gravity, they hover over it, if left undisturbed, apparently not paying much heed to the claims of hunger, but feeding on whatever crustacea, sand eels, or other small forms come in their way. The spawn once ripe, they congregate at the bottom, the females depositing the roe on the rocks and seaweeds, to which it at once firmly adheres, and the males fertilising it with their milt. How long a period is required for the whole of the roe to escape has yet to be ascertained. Soon after the "shotten" condition is reached, both males and females begin to leave the spawning ground,—hunger being probably the chief factor in the dispersal of the spent fish,—and this goes on until the whole shoal is dispersed, the hungry disbanded members, either singly or in small companies, hurrying hither and thither in anxious search of food. When they have partly recovered from their exhausted condition they may collect into larger groups; but their further movements are probably largely influenced by the shoals of crustacea on which they chiefly subsist. In all probability their principal feeding ground lies somewhere between the Shetland Islands and the Scandinavian coast. This region is probably the great reserve feeding ground for the fish of the North Sea, and it should at an early date be carefully explored.

The examination of the three firths—Dornoch, Cromarty, and Inverness—has shown that they are all extremely well adapted for producing mussels. Part of the Dornoch Firth already is a considerable source of wealth to the authorities of Tain, but even there the cultivation might be greatly extended. The demand for mussels is great, and the want of them, when herring are unattainable, is often a great hardship to the fishermen; with a little care, the three firths mentioned would supply bait for the whole east coast of Scotland.

The Committee recommend the Board to remit the consideration of the Scottish mussel and oyster banks to a special committee, with the view of taking steps to have their complete control transferred from the Board of Trade to the Scottish Fishery Board.

As the work of the Committee proceeded they have been impressed with the fact that almost everything has still to be learned regarding the habits and life-history of all our food fishes, and they concur in the truth of the following extract from a recent report of the International Fisheries Exhibition:—"It is a very striking fact that the one point on which all speakers at the conferences held during the past summer at the Exhibition were agreed was this—that our knowledge of the habits, time and place of spawning, food peculiarities of the young, migrations, &c., of the fish which form the basis of British fisheries is lamentably deficient, and that without further knowledge any legislation or attempts to improve our fisheries by better modes of fishing, or by protection or culture, must be dangerous, and, indeed, unreasonable."

Further, your Committee feel that in order to make any progress the work must be undertaken in a systematic manner; the investigations must not be carried on by fits and starts, but continuously from month to month and from year to year, until all the facts have been collected and all the experiments made that are likely to throw any light on the difficult problems.

It having been alleged that the food fishes were disappearing from the eastern coasts of the United States, the Central Government in 1871 appointed a commissioner of fish and fisheries to inquire into the matter. The commissioner, instead of contenting himself with collecting evidence from people who knew little or nothing about the subject, proceeded to make careful and elaborate investigations. As the result of these inquiries the United States fisheries have been greatly improved, to the benefit of both the general public and the fishermen, and our knowledge of fish has been materially increased.

In the same way, and about the same time, a German Commission set to work, and although their results are not so striking, they are extremely interesting, a fourth section of their report, only published the other day, containing a careful description, with an outline drawing, of all the fish found in the Baltic.

The example set by America, Germany, and other Continental States we must follow. We have as a nation at last made a liberal acknowledgment of our ignorance, and at the conferences of the International Fisheries Exhibition expressed regret.

It is satisfactory that, while we are taking steps to increase our knowledge, we shall at one and the same time be improving our inshore fisheries. The measures necessary, *e.g.* for enabling us to discover for the first time when herring fry become maties, and when maties reach the stage of full herrings, are exactly the measures required for the artificial cultivation of the herring. From experience gained during the autumn we are now able to hatch immense numbers of herring; each herring produces from 30,000 to 50,000 eggs, but so small are they that 20,000 one layer thick can be placed on a square foot of glass, and from 1000 herrings it would be possible to obtain about 30,000,000 fry, and this in from ten to fifteen days. It is well known that where there is an abundance of herring there is also an abundance of cod and other food fish, hence the annual introduction of some millions of young herring into our territorial waters might serve to attract numerous large food fishes to our shores. And what is true of the herring holds for many other useful fishes, and some of them, such as the sole and turbot, which are less migratory than the herring, might be manipulated in much the same way as trout and salmon, if we only knew more of their habits.

In order to be able to carry on the work of investigation, the importance of which is now universally recognised, the Committee recommend that an application be made for sufficient funds to enable the Board to establish a marine station, and further that a steam vessel take the place of the *Vigilant* at present at the service of the Board.

The *Vigilant* is in every respect inadequate for the ordinary work of the Board, and if there is added to that work the acquiring of new knowledge as to the habits of our food fishes, the nature of their food, their time and place of spawning, and the way in which these may be influenced by the various modes of fishing, a steam vessel will be absolutely necessary.

The Committee have much pleasure in stating that they are deeply indebted to Lieut. Prickett, in command of H.M.S. *Jackal*, for the ready assistance rendered by him and his officers, and for their unfailing courtesy and kindness during the expedition.

They have also to state that it was a source of great satisfaction to them to find that the commander of the *Vigilant* was not only greatly interested in the work of the Committee, but that, having a strong instinct for scientific work, he will be able to render much assistance in any further investigations that may be undertaken.

To Mr. Romanes, F.R.S., the Committee are greatly indebted for many valuable suggestions, and they are also indebted for the use of the Marine Laboratory instituted some years ago by Mr. Romanes and Prof. Ewart. Without this laboratory much of the work which will form the substance of the forthcoming Report could not have been undertaken.

J. Cossar Ewart, Convener
J. R. Gibson-Maitland
A. Forbes Irvine
J. Maxtone Graham

Edinburgh, November 5

THE ORIGIN OF CORAL-REEFS

So much additional information has in recent years been obtained regarding the physical and biological conditions of the sea that such a problem as that presented by the coral-islands of mid-ocean may well be reconsidered. Several able naturalists have lately called attention to this problem, and have insisted that the generally received solution of it is not satisfactory. Among geologists there may not unreasonably be a good deal of unwillingness to admit that this contention can be well-founded. They have long been accustomed to regard Darwin's theory of coral-formation with justifiable pride as a masterpiece of exhaustive observation and brilliant generalisation. It has played an important part in their speculations regarding the larger movements of the earth's crust, and they have been so deeply impressed with its simplicity, and the grandeur of the conclusions to which it leads, that they will naturally and rightly refuse to surrender any portion of it save under the strongest compulsion of evidence. Some, indeed, may be inclined even to resent, almost with the warmth inspired by a personal injury, any attempt to show that it can no longer claim the general applicability which has been regarded as one of the strongest arguments in its favour. But the example of Darwin's own candour and overmastering love of truth remains to assure us that no one would have welcomed fresh discoveries more heartily than he, even should they lead to the setting aside of some of his own work. I propose to give here somewhat in detail the more important data accumulated in recent years on this subject, and to state the conclusions to which a careful consideration of the evidence seems to me inevitably to lead.

Before the memorable voyage of the *Beagle*, the generally received opinion regarding the origin of the circular coral-reefs or atolls of mid-ocean was that they had grown up on the rims of submerged volcanic craters. The enormous size of some of the atolls—thirty miles in diameter—might have been thought a sufficiently formidable objection to this explanation. But it did not appear insuperable even to so cautious a philosopher as Lyell, who only noticed it to refer his readers to the great dimensions reached by truncated volcanic cones, which he thought might retain their forms more easily under a deep sea than on land.[1]

An earlier and better theory, as Darwin admitted, had been started by Chamisso, who supposed that the circular form of an atoll was due to the fact that, as the more massive kinds of coral thrive most vigorously in the play of the surf, they naturally keep to the outside of the reef, and raise that portion to the surface

[1] "Principles of Geology," 4th edit. (1835), vol. iii. p. 310.

first. But when Darwin's own views were published, first in abstract before the Geological Society in 1837, and subsequently more fully in his separate volume on the Structure and Distribution of Coral-reefs in 1842, they were soon generally accepted, and were regarded not only as affording a satisfactory explanation of the whole phenomena, but as comprising one of the most impressive generalisations with which geology, fertile in such achievements, had yet astonished the world.

The theory proposed by Darwin, now so familiar, connected all the types of reef together as stages of one long process, every step in which could be illustrated by actual examples. At the one end stood the fringing-reefs, some of which might only lately have been started upon a recently upraised sea-bottom. Out of this stage, by continuous or intermittent subsidence, came barrier-reefs. Then as depression went on and the islands encircled by the barrier-reefs disappeared, their sites were taken by atolls. Lastly, where the rate of subsidence was too rapid for the upward growth of the corals, an atoll might become a submerged bank. Not only was this explanation self-consistent, but it harmonised well with the conclusion, derived from totally different evidence, that there may have been widespread and long-continued subsidence over the ocean basins. It was moreover supported by the independent testimony of competent observers, who, with at least equal opportunities of studying the subject, had espoused Darwin's views. Of these witnesses the most important was undoubtedly Prof. Dana, who accompanied the Wilkes Exploring Expedition of 1838-42.[1] Another powerful ally was found in Mr. Couthouy, who had studied coral-growth in the Pacific and in the West Indian seas.[2] But even without the concurrent testimony of eye-witnesses the theory proposed by Darwin fitted so admirably into the geological theory of the day that it came itself to be used as one of the most cogent proofs of vast oceanic depression. And such is still the position which it holds.

By a gradually widening circle of observation, however, a series of facts has been established, which were either not known or only partially known to Darwin. It should be borne in mind that, compared with more recent explorers, he did not enjoy a large opportunity of investigating coral-reefs. So far as can be judged from his published works, he appears to have examined only one atoll—the Keeling reef; and one barrier reef—that of Tahiti. The Admiralty charts, the work of previous voyagers, and unpublished information communicated to him, enabled him to extend his generalisation over the whole of the rest of the coral-regions which he had not personally explored. The deep-sea expeditions of recent years have now brought so much new light to bear on the whole question that we are in a much better position to discuss it than he was, nearly half a century ago. Of a few of the more important investigations a brief *résumé* may here be given, and their bearing upon Darwin's theory of coral-reefs will then be discussed.

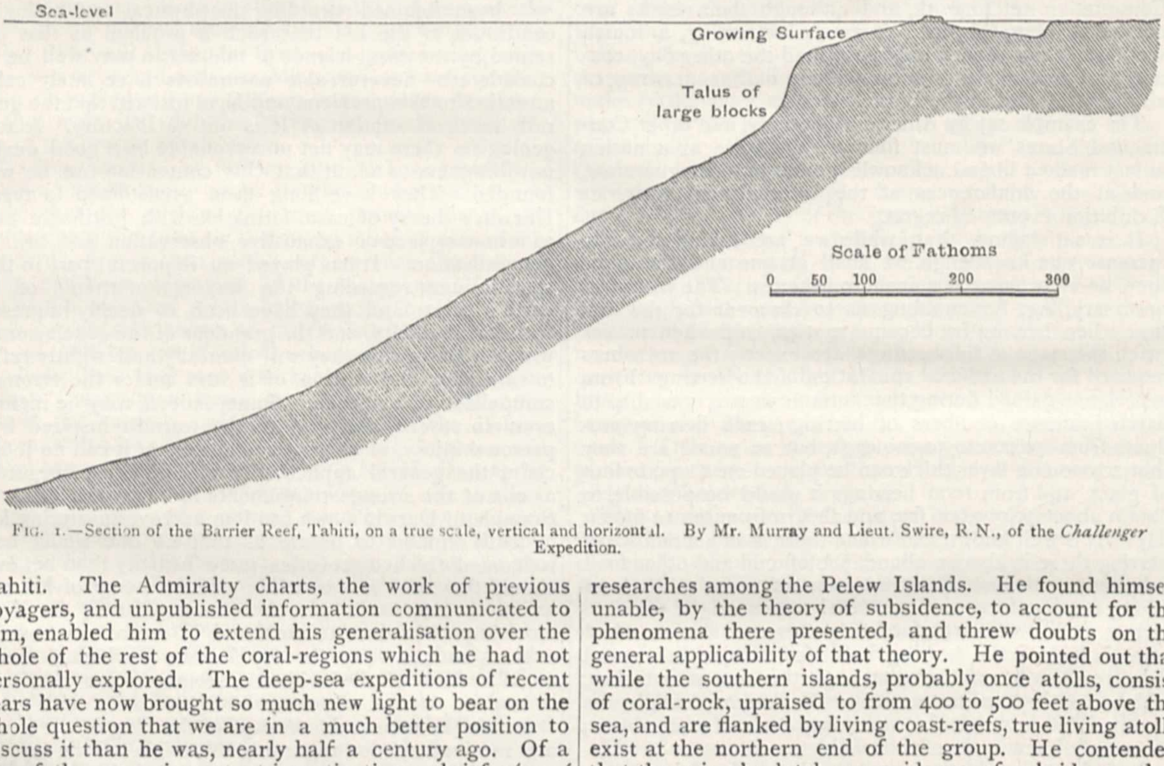

FIG. 1.—Section of the Barrier Reef, Tahiti, on a true scale, vertical and horizontal. By Mr. Murray and Lieut. Swire, R.N., of the *Challenger* Expedition.

As far back as the year 1851 the late L. Agassiz stated that, in his opinion, the theory of subsidence could not be applied in explanation of the Florida reefs; that on the contrary the southern end of Florida is built up on successive concentric barrier-reefs which have been gradually connected and cemented into continuous dry land by the accumulation of mud-flats between them, and that this process is still going on and must eventually convert the present keys and reefs from Cape Florida to the Tortugas into similar land.[1]

In 1863 Prof. Carl Semper published the results of his researches among the Pelew Islands. He found himself unable, by the theory of subsidence, to account for the phenomena there presented, and threw doubts on the general applicability of that theory. He pointed out that while the southern islands, probably once atolls, consist of coral-rock, upraised to from 400 to 500 feet above the sea, and are flanked by living coast-reefs, true living atolls exist at the northern end of the group. He contended that there is absolutely no evidence of subsidence, that the association of all the different kinds of reefs within so circumscribed an area seems entirely to disprove the notion of subsidence, and that, at least in this group of islands, Darwin's theory cannot be applied. In some suggestive observations on their probable origin, he remarks that the reefs depend mainly for their form upon the nature of the bottom on which they begin. Atolls are formed on submarine banks. A species of *Porites* takes root in little colonies varying from the size of the fist to masses six or eight feet in diameter. In time the central portions of these growing colonies die, while the outer

[1] *Bull. Mus. Comp. Zool.*, vol. i. See also J Le Conte, *Silliman's Journal*, xxiii. (1857), p. 46, and E. B. Hunt, *op. cit.* xxxv. (1863), p. 388.

[1] The narrative containing Prof. Dana's observations on coral-reefs was published among the Reports of the Expedition. In 1872 he published a volume on "Coral and Coral-Reefs," where he again gave the weight of his authority to the theory of subsidence.

[2] *Boston Journ. Nat. Hist.*, iv. (1843-44), p. 137.

parts flourish and gradually build up a ring of coral. This ring, which may be circular or elongated in form, is sometimes continuous, but more commonly is traversed by one or more channels. The interior portions are scoured out and deepened by the tidal currents. Or if the form of the bottom and other conditions be suitable, a great many individual masses of coral gradually grow into a more or less continuous reef, through which the strong ebb and flow of the tides serve to keep open some channels. Thus fringing-reefs, through the scour of the sea, become barrier-reefs, which retreat from the adjacent coast in proportion to the gentleness of the slope on which they are built. On a steeply shelving sea-bottom the reefs must obviously remain fringing-reefs.

Dr. Semper admitted that possibly many atolls and barrier-reefs were formed during subsidence, and even that the downward movement may in many cases have furnished the conditions for starting them into existence. The solution of the problem ought in each case, he thought, to be determined by actual detailed observation. But that the alternate currents of the tides are the main agents in the building of coral-reefs could be proved, he maintained, by many cases which, on the theory of subsidence, must be regarded as exceptional or inexplicable, such as the occurrence of true atolls in the midst of areas of elevation.[1]

In the second edition of his "Coral Islands," published in 1874, Darwin briefly referred to these observations. He thought it not improbable that the Pelew Islands originally subsided, were afterwards upraised, and again subsided, but admitted that the proximity of fringing-reefs was opposed to his views. He suggested that if the submarine slope were steep reefs which began as fringing-reefs would continue to be of that form, even during subsidence. There is, however, no admission that any valid objection had been made to his theory, or that true atolls and barrier-reefs might be formed in many places without subsidence.

In 1868 Prof. Semper reiterated his dissent from the prevailing theory of coral-reefs.[2] Next year he reprinted his original paper (which seemed to him to have remained unknown to most naturalists) in a general account of the Philippine Islands, wherein he appended some additional notes.[3] In one of these he refers to the observations of Pourtales and others on a submarine calcareous deposit which in some regions is slowly being upraised to serve as a foundation for coral-reefs. To the objection that if atolls and barrier-reefs could be formed during a period of elevation, they ought to be found not merely at, or only slightly above sea-level, he replies that they are not in fact confined to that limited zone, but that even if they were, this would not invalidate his conclusion that the reefs are due to a complex cooperation of coral-growth with the waves and currents of the sea, and not to the one cause—the subsidence of entire regions—invoked by Darwin.

In the following year another contribution to the anti-subsidence literature was made by Dr. J. J. Rein, who, in an interesting memoir on the physical geography of Bermuda, offered some observations on the coral-reefs of those islands.[4] He suggested that the Bermuda group might originally have been a submarine mountain or bank on which colonies of deep-water corals took root, and where other organisms flourished in such abundance as gradually to raise the top of the submerged ground to the zone in which reef-building corals could flourish. He adduced no evidence in support of this suggestion further than that there is no proof in Bermuda of subsidence,

[1] *Zeitsch. Wissensch. Zoologie*, 1863, xiii. p. 558. Reprinted in 1869 in "Die Philippinen und ihre Bewohner," with additional notes.

[2] *Verhandl. Physik-med. Gesellsch. Wurzburg; Sitzungsber.*, February 1, 1868.

[3] "Die Philippinen und ihre Bewohner." Würzburg, 1869, pp. 100-109. A brief account of the coral-reefs of the Philippine Islands will be found at pp. 19-33.

[4] *Bericht. Senckenberg. Naturforsch. Gesellsch.*, 1869-70, p. 157.

which, however, as Darwin had so cogently shown, from the very fact of the movement being downward, is in most cases not to be looked for.

An important memoir, marking a totally new departure in coral-reef literature, appeared in 1880 containing an abstract of observations made by Mr. Murray during the great voyage of the *Challenger*.[1] The chief features of this contribution may be thus briefly summarised:—With hardly an exception the oceanic islands are of volcanic origin, and it is therefore to be presumed that the submarine ridges and peaks, which rise to within various distances from the surface, are likewise due to the protrusion of volcanic materials. There is thus no actual evidence of the still unsubmerged portions of any extensive continent or mass of land such as Darwin's theory requires. Whether built up above the sea-level into islands, or brought up to varying heights below that level, the volcanic eminences of the ocean may conceivably be brought into the condition of platforms for reef-builders by two causes. In the first place the erosive force of waves and tidal scour must tend to reduce all prominent oceanic summits to the lower limit of breaker-action, and thereby to produce truncated cones or flattened domes and ridges on which coral-reefs, if not already established, might spring up. In the second place, submarine eminences may have been brought up to within the zone of the reef-builders by the deposit of organic detritus upon them. One of the most remarkable results of recent deep-sea exploration has been the accumulated evidence of the extraordinary profusion of pelagic life in the tropical surface waters. From experiments made during the cruise of the *Challenger*, Mr. Murray estimated that, if the organisms are as numerous down to a depth of 100 fathoms as they were found to be in the track of the tow-net, there must be more than sixteen tons of carbonate of lime in the form of calcareous shells in the uppermost hundred fathoms of every square mile of ocean. The shells and skeletons of these organisms fall in a constant rain to the bottom, where they supply some of the food needed by the fauna which there subsists upon the mud. By the accumulation partly of these superficial exuviæ, partly of the remains of the creatures living at the bottom, an organic deposit is growing over the sea-floor in the tropical regions wherein coral-reefs flourish. Owing probably to the greater solvent action of the increased proportion of carbonic acid in sea-water at great depths, or to the greater mass of water through which they must sink, the shells of the upper waters seem never to reach the bottom or at least soon disappear from it, for they are seldom met with in deep dredgings. But in shallower portions of the ocean they abound. Consequently it may be legitimately inferred that the rate of growth of the calcareous organic deposit on the sea-bottom must be more rapid in the shallower waters. The tops of submarine peaks and banks, being constantly heightened from this cause, will in course of time be brought up to a depth at which sponges, hydroids, deep-sea corals, annelids, alcyonarians, mollusks, polyzoa, echinoderms, and other organisms can flourish abundantly. When this has taken place, the upward growth of the calcareous formation will be accelerated by the accumulation of the remains of this abundant fauna as it lives and dies on the bottom. At last the zone of reef-building corals will be reached, and thereafter a growth of coral-rock will bring the sea-floor up to the level of low water. That coral-reefs undistinguishable from barrier-reefs and even atolls might be formed upon banks of sediment in a deep sea was admitted by Darwin.[2] But the assumption of so many submerged banks as this explanation would require, seemed to him so improbable that he dismissed it from further consideration. He was not aware, however, of the enormous abundance of minute cal-

[1] *Proc. Roy. Soc. Edin.* (1879-80). x. p. 505.

[2] "Coral Islands," 2nd edit. p. 118.

careous organisms in the surface waters and of the comparative rapidity with which these remains might be accumulated on the sea-bottom.

Reef-builders starting on a submarine bank, whether prepared for them by erosion, by subsidence, or by the upward growth of organic deposits, would form reefs that must necessarily tend to assume the atoll form. The central portions of the colony or clump of coral will gradually be placed at a disadvantage as compared with the peripheral parts of the mass in being further removed from the food-supply, and will consequently dwindle and die. In proportion as the reef approaches the sea-level these central parts are brought into increasingly uncongenial conditions, until at last an outer ring of vigorous, growing coral-reef encircles an inside lagoon overlying the central stunted and dead portions. The possibility of such a sequence of events was likewise recognised by Darwin. "If a bank, either of rock or of hardened sediment," he says, "lay a few fathoms submerged, the simple growth of the coral, without the aid of subsidence, would produce a structure scarcely to be distinguished from a true atoll."[1]

As the atoll increases in size the lagoon becomes proportionately larger, partly from its waters being less supplied with pelagic food and therefore less favourable to the growth of the more massive kinds of coral, partly from the injurious effects of calcareous sediment upon coral-growth there, and partly also from the solvent action of the carbonic acid of the sea-water upon the dead coral. The solution of dead calcareous organisms by sea-water is undoubtedly one of the most interesting facts brought to light by the naturalists of the *Challenger* Expedition.

Moreover, a connected chain of atolls might be formed on a long, submarine bank, and similar conditions of growth would then be displayed as in the case of a single atoll. The marginal atolls having a better supply of food would grow more vigorously than those towards the centre, and would tend to assume elongated forms, according to the shape of the bank beneath them. Many of them might coalesce, and might even ultimately give rise to one large atoll. Such a chain of atolls as that of the great Maldive group may be thus explained without the necessity for any disseverment by oceanic currents as Darwin supposed. On the other hand, the submerged coral-banks of the Lakadivh, Caroline, and Chagos archipelagos may be regarded as representing various stages in the growth of coral-reefs, some of them being still too deep for reef-builders, others with coral-reefs which have not yet quite grown up to the surface. But scattered among these banks are some of the most completely formed atolls. Mr. Murray contends that it is difficult to conceive how such banks can have been due to subsidence, when their situation with respect to each other and to the perfect atolls is considered. He reverses the order of growth as given by Darwin, who cited the great Chagos bank as probably an example of an atoll which had been carried down by a subsidence more rapid than the rate at which the corals could build upwards.

From a careful study of barrier-reefs Mr. Murray concludes that, in their case also, all the phenomena can be explained without having recourse to subsidence. He found from personal observation and a comparison of the Admiralty charts that most exaggerated notions prevail regarding the depth of water immediately outside the reef, which is usually supposed to be very great. After minutely exploring the barrier-reef of Tahiti, and sounding the water both inside and outside the reefs, he found that the slopes are just such as might be looked for on the supposition that the corals have grown up without any sinking of the bottom. The accompanying section (Fig. 1), drawn to a true scale will show that there is nothing abnormal in the declivities. Beginning near the shore or wherever the bottom whether of rock or sediment comes within the range of the reef-builders, a barrier-reef grows vigorously along its outer face, while its inner parts, as in the case of an atoll and for the same reason, are enfeebled and die. The force of the breakers tears off huge masses, sometimes 20 or 30 feet long, from the face of the reef, especially where from the borings of mollusks, sponges, &c., the coral-rock has been weakened. These blocks tumble down the seaward face of the reef, forming a remarkably steep talus. It is this precipitous part of the reef which has probably given rise to the notion that the water outside suddenly descends to a profound depth. The steep front of fallen blocks is succeeded by a declivity covered with coral sand, beyond which the bottom slopes away at an angle of no more than 6°, and is covered chiefly with volcanic detritus. Mr. Murray insists that any seaward extension of the reef must be on the summit of the talus of broken coral. The reef will gradually recede from the shore of the island or continent, and will leave behind here and there a remnant to form an island in the slowly broadening lagoon-channel.

[1] *Op. cit.* p. 134.

The very general occurrence of proofs of elevation among the regions of barrier-reefs and atolls is in harmony with the volcanic origin of the ground on which these coral-formations have grown, but is, as Mr. Murray contends, most difficult of explanation on the theory of widespread subsidence. He affirms that all the chief features of coral-reefs and islands not only do not necessarily demand the hypothesis of subsidence, but may be satisfactorily accounted for, even in areas where the movement is an upward one, by the vigorous outward growth of the corals on the external faces of the reef in presence of abundant food, by their death, disintegration, and removal by the mechanical and chemical action of the sea in the inner parts, and by the influence of subaërial agencies and breaker-action in lowering the level of the upraised areas of coral-rock. ARCH. GEIKIE

(*To be continued.*)

NOTES

It will be seen from our Diary that the meeting of the Linnean Society on December 6 is to be exclusively devoted to the reading of a posthumous essay on Instinct by the late Mr. Darwin. We are informed that this essay is full of important and hitherto unpublished matter with regard to the facts of animal instinct considered in the light of the theory of natural selection; and as the existence of the essay has only now been divulged, we doubt not that the next meeting of the Linnean Society will be of an unusually interesting character.

The death is announced, at the age of seventy-six, of Mr. John Eliot Howard, F.R.S., well known as a chemist and quinologist. He was the son of Mr. Luke Howard, F.R.S., a well-known meteorologist in his day.

We announced some time ago that the Finnish Senate had voted a sum of 37,000 marks to Prof. Lemström for the continuation of his experiments with the aurora borealis at Sodankylä in the Finnish Lappmark during 1882–83, of which he gave an account in NATURE (vol. xxvii. p. 389). The plan to be followed during the present winter at this station is to make observations three times in every twenty-four hours, with the exception only of the first and fifteenth of every month, when they are made every five minutes throughout the twenty-four hours, and three days of the month when they will be effected every half minute during two hours. In order partly to obtain the necessary data for the control of the variation of the current from the atmosphere with the latitude, and partly to reduce the effect of probable influences, a branch station will be temporarily established during the months of November, December, January, February, and part of March at the buildings of the Kultala gold works, some distance from the principal station at Sodankylä. At Kultala exhaustive experiments will be made as to the effect which the increase of the area of the "utströmnings" apparatus, invented by Prof. Lemström for producing the aurora borealis, has on the intensity of the current. The observations will in other respects be the same at both stations. At Sodankylä they will be continued until September 1, 1884.

THE Report by the Board of Trade on their Proceedings and Business under the Weights and Measures Act, 1878, for the past year has been issued. The following are some of the leading points in the Report: During the past year the Standards Department has had the opportunity of assisting the United States Government in a comparison of their standard of length (Yard No. 57), with the standards at this office. Prof. C. S. Peirce, of the United States Coast and Geodetic Survey, came to London for this purpose in June last, on behalf of Prof. J. E. Hilgard, who has charge of the Bureau of Weights and Measures at Washington. A large number of comparisons of these measures was made with all possible care, and it was found that at 62° F., Yard No. 57 was 0·000022 inch longer than the Yard No. 1 deposited at this office. The results of these comparisons, as calculated by Prof. Peirce, will be referred to in a printed memorandum which will be separately drawn up. It was found necessary to test the accuracy of the standard kilogram, and the only resource was to apply to the Comité International des Poids et Mesures for permission to compare the British standard kilogram with that deposited at their bureau near Paris. By the report of this comparison, it is seen that our standard kilogram is now 2·0178 milligrams too light. The Report rather naïvely points out that, but for the courtesy of the Comité, the Standards Department would have been unable to re-verify our unit of metric weight, as this country is not represented on the Comité, and consequently does not contribute towards its expenses. In a previous Report it is also pointed out that the Board of Trade had been then able to avail itself of the results of the scientific researches which had been carried out under the directions of the Bureau. A note on the instrumental equipment of the Bureau of the Comité International is attached to the Report; of the equipment of this Bureau we recently gave a detailed description. The tables of densities and expansions hitherto in use at the Standards Office not having been found entirely in accord with the most recent scientific research, new tables have been drawn up for future use in the accurate comparisons of standards of measure and weight, and these are given in the Appendix. At the last annual trial of the pyx, the Report states, the differences in weight and fineness of the new coins then submitted for testing were again found to be far within the legal amounts allowed, *particularly on those allowed in the fineness of the gold coin.* With reference to the Electric Lighting Act, the Report remarks that with the advance of science there arise from time to time measures and weights of new forms and denominations which, in their application to commercial purposes, subsequently receive the sanction and force of legislative enactment. Among the most important of such new measures are those for the measurement of mechanical and of electrical energy, as applied to the measurement of electricity under the Electric Lighting Act of last year. A present unit of measurement has been taken in Provisional Orders under this Act, which is equivalent to "the energy contained in a current of 1000 amperes flowing under an electromotive force of one volt during one hour." No practical meter of electricity capable of use in commerce and daily life has yet received official sanction. The Report and Appendices show that Mr. Chaney continues the work of his office as efficiently as his means will permit.

AT the last sitting of the Academy of Sciences M. Pasteur read and commented on a posthumous paper by Dr. Thuilier his pupil, who died in Alexandria, where he was sent in August, in order to make observations on cholera. The late Dr. Thuilier takes an intermediate position between M. Pasteur and M. Bouchardat. M. Pasteur seems not to be quite opposed to the views of his pupil.

THE German Cholera Commission are going, not, as they originally intended, to Bombay, but to Calcutta, as they consider the latter place more suitable for their investigations.

IN an official pamphlet published at Washington there is an interesting sketch of the work and history of the United States Bureau of Education. Not only does the Bureau publish reports on education in the United States, but at frequent intervals issues "Circulars of Information" containing data of great value, and in many cases not otherwise accessible. Among other things these circulars contain information on the systems of education in nearly every civilised country, including China; the pamphlet referred to contains a useful list of all the circulars issued, with their contents.

IN the report by Dr. Daniel Draper on the New York Meteorological Observatory for 1882, it is shown that the actual hours of sunshine at Greenwich Observatory were 1245 in 1878 and 977 in 1879, when the possible hours were 4447; whereas at New York in the former year the actual hours were 2936, and in the latter 3101, when the possible hours were 4449.

THE "Howard" Medal of the Statistical Society for 1883, with a prize of 20*l.*, has been awarded to Dr. R. D. R. Sweeting, S.Sc. Cert. Camb., Medical Superintendent of the Western District Fever Hospital, Fulham, for the best essay on "The experiences and opinions of John Howard on the preservation and improvement of the health of the inmates of schools, prisons, workhouses, hospitals, and other public institutions, as far as health is affected by structural arrangements relating to supplies of air and water, drainage," &c.

THE cultivation of Sorghum (*S. saccharatum*) and the manufacture of sugar from its stems has of late occupied a large share of attention by the Government in America, reports on which have been issued at different times. The most recent of these is an "Investigation of the Scientific and Economic Relations of the Sorghum Sugar Industry." This is in the form of a report drawn up by the committee of the National Academy of Sciences, in which the subject of the cultivation, production, and manufacture of the sugar is treated in considerable detail. The report is one of considerable value, especially to those interested in the progress of this industry.

FROM Dr. King's Annual Report of the Royal Botanic Garden, Calcutta, for the year 1882–83, and Mr. J. F. Duthie's Report of the Government Botanical Gardens at Saharunpur and Mussoorie for the year ending March 31, 1883, both of which have recently reached us, we learn something of the progress of botany at these botanical centres in India. It is satisfactory to note that at Calcutta considerable improvements have been effected during the year, not only in the general arrangements of the garden itself but also in the scientific department, for Dr. King informs us that "the bamboo and mat erections which used to do duty as conservatories have been replaced by three large, handsome, and efficient structures of iron, on which a thin thatch of grass is spread, and under shelter of which tropical plants thrive admirably." As usual at Calcutta considerable attention has been given to various economic plants, notably those which produce the valuable article indiarubber, and which have occupied so much attention of late. Dr. King says the cultivation of the soy bean of Japan (*Glycine soja*) has of late been pressed on the people of India, and "more in obedience to the loudness o this clamour than from a belief in its soundness" he has arranged for a supply of the beans from Japan, which he proposes to distribute extensively for trial. Much consideration has also been given to the utilisation of the various fibrous plants. In the Lloyd Botanic Garden, Darjeeling, much damage continued to be done by the cockchafer grubs until pretty nearly every plant in the garden was killed. "The whole of the grass in the garden and all herbaceous plants rapidly succumbed to its ravages, as did many of the flowering shrubs, only the deeper rooting shrubs and trees being spared. Even the plants in the conservatories did not altogether escape; eggs of the insect having got in considerable numbers into the soil of the pots." In response to vigorous efforts to exterminate this plague about six millions of the grubs were collected and destroyed by the garden labourers, so that at the time of writing the Report it was showing signs of disappearing. In Mr. Duthie's Report it is satisfactory to find that economic plants, as at Calcutta, are largely cared for, and that the cultivation of medicinal plants and the preparation of drugs from them is being proceeded with. Amongst these may be mentioned Alexandrian senna (*Cassia acutifolia*), henbane (*Hyoscyamus niger*), belladonna (*Atropa belladonna*), &c. Additions are also being constantly made to the museum.

PART VI. of the "Herefordshire Pomona" has been issued, and Part vii. and last will be published in the autumn of next year, after the Congress and Exhibition of the Pomological Society of France, to be held at Rouen in October.

IN the *Japan Mail* of August 23 and September 24, Mr. E. Knipping describes the course of two storms which occurred, one on August 17 to 20, and the other September 11 to 14. These descriptions show how very completely the Japan meteorological service is organised, and that good work is being done in the Far East in collecting data for scientific meteorology.

MESSRS. MACMILLAN AND CO. have published as one of their "NATURE Series" volumes, Drs. Gladstone and Tribe's "Chemistry of the Secondary Batteries of Planté and Faure." "About Photography and Photographers" is the title of an interesting gossipy little volume by Mr. H. Baden Pritchard, published by Messrs. Piper and Carter.

MISS J. M. HAYWARD wishes to state with reference to Mr. Denning's letter (p. 56) that she did give the hour (10.30) at which her letter was written, with the date, at the end. She adds that a clock struck ten shortly before she saw the meteor; but she thinks the clock was probably slow, as it generally is. She has no doubt it was the same meteor as that seen at Bath, Bristol, and Chelmsford about the same time.

THE additions to the Zoological Society's Gardens during the past week include two Bonnet Monkeys (*Macacus sinicus*) from India, presented respectively by Mr. H. G. Rose and Miss Morant; a Common Fox (*Canis vulpes*), British, presented by Mr. H. Vaughan; two Bullfinches (*Pyrrhula europæa*), European, presented by Mr. Archibald Aitchison; four Moorish Toads (*Bufo mauritanicus*) from Tunis, presented by Mr. Frederick Bridges; twelve Ruffe, or Pope (*Acerina cernua*) from British waters, presented by Mr. T. E. Gunn; two Michie's Tufted Deer (*Elaphodus michianus* ♂ ♀), a Chinese Water Deer (*Hydropotes inermis*), two Elliot's Pheasants (*Phasianus ellioti*) from China, deposited; six Coal Titmice (*Parus ater*), British, purchased; a Spotted Ichneumon (*Herpestes nepalensis*) from Nepal, five Blue-crowned Hanging Parrakeets (*Loriculus galgulus*) from Malacca, received in exchange.

OUR ASTRONOMICAL COLUMN

PONS' COMET.—Mr. S. C. Chandler has communicated to the *Astronomische Nachrichten* his own experiences at the Observatory of Harvard College with reference to the remarkable increase in the brightness of this comet on September 22, which has been already mentioned in NATURE (vol. xxviii. p. 624). He observed with an aperture of 6¼ inches. On September 21, between 8h. 55m. and 11h. M.T. he found the comet very faint and diffuse; the central condensation or nucleus about equal to a star of 11 m. On September 22, about 7h. M.T. he was astonished to find exactly in its place a bright, clearly-defined 8 or 8½ mag. star without sensible trace of nebulosity, except with a power of only 50, giving a field of 1¼ degrees, and even with that not noticeable except with attention. It was so distinctly stellar an object that an experienced observer might have failed to distinguish it from stars of similar brightness in the neighbourhood. On September 23, at 7h. 30m., he found the physical appearance again greatly changed. The nucleus seemed spread out into a confused bright disk about a half minute (arc) in diameter, outside of which was a nebulous envelope much brighter than on the preceding night, and about one minute and a half in diameter. The comet was judged to be a half magnitude brighter than on September 22. On September 25 it appeared spread out into a confused disk two minutes in diameter, a faint nucleus or concentration of light not brighter than 11 m. So rapid an increase and diminution of light is a very unusual phenomenon; Mr. Chandler thinks that phases of this kind may be characteristic of the comet's mode of light development, as the same variation was repeated on a smaller scale on October 15, when a nucleus of about 9·3 m. appeared, which gradually dissipated on the following evenings, through expansion into the general nebulosity. The comet's distance from the sun when Mr. Chandler remarked the great increase of brightness was 2·18, the earth's mean distance being taken as unity, not the least surprising condition in the case.

In the same number of the *Astronomische Nachrichten* Prof. Schiaparelli gives some account of his observations on the physical appearance of the comet at Milan, which are of much interest in connection with those of Mr. Chandler. On September 22 he found the comet about 3′ in diameter, faint and diffuse, the nucleus about 13m., but the sky was not perfectly clear; the observations for position were made at 8h. 30m. M.T. On September 23, about 8h. 13m., the comet had increased in brightness since the previous evening in an extraordinary manner; it now appeared as a star of 8 m., with a very faint surrounding nebulosity of from 1′ to 1½′ diameter. The central part was not exactly a luminous point, but had a sensible diameter and indistinct outline. On the 25th it was still bright, but the nucleus of the 23rd had spread out so as to form a circular nebulosity 3′ in diameter, without notable central condensation.

Comparing the Milan and Harvard observations, it would appear that the rapid increase in the light of the comet took place between September 22, at 7h. 45m. and 11h. 45m. Greenwich mean time; it remains to be seen how observations elsewhere will accord with this inference. Mr. Chandler suspected, from a comparison of his own notes with those made by the observers at Kiel and Vienna, that the increase would be found to have taken place between the European and American observations on September 22.

M. Bigourdan, of Paris, says on November 19, "The comet is a nebulosity of from sixth to seventh magnitude, with nucleus: the brightest part of the coma, that which borders on the nucleus, is not symmetrical about it; it is less extended in the angle 110°—140°, and is brightest in the angle 280°—290°." Taking the comet's theoretical intensity of light on November 19 as unity, the intensity on December 31 will be 9·5, and on January 14 (when it is at its maximum), 13·0. In the absence of moonlight the comet must be, for some time, a naked eye object.

THE GENERAL THEORY OF THERMODYNAMICS

THE first of the six lectures on "Heat in its Mechanical Applications" at the Institution of Civil Engineers was delivered on November 15 by Prof. Osborne Reynolds, M.A., F.R.S., the subject being as given in the title. The following is an abstract of the lecture:—

Thermodynamics, Prof. Reynolds said, was a very difficult subject. The reasoning involved was such as could only be expressed in mathematical language; but this alone would not prevent the leading facts and features of the subject being expressed in popular language. The physical theories of astronomy, light, and sound involved even more mathematical complexities than thermodynamics, but these subjects had been rendered popular, and this to the great improvement of the theories.

What rendered the subject of thermodynamics so obscure was that it dealt with a thing or entity (heat) which, although its effects could be recognised and measured, was yet of such a nature that its mode of operation could not be perceived by any of our senses. Had clocks been a work of nature, and had the mechanism been so small that it was absolutely imperceptible, Galileo, instead of having to invent a machine to perform a definite function, would have had, from the observed motion of the hands, to discover the mechanical principles and actions involved. Such an effort would have been strictly parallel to that required for the discovery of the mechanical principles of which the phenomena of heat were the result.

In the imagined case of the clock, the discovery might have been made in two ways. By the scientific method: from the observed motion of the hands the fact that the clock depended on a uniform intermittent motion would have led to the discovery of the principle of the uniformity of the period of vibrating bodies; and on this principle the whole theory of dynamics might have been founded. Such a theory of mechanics would have been as obscure but not more obscure than the theory of thermodynamics based on its two laws. But there was another method; and it was by this that the theory of dynamics was brought to light—to invent an artificial clock, the action of which could be seen. It was from the actual pendulum that the principles of the constancy of the periods of oscillating and revolving bodies were discovered, whence followed the dynamical theories of astronomy, of light, and of sound.

As regarded the action of heat, no visible mechanical contrivance was discovered which would afford an example of the mechanical principles and motions involved, so that the only apparent method was to discover by experiment the laws of the action of heat, and to accept these as axiomatic laws without forming any mental image of their dynamical origin. This was what the present theory of thermodynamics purported to be.

In this form the theory was purely mathematical and not fit for the subject of a lecture. But as no one who had studied the subject doubted for one moment the mechanical origin of these laws, Prof. Reynolds would be following the spirit if not the letter of his subject, if he introduced a conception of the mechanical actions from which these laws sprang. This he should do, although he doubted if he should have so ventured, had it not been that while considering this lecture he hit upon certain mechanical contrivances, which he would call kinetic engines, which afforded visible examples of the mechanical action of heat, in the same sense as the pendulum was a visible example of the same principles as those involved in the phenomena of light and sound. Such machines, thanks to the ready help of Mr. Foster his assistant in constructing the apparatus, he should show, and he could not but hope that these kinetic engines might remove the source of the obscurity of thermodynamics on which he had dwelt.

The general action of heat to cause matter to expand was sufficiently obvious and popularly known; also that the expanding matter could do work was sufficiently obvious. But the part which the heat played in doing this work was very obscure.

It was known that heat played two, or it might be said three, distinct mechanical parts in doing this work.

These parts were:—

1. To supply the energy necessary to the performance of work.

2. To give to the matter the elasticity which enabled it to expand—to convert the inert matter into an acting machine.

3. To convey itself, *i.e.* heat, in and out of the matter.

This third function was generally taken for granted in the theory of thermodynamics, although it had an important place in all applications of this theory.

The idea of making a kinetic engine which should be an example of action such as heat, had no sooner occurred to him than various very simple means presented themselves. Heat was transformed by the expansion of the matter caused by heat.

At first he tried to invent some mechanical arrangement which would expand when promiscuous agitation was imparted to its parts, but contraction seemed easier—this was as good. All that was wanted was a mechanism which would change its shape, doing work when its parts were thrown into a state of agitation.

In order to raise a bucket from a well either the rope was pulled or the windlass wound—such a machine did not act by promiscuous agitation; but if the rope was a heavy one (a chain was better) and it was made fast at the top of the well so that it just suspended the bucket, then if it was shaken from the top waves or wriggles would run down the rope until the whole chain had assumed a continually changing sinuous form. And since the rope could not stretch, it could not reach so far down the well with its sinuosities as when straight, so that the bucket would be somewhat raised and work done by promiscuous agitation. The chain would have changed its mechanical character, and from being a rigid tie in a vertical direction would possess kinetic elasticity, *i.e.* elasticity in virtue of the motion of its parts, causing it to contract its vertical length against the weight of the bucket. Now it was easy to see in this case that to perform this operation the work spent in shaking the rope performed the two parts of imparting energy of motion to the chain and raising the bucket. A certain amount of energy of agitation in the chain would be necessary to cause it to raise a bucket of a certain weight through a certain distance, and the relation which the energy of agitation bore to the work done in raising the bucket followed a law which if expressed would coincide exactly with the second law of thermodynamics. The energy of agitation imparted to the chain was virtually as much spent as the actual work in raising the bucket, that was to say, neither of these energies could be used over again. If it was wanted to do further work the raised bucket was taken off, and then to get the chain down again it must be allowed to cool, *i.e.* the agitation must be allowed to die out; then attaching another bucket, it would be necessary to supply the same energy over again.

He had other methods besides the simple chain which served better to illustrate the lecture, but the principle was the same.

In one there was a complete engine with a working pump. By mere agitation the bucket of the pump rose, lifting 5 lbs. of water one foot high; before it would make another stroke the agitated medium must be cooled, *i.e.* the energy which caused the elasticity must be taken out, then the bucket descended, and, being agitated again, made another stroke.

He felt that there was a childish simplicity about these kinetic engines, which might at first raise the feeling of "Abana and Pharpar" in the minds of some of his hearers. But this would be only till they realised that it was not now attempted to make the best machine to raise the bucket, but a machine that would raise the bucket by shaking. These kinetic engines were no mere illustrations or analogy of the action of heat, but were instances of the action of the same principles. The sensible energy in the shaking rope only differed in scale from the energy of heat in a metal bar. The temperature of the bar, ascertained from absolute zero, measured the mean square of the velocity of its parts multiplied by some constant depending on the mass of these parts. So the mean square of the velocity of the links of the chain multiplied by the weight per foot of the chain really represented the energy of visible agitation in the chain.

The waves of the sea constituted a source of energy in the form of sensible agitation; but this energy could not be used to work continuously one of these kinetic machines, for exactly the same reason as the heat in the bodies at the mean temperature of the earth's surface could not be used to work heat-engines.

A chain attached to a ship's mast in a rough sea would become elastic with agitation, but this elasticity could not be used to raise cargo out of the hold, because it would be a constant quantity as long as the roughness of the sea lasted.

Besides the waves of the sea there was no other source of sensible agitation, so there had been no demand for kinetic engines. Had it been otherwise, they would not have been left for him to discover—or, had they been, he might have been tempted to patent the inventions. But there had been a demand for what might be called sensible kinetic elasticity to perform for sensible motion the part which heat-elasticity performed in the thermometer.

And it had not been left for him to invent kinetic mechanism for this purpose, although it might be that its semblance to the thermometer had not been recognised. The principle was long ago applied by Watt. The common form of governors of a steam-engine acted by kinetic elasticity, which elasticity, depending on the speed at which the governors were driven, caused them to contract as the speed increased. The governor measured by contraction the velocity of the engine, while the thermometer measured by expansion the velocity in the particles of matter which surrounded it; so that it could now be seen that having to perform two operations, the one on a visible scale, the other on a molecular scale, the same class of mechanism had been unconsciously adopted in performing both operations.

The purpose for which these kinetic engines was put forward was not that they might be expected to simplify the theory of thermodynamics, but that they might show what was being done. The theory of thermodynamics could be deduced by the laws of motion from any one of these kinetic engines, just as Rankine deduced it from the hypotheses of molecular vortices.

Nothing had yet been said of the third part which heat played in performing work, namely, conveying heat in and out of matter. It was an innovation to introduce such considerations into the subject of thermodynamics, but it properly had a place in the theory of heat-engines. It was on this part that the speed at which an engine would perform work depended.

The kinetic machines showed this. If one end of a chain was shaken, the wriggle ran along with a definite speed, so that a definite interval must elapse before sufficient agitation was established to raise the bucket; further, an interval must elapse before the agitation could be withdrawn, so that the bucket might be lowered for another stroke. The kinetic machine, with the pump, could only work at a given rate. He could increase this rate by shaking harder, but then he expended more energy in proportion to the work done. This exactly corresponded with what went on in the steam-engine, only owing to the use of separate vessels, the boiler, cylinder, and condensers, the connection was much confused. But it was clear that for every h.p. (2,000,000 ft.-lbs. per hour) 15,000,000 ft.-lbs. had to be passed from the furnace into the boiler, as out of the 15,000,000 no more than 2,000,000 could be used for work; the remaining 13,000,000 were available for forcing the heat into the boiler and out of the steam in the condenser, and they were usefully employed for this purpose.

The boilers were made as small as sufficed to produce steam, and this size was determined by the difference of the internal temperatures of the gases in the furnaces, and the water in the boiler; and whatever diminished this difference would necessarily increase the size of the heating surface required, *i.e.* the weight of the engine. The power which this difference of temperature represented could not be used in the steam-engine, so it was usefully employed in diminishing the size of the engine.

Most of this power, which in the steam-engine was at least eight times the power used, was spent in getting the heat from the gases into the metal plates, for gas acted the part of conveyance far less readily than boiling water or condensing steam. If air had to be heated inside the boiler and cooled in the condenser with the same difference of temperature, there would be required thirty or forty times the heating surface—a conclusion which sufficiently explained why attempts to substitute hot air for steam had failed. In one respect the hot-air engines had an advantage over the steam-engine. During the operation in the cylinder the heat was wanted to be kept in the acting substance; this was easy with air, for it was such a bad conductor of heat, that unless it was in a violent state of internal agitation it would lose heat but slowly, although at a temperature of 1000 degrees and the cylinder cold.

Steam, on the other hand, condensed so readily that the temperature of the cylinder must be kept above that of the steam. It was this fact which limited the temperature at which steam could be used. Thus, while hot air failed on account of time economy, the practical limit of the economy of steam was fixed by the temperature which a cylinder would bear. These facts were mentioned because at the present time there appeared to be the dawn of substituting combustion-engines in place of steam-engines.

Combustion-engines, in the shape of guns, were the oldest form of steam-engine. In these, the time required for heating the expansive agent was zero, while they had the advantage of incondensible gas in the cylinder, so that if the cylinder was kept cool it cooled the gas but slightly, although this was some 3000 degrees in temperature.

The disadvantage of these engines was that the hot gas was not sufficiently cooled by expansion, but a considerable amount of the heat carried away might be used again could it be extracted and put into the fresh charge; to do this, however, would introduce the difficulty of heating-surface in an aggravated form. However, supposing the cannon to have been tamed and coal and oxygen from the air to be used instead of gunpowder. Thermodynamics showed that such engines should still have a wide margin of economy over steam-engines, besides the advantage of working with a cold cylinder and at an unlimited speed. The present achievement of the gas-engine, stated to be some 2,000,000 ft.-lbs. per lb. of coke, looked very promising, and it was thus not unimportant to notice that whatever the art difficulties might be, thermodynamics showed no barrier to further economy in this direction, such as that which appeared not far ahead of what was already accomplished with steam-engines.

But however this might be, he protested against the view which seemed somewhat largely held that the steam-engine was only a semi-barbarous machine, which wasted ten times as much heat as is used—very well for those who knew no science, but only waiting until those better educated had time to turn their attention to practical matters, and then to give place to something better. Thermodynamics showed the perfections not the faults of the steam-engine, in which all the heat was used, and could only enhance the admiration in which the work of those must be held who gave, not only the steam-engine, but the embodiment of the science of heat.

PROFESSOR AUGUST WEISMANN ON THE SEXUAL CELLS OF THE HYDROMEDUSÆ[1]

PROF. WEISMANN of Freiburg is most highly skilled and most indefatigable in research, and all the memoirs which he publishes are of extreme scientific importance, and abound in original views and suggestions which render them of peculiar and widely spread interest. His "Studien zur Descendenz Théorie," his researches on the Daphnoids and on the fauna of Lake Constance, which are known to all naturalists, may be mentioned as examples of his work. Since the spring of 1878 till the present year he has been engaged in investigating the mode of origin of the gonad elements of the Hydromedusæ, and the results are embodied in the present splendid work, which consists of a volume of text of about 300 pages quarto and twenty-four most beautifully executed coloured plates, the whole representing a vast amount of laborious research. Some portions of the results have already appeared in short preliminary papers, but they form a very small instalment of what is here put forth. In the course of the investigation, which has extended to thirty-eight species of Hydromedusæ, important new observations on the habits and composition of Hydroid colonies generally and on their histology were made, and the results of these are fully described here, since most of them have a direct bearing on the elucidation of the main subject of the monograph. The work thus forms secondarily, as stated in the title-page, "a contribution to the knowledge of the structure and vital phenomena of the Hydromedusæ generally."

The principal value of the work, however, lies in the importance of the bearings of the results of the investigations detailed in it upon the general question of the origin of gonad cells. The Hydromedusæ were selected as the subject of research because they appeared to be of all groups of the animal kingdom best adapted for the purpose both because of the transparent nature of their tissues and because they present in closely allied forms so many remarkable differences in the development of the gonad elements.

The work commences with an historical introduction, which can be but briefly referred to here. The question of the origin of the sexual elements in the Hydroida has undergone several important transformations. Prof. Huxley, when he first defined the body of the Medusa as consisting of two layers of tissue—ectoderm and endoderm, raised the question in which of the two layers do the gonad elements originate, and at first concluded that they were formed between the two, and subsequently in 1859, from physiological considerations mainly, that they must originate in the ectoderm. As soon as the advance of histological method permitted accurate direct observation to be made on the matter, Keferstein and Ehlers showed that in the Siphonophora with well developed medusoid sexual individuals, the Calycophoridæ and male Physophoridæ, the germinal cells are developed in what is now recognised as the ectoderm of the manubrium;

[1] "Die Entstehung der Sexualzellen bei den Hydromedusen." Zugleich ein Beitrag zur Kenntniss des Baues und der Lebenserscheinungen dieser Gruppe, von Dr. August Weismann, Professor in Freiburg-i-Br. (Jena: G. Fischer, 1883.)

whilst in the female Physophoridæ the origin of the single ovum is different (in the endocodon). As soon as the homogeny of the two layers of the Cœlenterata with the two primitive layers of the higher Metazoa became evident, the question arose whether the germinal cells of the Metazoa generally were of ectodermal or endodermal origin, and a large number of observers attempted to settle the question offhand by investigating the process of development of the germinal cells in some one Cœlenterate. Each assumed that his particular results must hold good for the entire group, and as the results were conflicting—the place of first appearance of the germinal cells lying as is well known in some Cœlenterates in the ectoderm and in others in the endoderm—much confusion arose. At this period, E. van Beneden's memoir appeared which, on the strength of the conditions occurring in a Hydractinia, a Campanularia, and a Clava, started the theory that the germ layers were themselves sexually differentiated, the female elements arising from the endoderm and the male from the ectoderm, and that in the union of a derivative of each layer lay the essence of impregnation, the necessary precursor of reproduction. This brilliant conception was soon shown by further observation to be erroneous, and as Prof. Weismann points out it was from the first not in accordance with the phenomena of parthenogenesis. As the next important phase in the question came the attempt of the brothers Hertwig to prove that the Cœlenterata belong to two distinct stocks, the one consisting of the Anthozoa and Scyphomedusæ, in which the germinal cells are derived from the endoderm (Endocarpæ), and the other of the Hydromedusæ and Ctenophora, in which they originate from the ectoderm (Ectocarpæ). If this position be correct, and, as will be seen in the sequel, one of the most startling of the conclusions arrived at in the present work is that, notwithstanding all the apparent evidence to the contrary, it probably is so in reality, then the important principle of inheritance and continuity in development in the germ layers receives a strong support, of which with regard to the gonad elements it seemed in great need. Prof. Weismann was led to undertake the present prolonged researches by his observing that in certain of the Hydromedusæ the germinal cells originate, not in the sexual individuals themselves nor even in the blastostyles that support them, but in the cœnosarc of the colony, in the common parenchym of the stem and its branches, and that this occurs not only in the case of the female but also in some instances in that of the male germinal cells. The existence of ovicells of cœnosarcal origin had been previously observed by Quatrefages, F. E. Schultze, Fraipont, and others, but these elements had not been recognised as the sole source of supply of the female gonophores with ova. E. van Beneden further had observed the origin of the egg-cells in Hydractinia, in that part of the blastostyle which subsequently becomes evaginated to form the gonophore. Kleinenberg published his account of his discovery of the migration of the egg-cells of Eudendrium from the ectoderm into the endoderm and in the opposite direction just before Weismann had arrived at a similar conclusion and had found in his preparations egg-cells in the act of boring through the basement membrane with one half lying in the ectoderm and the other in the endoderm. The establishment of the fact that migration of the sexual cells of a most remarkable character in the many forms in which he has proved it to occur is a constant phenomenon, the history of its details, and the discussion of the phylogenetic origin and general biological bearings of the curious phenomena presented by it, form the most important features of the present work.

The author as more convenient adopts—instead of Allman's terms, phanerocodonic gonophore and adelocodonic gonophore—"medusa" and "medusoid gonophore" respectively. He applies the latter term to all gonophores, not becoming free medusæ, in the walls of which any traces, however rudimentary, can be detected of the three layers, viz. the inner and outer ectoderm layers and the intervening endoderm lamella—of which the wall of the bell of the medusa is composed. He uses the term sporophore for those gonophore sacs in which no indication of anything beyond a single layer of ectoderm and endoderm can be discovered.

A structure which assumes great importance in the history of the wanderings of the ovicells is the duplicature of ectoderm, which grows inwards at the summit of the simple sac-like bud out of which a medusa is formed, depressing the endoderm lamella and forming the hollow of the bell. It is necessary that this embryonic organ or mass of cells, observed by so many investigators, should receive a special name, and it is termed "endocodon."

It is pointed out that each hydranth of a colony does not consist alone of that part containing the stomach and bearing the tentacles and hypostome, but also of a stem-shaped portion, which is developed at the same time with it out of the same bud. This region is termed the "hydrocope," and is included in the hydranth, the remaining region of which is the "hydro-

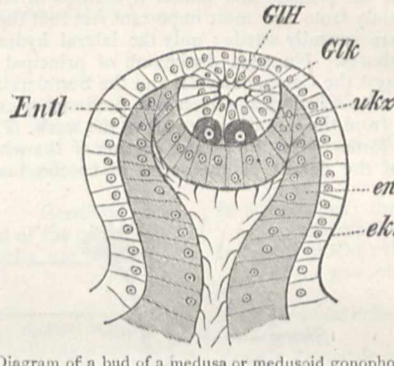

FIG. 1.—Diagram of a bud of a medusa or medusoid gonophore—*Glk*, endocodon; *GlH*, sub-umbrella space; *Entl*, primitive endoderm lamella; *ukz*, primitive germ cells; *ent*, endoderm; *ekt*, ectoderm.

cephalis." The hydrocope corresponds to the region in Tubularia which Allman terms hydrocaulus, but not to the whole system of stems and branches in an arborescent colony. In such colonies the production of buds is entirely confined to the hydrocope and its counterpart in the blastostyle, the "gonocope."

In the Tubularinæ it is necessary to distinguish amongst the

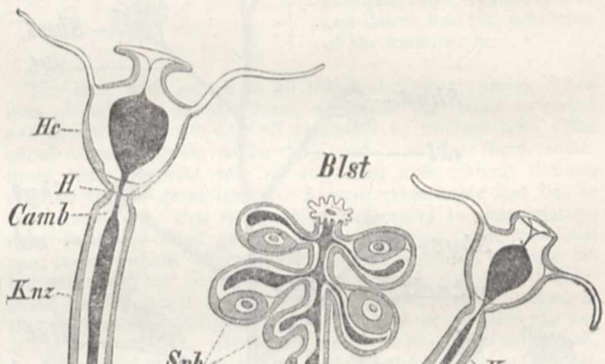

FIG. 2.—Diagram of a primary, *Hhy*, and lateral, *Shy*, hydranth of Eudendrium; *Hc*, hydrocephalis; *H*, neck; *Camb*, cambium zone; *Knz*, zone of gemmation; *Hcp*, hydrocope; *Sa*, lateral branch; *Blst*, blastostyle; *Gcp*, gonocope; *Sph*, sporophore.

hydranths of a stock the "principal" from the "lateral" hydranths. The principal hydranths are those which remain permanently at the extremities of the stems or branches throughout the growth of the stock by lateral budding. In the arborescent stocks of the Tubularidæ the first hydranth sprung from the egg remains permanently at the extremity of the principal stem, the lateral buds of which never surpass it in growth. In the same way the first formed hydranth of each lateral branch retains its position at the tip of that branch, and must be distinguished as a principal hydranth of secondary order, becoming such so soon as it produces a hydranth bud above its distal gonophore. This distinction is necessary not only because the primary and lateral hydranths often differ in size, but mainly from the most important fact that the principal hydranths are sexually sterile; only the lateral hydranths produce gonophores. No such distinction of principal hydranths occurs amongst the Campanularidæ and the Sertularidæ.

The above brief historical sketch and preliminary explanation is extracted from the introductory part of the work. The special part, which forms by far the greater portion of the whole, treats separately of the details of the series of species investigated.

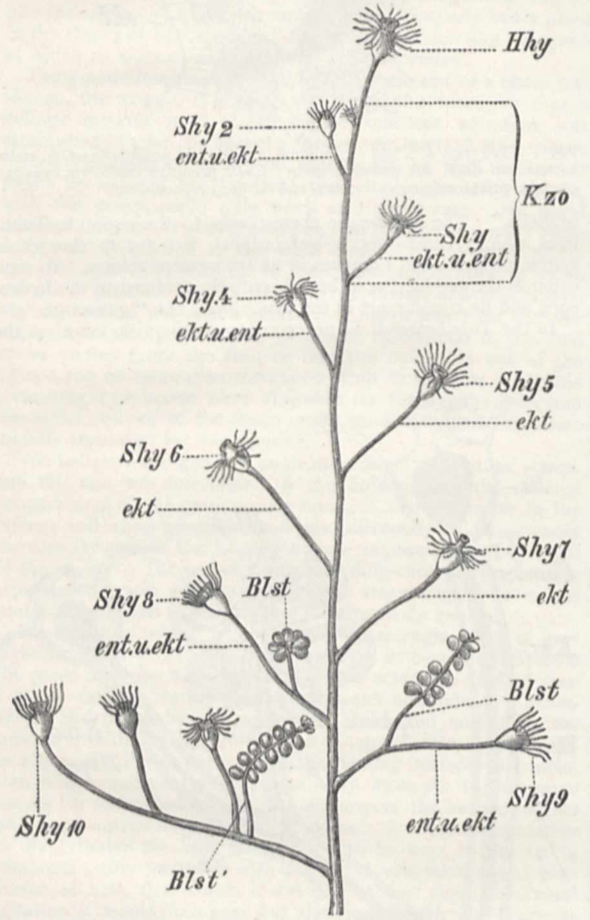

FIG 3.—Tip of a stem of *Eudendrium racemosum* (actual, not diagrammatic), with the principal hydranths, *Hhy*, and ten lateral hydranths, *Shy* 1-10; *Blst*, blastostyle, with female gonophores or ova; *Kzo*, germinal zone in wider sense, *i.e.* extent of the main stem and hydrocope containing egg-cells. The letters *ent* and *ect* indicate whether in the lateral hydrocopes of the specimen ovicells were present in the ectoderm or endoderm, or in both.

The results with regard to two of these forms, *Cordylophora lacustris* and *Eudendrium*, will be followed here, the former being chosen mainly because the account of it is illustrated by a woodcut, which it is advantageous to reproduce. The structure of *Cordylophora lacustris* is well known from F. E. Schulze's most excellent most excellent monograph. Weismann finds that the regular branching of the stock in this species depends on its following the law that "a principal or terminal hydranth of a principal stem or lateral branch produces no buds but those of hydranths, never those of gonophores, and that only the hydranths, and not the gonophores, can produce buds." The zone of gemmation of the hydranths lies in the hydrocope, just below the neck. In the female stocks the germinal cells do not take their origin in the gonophores, but arise in the cœnosarc in the ectoderm of the zone of gemmation of a principal hydranth and in this well defined and restricted region only.

The ovicells are certainly not preformed in the embryo or larva, but are formed in the zone before the lateral hydranth bud begins to appear out of ectoderm cells which differ in no respect from other young ectoderm cells. The ovicells migrate in the ectoderm from their place of origin to that where the bud of the lateral hydranth has begun to form, and, passing into the lateral hydrocope as it grows out, enter the gonophore as soon as it is developed, their entire course of travel lying in the ectoderm. Every ovicell becomes an ovum, and enough ovicells migrate in a group into the lateral hydranth to fill several gonophores; those not destined for the first formed gonophore move onwards past it, and a part of them pass later into the second gonophore when this becomes formed between the first and the neck of the lateral hydranth. This change of position of the ovicells must be partly due to active movement, since the simple shifting due to growth could not push the cells past the first gonophore, and long before the first gonophore is ripe these cells are found lying beyond it, whereas beforehand they lay below it (see Fig. 4, *wz*).

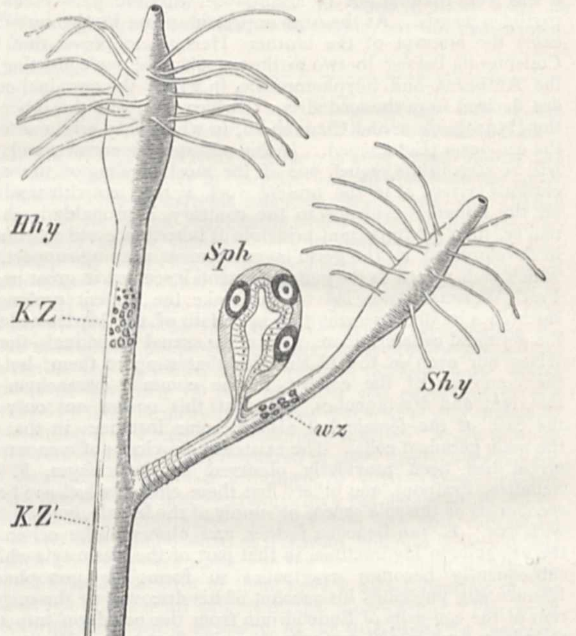

FIG 4.—A principal hydranth, *Hhy*, and a lateral hydranth, *Shy*, of Cordylophora: *KZ*, actual germinal zone, also zone of gemmation; *KZ'*, former position of the germinal zone, *Sph*, female sporophore; *wz*, migrating ovicells.

The migration must take place very slowly and in a particular direction, for the cells are never found scattered irregularly along the whole stem, but always together in a small troop, and they never make their way by accident into a hydrocephalus. The same process is repeated in the formation of the second, and, if ovicells enough be present, of the third gonophore. A fresh swarm of ovicells is never introduced from the main stem into a lateral branch, and no new ovicells are developed in any lateral hydranth until it ceases to become such by developing a hydranth bud above its distal gonophore. It then becomes a principal hydranth of secondary order, and acquires at once a germinal zone beneath its neck, which supplies the gonophores developed on its lateral hydranth buds with ova by migration, just as in the case of the primary principal hydranth. It produces no further gonophores itself, and differs in no respect from the primary principal hydranth excepting in that it was once a lateral hydranth, and produced a set of gonophores, whilst the primary principal hydranth never was lateral and never produced gonophores. The ova ripen in the ectoderm of the sporophores.

The primitive male germinal cells in Cordylophora are formed like the female from young ectoderm cells, but their place of origin lies in the zone of gemmation of the lateral hydranth at the spot where the gonophore bud is formed.

In the genus Eudendrium most remarkably there is a difference in the formation of the gonad elements in the case of different species. In *Eudendrium racemosum* the gonophores are not borne by the hydranths but on blastostyles, which bud out only from the lateral hydranths. Both male and female germinal cells have their place of origin not in the gonophores or blastostyles, but in the cœnosarc; the gonophores are only the ripening places of the cells. The blastostyles are not regarded by the author as hydranths which in an ontogenetical sense become atrophied in the history of each colony, in consequence of the exhaustive effect of the development of gonophores on them, but as special structures probably derived originally from hydranths, but which have undergone a permanent phylogenetic modification (at all events in *E. racemosum* and *E. capillare*) to adapt them for their peculiar function. The developing buds from which blastostyles are formed are very early to be distinguished from those forming hydranths, and do not vary in colonies of the same sex, though they show a constant difference in form in the two sexes. The male blastostyles have no hypostome, mouth, or trace of tentacles. The female have also no hypostome but have a double crown of tentacles, and appear at the time when the gonophores are ripe to have a small temporary mouth, which it is suggested may possibly swallow the spermatozoa to effect fertilisation.

In the female stocks of *Eudendrium racemosum* when in full sexual maturity the cœnosarcal tubes at all the free ends of the branches contain large quantities of ovicells. The fine twigs are often full of hundreds of them. They occur in both ectoderm and endoderm, but far more abundantly in the former, where they are found in all stages of development, whereas in the endoderm scarcely any but large egg-cells are found. The primitive germinal cells are derived from ordinary young ectoderm cells, with which in rapid process of multiplication the whole germinal zone is filled. This zone lies only in the principal hydranths, commencing a little below their necks and extending a shorter or further distance down the stem, but as a rule not further than the second lateral hydranth (*Kzo*, Fig. 3). Within this zone the production of new ovicells is almost entirely restricted to its uppermost region. As the principal hydranth grows, the germinal zone, which maintains a constant length, rises with it, and as soon as it rises above the point of junction of any lateral hydranth, this hydranth is cut off from any further supply of ovicells. The ovicells never occur in the endoderm within the germinal zone, but are only found in that layer within the hydranth and gonocope. This is because of the remarkable migrations which the cells perform, which take place in perfectly definite directions at definite times. The cells remain in their place of origin, the ectoderm of the germinal zone, until a new lateral hydranth bud begins to be formed, and into this they migrate through the ectoderm, not at once, but as soon as the hydranth has attained a well defined stem. They wait here in the ectoderm, growing considerably, until they have attained a certain size, and then bore their way into the endoderm, nearly all the cells in each lateral hydrocope effecting the penetration of the basement membrane simultaneously, just at the time when a blastostyle bud commences to form. The cells hold on to the basement membrane on its inner face by one end, and stretch forwards the other in the direction of the position of the future blastostyle, and become remarkably elongate, their free ends being drawn out into long slender filaments amongst the endoderm cells. As soon as a hollow is formed in the blastostyle bud they creep in, still clinging to the basement membrane and always to its endodermal face. As the hollow enlarges, more and more creep in, and the bud takes on a pear shape. As the gonophores are budded out from the blastostyle the cells pass into the endoderm of these, then almost simultaneously bore through the basement membrane again, and reach the ectoderm layer of the sporophores, their final ripening place. The ovicells never reach maturity on the hydranths in which they originate, but always in the blastostyle of a lateral hydranth.

In the male stocks of *Eudendrium racemosum* the place of origin of the germinal cells is the ectoderm of the region of gemmation of the lateral hydranths. Thence they migrate by the endoderm into the sporophores, and then like the ovicells bore their way out into their ripening place, the ectoderm of the sporophores.

In the other species of Eudendrium examined, *E. capillare*, the place of first appearance of both male and female germinal cells is in the endoderm.

The results obtained as to the history of the generative elements in the various species examined are given in a concise tabular form under a series of headings, the importance and distinctness of which will now be recognised. The case of Podocoryne is taken as an example. The German terms are not easy to find English equivalents for.

Podocoryne carnea

Keimstätte. Germinal place. (Layer in which the earliest appearance of the germinal cells can be detected.)	Male germinal cells: the ectoderm. Female germinal cells: the endoderm.
Keimzone. Germinal zone. (Region of the colony where these cells are earliest detected.)	In male stocks: the manubrium of the Medusa buds. In female stocks: the endoderm sac of the gonophore bud.
Abkunft. Actual origin of the most primitive germinal cells, (in very many cases a matter of inference only).	Male germinal cells: young ectoderm cells. Female germinal cells: probably ectoderm cells which have migrated into the endoderm.
Ripening place.	The ectoderm of the manubrium of free-swimming Medusæ.
Migrations.	The male cells none. The female cells out of the primary endoderm sac of the gonophore bud into the spadix and thence into the ectoderm of the manubrium.

The facts with regard to all the investigated species, when thus placed in a tabular form, appear at first sight so varied and complicated as to defy all reduction to uniform law. The germinal cells appear to be developed sometimes here, sometimes there, without rule of any kind and without definite relation to the germ layers. A most remarkable fact lies in the circumstance that the greatest differences in these matters occur in closely allied genera and even species. But, since this can occur without affecting the general evidences of these relationships, "the variations must depend on such differences as can occur amongst nearly related forms." And in this circumstance really lies in Prof. Weismann's opinion the key to the whole matter. By careful use of the comparative method, he has arrived at the conclusion that the differences in the position of the place of first appearance of the germs depend on a "phylogenetic shifting" of this position, and have ensued *pari passu* with the degeneration of the primitive free medusæ unto sessile brood sacs. The advantage gained by the animal in the shifting which has brought this about, has lain in the earlier ripening of the gonad elements.

In accordance with a widely accepted view, the sessile gonophores of all the attached hydromedusæ except hydra, are probably to be regarded as degenerated medusæ. In the ancestral medusæ the gonad elements of both kinds originated in the ectoderm of the manubrium, and ripened there as they do now in six out of seven Tubularine genera bearing medusæ examined by the author, viz. Dendroclava, Bougainvillia, Perigonimus, Cladonema, Corymorpha, Syncoryne. Both the origination and ripening of the germinal cells occurred during the free life of the medusæ. Certain causes rendered the free medusa stage disadvantageous, and in many instances the gonophores in consequence became sessile, whilst the sexual elements originated and ripened in them at an earlier stage. At first the elements retained the same place of origin as in the free medusæ, a condition which survives in the medusoid gonophores of the existing Cladocoryne. But it became advantageous that the elements should not wait for their formation by cell division and for their gradual maturation until the process of construction of the gonophores by budding had been completed, and thus the formation of the ovicells became shifted, and appeared in an earlier stage. What may be regarded as a first stage in this process is represented in Pennaria and Tubularia, in which the germinal cells of both sexes first appear in the endocodon (see Fig. 1) of the gonophore bud, being carried afterwards, as development proceeds, to the original ripening place, the manubrium. As a further stage in the process, the primitively ectodermal germinal cells migrated into the endoderm, and here we find them making their first appearance in all the Tubularinæ bearing medusæ or medusoid gonophores, in which they do not originate in the ectoderm of the manubrium or in the endocodon. Most important is the fact that in Podocoryne and Clava, and other forms, the male elements have a different place of first appearance from the female. In Podocoryne the male germinal cells arise in the ancestral place, the ectoderm of the manubrium; the female, however, first appear in the endoderm of the medusa bud. In Clava the male elements originate in the endocodon; in the female they are first detected in the endoderm of the gonophore stem.

Here the phylogenetic shifting of the place of first differentiation of the germinal cells has operated only in one sex or in one more than the other. In all such cases it is the place of first differentiation of the female elements which has undergone further shifting than that of the male, apparently because, under similar circumstances, owing to their more minute subdivision, spermaries become more easily and rapidly ripened than ovaries. In the case of *Eudendrium racemosum*, already described, three further stages of the shifting back of the place of origin of the germinal cells appear to have been undergone by the female stocks beyond those evidenced in Podocoryne.

In some forms, as in Cordylophora already described, the entire long migration takes place entirely in the ectoderm, and it is plain that the shifting of the place of origin of the germinal cells backwards from the gonophores has taken in different forms two different lines of progress, one into the endoderm, the other through the ectoderm only. It is a remarkable fact that in no real medusa is the place of first appearance of the germinal cells shifted further back than at most to the endoderm of the gonophore. The difference of position of the generative elements in the medusæ of the Campanularinæ is regarded by the author as secondary, derived from a primitive disposition, as in the Anthomedusæ, by phyletic shifting from the manubrium to the radial canals, evidence in proof of which is adduced.

A most intensely interesting section is that devoted to the subject of the migration of the germinal cells. These cells seem to be guided in their movements by an extraordinary instinct. Every ovicell on setting out for its travels appears to have before it a definite route to a particular gonophore, and to follow it with certainty; and, further, to be able to distinguish a young hydranth bud from a young blastostyle bud, never entering the one in error for the other. The migrations may be compared to those of certain birds the young of which are believed by some ornithologists to find their way to their distant home without the aid of any old birds who have already made the journey to guide them. The author suggests that it must be the outcome of an excessively fine sense of minute differences of pressure which enables the ovicells of Podocoryne, after they have bored their way into the ectoderm, to arrange themselves in four longitudinal rows in the interradii of the manubrium, instead of forming an even zone round it. No doubt, as he points out, the same laws are at work here which determine the size, shape, number, and sequence of the cells in every organism; but this free mobility of these germinal cells in the Hydroida, with their definite line of march and goal, is a new factor, to which there seems to be no parallel known in other groups, although migrating cells pursuing comparatively indefinite courses are known in most Metazoa. As having a nearer resemblance to these movements are cited those of the mesoblast cells which are set free from the blastophore of the gastrula larva of Echinoderms, and which arrange themselves in regular order on the inner surfaces of its cavity. That there is no absolute difference between these curious tissue-building migrations and ordinary growth follows from the evident fact that they have arisen phylogenetically out of the formation of organs by ordinary process of growth.

The question of the immediate origin of the primitive germinal cells of the Hydroids is discussed in a most able summary chapter of the utmost interest, but which it is impossible to do justice to here. With regard to the relations of the elements to the two layers, the conclusion is that in all the Hydromedusæ, including the Siphonophora, the actual origin of the primitive germinal cells is from ectoderm cells. In all cases in which the first traces of the germinal cells can only be detected in the endoderm, the parent primitive germinal cells have migrated out of the ectoderm. This position is supported by two lines of argument, the one drawn from the comparison of the various stages in the shifting of the place of origin of the germinal cells exhibited in the various species of Hydromedusæ, and especially in the two sexes of the same species, which points clearly to the original and essential source of both sexual elements having lain in the ectoderm, as is still the case in the primitive, hermaphrodite, freshwater Hydra; whilst the other dwells on the circumstance that in all Hydroids in which the first appearance of the germinal cells takes place in the endoderm, a satisfactory proof of the endodermal origin of these cannot be brought forward. Where they originate in the ectoderm their identity with young ectoderm cells is obvious. When found in the endoderm, at the bases of the peculiar flagellate cells composing this layer, they have a similar appearance to the primitive germinal cells found in the ectoderm, but no connection of gradation between them and the endoderm cells can be detected, nor any subdivision of the endoderm cells tending to their production.

Having arrived at the above conclusion, the author is led to believe, as already mentioned, that the division of the Cœlenterata into Endocarpæ and Ectocarpæ introduced by the brothers Hertwig may very probably still hold good, the Hydromedusæ, with the Siphonophora and Ctenophora, being sprung from a separate phylum of the primitive Cœlenterates from that comprising the Anthozoa and Scyphomedusæ.

The work closes with a reference to the question of the alternation of generations in the Hydromedusæ. Now that the cœnosarcal origin of the germinal cells is proved in so many instances, can the gonophores or medusæ, the sexual cells of which are formed in the cœnosarc of the hydranth or stem before they themselves are begun to be developed, be regarded as sexual individuals? It is obvious that it would lead only to confusion if the old way of regarding the matter was upset. The past history of the gonophores must be taken into account, and the fact that the sexual elements, though now developed at a greater or less distance in many species, formerly undoubtedly originated within the gonophores. If an opposite view were adopted, the absurd difficulty would arise that the male gonophores in some species would have to be taken as sexual individuals and the females in the same species as not.

The author's discovery of the gradual phylogenitic shifting of the place of origin of the sexual elements in Hydromedusæ seems, as he points out, to throw most happy light on the vexed controversy between Brooks and Salensky as to the alternation of generations in the Salpæ. The ovarium in the stolon of the solitary Salpa discovered by Brooks doubtless belonged originally to the sexual chain Salpæ and has become shifted in order to hasten its maturation into the stolon of the nurse, which is no more to be regarded as sexual because of its preparing an ovary for the buds than are the principal hydranths of *Eudendrium racemosum* to be regarded as such because they supply the ovicells to the gonophores borne by the blastostyles. As in so many of the Hydromedusæ, the male elements of the sexual individuals have undergone no corresponding shifting. The discrepancies between the results of the two observers probably depend on the circumstance that the process of phylogenetic shifting has attained, as in Hydromedusæ, different stages of development in the various species. The mode of reproduction of the Salpæ is still to be regarded as a case of alternation of generation, even should Salensky's well founded suspicion that the chain Salpæ are themselves able to produce a second ovary after the first has been used up prove invalid.

The remarkable differences in the development of the germinal cells in nearly allied Hydromedusæ seem to be paralleled to some extent by the extraordinary condition in the early embryology of the Salpæ discovered by Salensky,[1] where the differences occurring in the different species are so great and important that, as he writes, "they hardly bear comparison with one another." In all Salpæ the early segmentation of the ovum takes place as usual, but then "gonoblasts," cells derived from the epithelium of the egg-follicle, not sexually fertilised elements, suppress the blastomeres, which atrophy whilst the entire embryo is formed from the gonoblasts with or without other unfertilised matter. Salensky calls this extraordinary process, which is without parallel in the rest of the animal kingdom, "follicular budding."

Possibly some of the curious differences as to the extent to which the gonoblasts and parts of the ovary and oviduct enter into the formation of the embryo in Salpæ (Gymnogonæ and Thecogonæ) may be hereafter explained on some such principle as that of Prof. Weismann of "phylogenetic shifting."

H. N. MOSELEY

[1] Prof. W. Salensky, "Neue Untersuchungen über die embryonale Entwickelung der Salpen." II. Th. Schluss, "Mittheilungen aus der Zool. Station zu Neapl.," Bd. iv. Heft 3.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Public Orator (Mr. J. E. Sandys) made the following address to the Senate in presenting Mr. Andrew Graham, First Assistant to Prof. Adams at the Observatory, for the complete degree of M.A. *honoris causâ*. Mr. Graham discovered the ninth minor planet *Metis*, a fact cleverly turned to account by the Orator:—

"Dignissime domine, Domine Procancellarie et tota Academia:

"Quam invidenda nobis illorum vita est, qui a rerum terrestrium strepitu remoti, templum quoddam observando cælo dedicatum incolunt, ubi noctibus serenis tot lucidorum orbium ortus obitusque contemplantur, tot stellarum immotarum stationes perpetuas accuratissime definiunt, tot siderum errantium cursus prius ignotos admirabili quadam divinatione augurantur. Consentaneum nimirum est eum, cui primo quondam Oceani filia, Metis, inter sidera affulserat, tot annos in rure illo suburbano cum Neptuni inventore nostro celeberrimo feliciter esse consociatum. Iuvat certe tanti viri adiutorem fidelissimum hodie civitate nostra donare, virum et linguarum recentiorum et studiorum mathematicorum perquam peritum, neque in numeris tantum computandis sollertissimum, sed in sideribus quoque observandis perspicacissimum. Ipse rerum omnium Fabricator, cetera quidem animalia terram prona spectare passus,

> 'os homini sublime dedit cælumque tueri,
> iussit et erectos ad sidera tollere voltus;'

quanto igitur honore illi digni sunt qui, qua in re ceteris animantibus homines præstant, in ea hominibus ipsis tam præclare antecellunt.

"Vobis præsento virum et de scientia astronomica et de Academia nostra optime meritum, Andream Graham."

SOCIETIES AND ACADEMIES

LONDON

Geological Society, November 7.—J. W. Hulke, F.R.S., president, in the chair.—James Diggle, Charles Anderson Ferrier, and Prof. W. Stephens were elected Fellows of the Society.—The following communications were read:—On the geology of the South Devon coast from Tor Cross to Hope Cove, by Prof. T. G. Bonney, F.R.S., Sec.G.S. The author, after a brief reference to the literature of the subject, stated that the chief petrographical problem presented by this district was whether it afforded an example of a gradual transition from slaty to foliated rocks, or whether the two groups were perfectly distinct. He described the coast from Tor Cross round by the Start Point to Prawle Point, and thence for some distance up the estuary leading to Kingsbridge. Commencing again to the north of Salcombe, on the other shore of this inlet, he described the coast round by the Bolt Head and Bolt Tail to Hope Cove. These rocks, admittedly metamorphic, consist of a rather thick mass of a dark mica-schist and of a somewhat variable chloritic schist, which also contains a good deal of epidote. In the lower part of this are some bands of a mica-schist not materially different from the upper mass. It is possible that there are two thick masses of mica-schist, one above and one below the chloritic schist; but, for reasons given, he inclined to the view that there was only one important mass, repeated by very sharp foldings. The junction between the admittedly metamorphic group and the slaty series at Hope Cove, as well as that north of Salcombe, is clearly a fault, and the rocks on either side of it differ materially. Between the Start and Tor Cross the author believes there is also a fault, running down a valley, and so concealed. On the north side of this the rocks, though greatly contorted and exhibiting such alterations as are usual in greatly compressed rocks, cannot properly be called foliated, while on the south side all are foliated. This division he places near Hallsands, about half a mile to the south of where it is laid down on the geological map. As a further proof of the distinctness of the two series, the author pointed out that there were clear indications that the foliated series had undergone great crumpling and folding after the process of foliation had been completed. Hence that it was long anterior to the great earth-movements which had affected the Palæozoic rocks of South Devon. He stated that the nature of these disturbances suggested that this district of South Devon had formed the flank of a mountain-range of some elevation, which had lain to the south. Of the foundations of this we may see traces in the crystalline gneisses of the Eddystone and of the Channel Islands, besides possibly the older rocks of South Cornwall and of Brittany. He also called attention to some very remarkable structures in the slaty series near Tor Cross, which appeared to him to throw light upon some of the structures observed at times in gneisses and other foliated rocks.—Notes on Brocchi's collection of Subapennine shells, by J. Gwyn Jeffreys, F.R.S. In this paper the author gave the results of an examination of the collection of fossil shells from the Subapennine Pliocene described by Brocchi in his "Conchiologia fossile Subapennina," and now preserved in the Museo Civico at Milan. The author cited fifty-five of Brocchi's species, upon most of which the collection furnished more or less interesting information. In conclusion he remarked upon the importance of identifying Brocchi's species with forms still living in the neighbouring seas, and also upon the difficulty of distinguishing between the Upper, Middle, and Lower Pliocene in Italy. From his examination of Italian Pliocene shells he concluded that the deposits containing them were for the most part formed in comparatively shallow water, probably not more than fifty fathoms in depth, a remark which also applies to the Italian Miocene; and that in the case of species still existing no difference can be recognised between Pliocene and recent specimens.—British Cretaceous Nuculidæ, by John Starkie Gardner, F.G.S. The author commenced by discussing the question whether the Nuculidæ should be separated as a family from the Arcidæ, and stated that species of *Leda* and *Nucula* exist and sometimes abound in the marine Cretaceous deposits, with the exception of the White and the Red Chalk, from which, however, he thought that the shells may have been dissolved out. He also referred to the probable derivation of the species from preexisting forms, and discussed the question of how far the relationships thus established could be expressed in the nomenclature of the species, his researches upon the Nuculidæ leading him in some cases to suggest a trinomial nomenclature. The probable lines of descent of the shells described in the present paper were also discussed at some length.

Anthropological Institute, November 13.—Prof. Flower, F.R.S., president, in the chair.—The election of the following new members was announced:—Dr. G. B. Barron, Prof. D. J. Cunningham, H. O. Forbes, J. S. Hunt, Capt. E. C. Johnson, R. Morton Middleton, jun., Capt. C. A. Moloney, S. B. J. Skertchley Joseph Smith, jun., and Dr. Johnson Symington.—Mr. J. E. Price exhibited a selection of objects from ancient grave mounds in Peru.—Dr. Garson exhibited two iron lamps that he had procured from the Orkney Islands for the Oxford University Museum. They were very similar to the lamps of the Esquimaux described by Dr. E. B. Tylor in his paper read before the Institute at the end of last session, and each consists of two flat receptacles prolonged into a spout-like depression on the anterior portion.—Prof. Flower exhibited the skull of a young chimpanzee (*Troglodytes niger*) which had been sent to him from Lado in the Soudan, by Dr. Emin Bey. It was the subject of acrocephalic deformity, associated with complete synostosis of the coronal suture, and partial obliteration of the sagittal suture, both of which are normally open long after the age to which this individual had attained.—The Director read a paper by Mr. Edward Palmer on some Australian tribes.

Zoological Society, November 20.—Prof. W. H. Flower, F.R.S., president, in the chair.—A letter was read from Mr. G. B. Sowerby, jun., in which he proposed to change the name of *Thracia jacksonensis*, given in his paper "On New Shells," read in January, 1883, to *Thracia brazieri*.—A letter was read from Mr. W. H. Ravenscroft, of Colombo, Ceylon, describing the effectual mode in which a female Axis Deer in confinement concealed its young one from observation.—The Secretary exhibited, on the part of Major C. H. T. Marshall, F.Z.S., a specimen of a new Impeyan Pheasant from Chumba, N.W. India, which Major Marshall proposed to name *Lophophorus chumbanus*, and some other birds from the same district.—Mr. H. Seebohm, F.Z.S., exhibited and made remarks on a new Owl from Japan, which he proposed to call *Bubo blakistoni*, after Capt. Blakiston, its discoverer.—Mr. H. E. Dresser, F.Z.S., exhibited and made remarks on some Ringed Pheasants from Corea.—Prof. Bell, F.Z.S., exhibited and made remarks upon some Australian Crinoids infested by a large number of Myzostomata.—Prof. Flower read a paper on the characters and divisions of the family Delphinidæ, in which the following generic divisions were admitted and defined:—*Monodon*, *Delphinapterus*, *Phocæna*, *Neomeris*, *Cephalorhynchus*, *Orca*, *Or-*

cella, *Pseudorca*, *Globicephalus*, *Grampus*, *Feresia*, *Lagenorhynchus*, *Delphinus*, *Tursiops*, *Clymenia*, *Steno*, and *Sotalia*. Critical remarks were added upon the characters and synonymy of the best-known species of each.—Prof. Flower also gave an account of a specimen of Rudolphi's Rorqual, *Balænoptera borealis*, Lesson (= *Sibbaldius laticeps*, Gray), lately captured in the River Crouch, Essex, being the first well-authenticated example of this species met with in British waters.—A communication was read from Dr. M. Watson, F.Z.S., containing additional observations on the structure of the female organs of the Indian Elephant (*Elephas indicus*).—A communication was read from Mr. F. Moore, F.Z.S., containing the descriptions of some new Asiatic Diurnal Lepidoptera.—A communication was read from Mr. R. Trimen, F.R.S., in which he gave a description of a remarkable semi-melanoid variety of the Leopard (*Felis pardus*) in the Albany Museum, Grahamstown, which had been obtained in the east of the Cape Colony.—A communication was read from the Count H. von Berlepsch and Mr. L. Taczanowski, in which an account was given of an extensive collection of birds made by MM. Stolzmann and Siemiradzki in Western Ecuador.

EDINBURGH

Royal Physical Society, November 21.—The first meeting of the 113th session was held in the Institution Rooms, St. Andrew Square, Dr. Ramsay H. Traquair, F.R.SS. London and Edinburgh, president, in the chair.—A nest of the reed-warbler, found near Combe Abbey, Warwickshire, was exhibited to the Society by Dr. Herbert.—The opening address of the session was then delivered by Dr. Archibald Geikie, F.R.SS. London and Edinburgh, Director-General of the Geological Survey of Great Britain and Ireland on "The Relation between Geology and Palæontology."

SYDNEY

Linnean Society of New South Wales, September 26.—Dr. James C. Cox, F.L.S., in the chair.—The following papers were read:—On a very dolichocephalic skull of an Australian aboriginal, by Baron N. de Miklouho Maclay. The cephalic index of this skull, which was found in the interior of Queensland, was only 58·9, calculated on the ophrio-occipital length, and 58·3, calculated by the glabello-occipital length, an index lower probably than that of any skull hitherto described. The skull was not a deformed one in the ordinary sense, but was a fair example of the so-called roof-shaped type of cranium.—On a fossil humerus, by Mr. C. W. De Vis.—Notices of some undescribed species of Coleoptera from the Brisbane Museum, by William Macleay, F.L.S. The species described are a few unnamed Coleoptera occurring in a large collection sent by Mr. De Vis to the author for identification. Their names are:—*Pamborus viridiaureus*, *Catascopus laticollis*, *Eutoma ponctipenne*, *Carenum terræ-reginæ*, *C. ianthinum*, *C. De Visii*, *C. pusillum*, *Tibarisus robustus*, *Pœcilus lævis*, *Diphucephala hirtipennis*, *D. cærulea*, *D. latipennis*, and *Liparetrus convexiusculus*.

PARIS

Academy of Sciences, November 19.—M. Blanchard, president, in the chair.—Remarks on the recent volcanic disturbances in Sunda Strait; mineralogical analysis of the ashes collected, by M. Daubrée. From the examination of these ashes, which fell at Batavia on August 27, the author considers it highly probable that the surface waters penetrating deeply into the underground cavities, and there becoming superheated, form the chief agency in such volcanic eruptions as those of Krakatoa and Ischia.—On the velocities acquired in the interior of a vessel by the various elements of a fluid during its discharge through a lower orifice (continued), by MM. de Saint-Venant and Flamant.—On the process of purple dyeing amongst the ancients according to a fragment attributed to Democritus of Abdera, by M. Berthelot.—On the production of extremely low temperatures by means of continuous apparatus, by M. Cailletet.—Report on the French expedition to Cape Horn, by M. Martial. The expedition, undertaken mainly to observe the transit of Venus, embarked on board *La Romanche* at Cherbourg on July 17, and reached its destination on September 6. Three contacts were observed under favourable conditions by M. Courcelle-Seneuil. A great part of Tierra del Fuego was visited, numerous dredgings were made at various points, and rich collections, especially botanical and ethnological, were brought back These included living specimens of most of the Fuegian flora, two native canoes with their full equipment, a complete hut with all the utensils, arms, and other objects in use amongst the aborigines. A cairn twenty feet high was erected in Orange Bay to commemorate the French expedition to Cape Horn.—On the transformations of which certain equations of the second order are susceptible, by M. R. Liouville.—On the electrochemical energy of light, by M. F. Griveaux.—Observations of the Pons-Brooks comet made at the Paris Observatory (equatorial of the west tower), by M. G. Bigourdan.—Observations of the same comet and of the planet 234 made at the Marseilles Observatory, by M. Coggia. — Photometric observation of an eclipse of the first satellite of Jupiter, by M. A. Obrecht. — Remarks on a formula of Tisserand connected with celestial mechanics, by M. R. Radau. — On the resisting power of a ring, by M. J. Boussinesq.—On the curve-lines of wave surfaces, by M. G. Darboux.—Application of a proposition in mechanics to a problem connected with the figure of the earth, by M. E. Brassinne.—Note on the action of carbonic acid on saccharine dissolutions more or less charged with lime, by M. D. Loiseau. —On a new kind of ureometer (one illustration), by M. W. H. Greene.—Experiments on the passage of charbon bacteridæ into the milk of animals affected by charbon, by MM. J. Chambrelent and A. Moussous.—On the embryogeny of *Sacculina carcini*, an endoparasitic crustacean of the order of Kentrogonides, third note, by M. Yves Delage. In this highly important contribution to the study of parasitic entomology the author proposes to constitute a new order of Kentrogonides, distinct from, but allied to, that of the Cirrhipedes.—Development of the Stylorhynchus, by M. A. Schneider.—On the genus Ptychogaster, Pomel, a fossil Chelonian found associated with the remains of crocodiles in the Saint-Gérand-le-Puy formations, by M. L. Vaillant.—On "vaugnerite," a phosphatiferous rock occurring in the Irigny district on the banks of the Rhone, by M. F. Gonnard.—Note on a prehistoric flint mine worked during the Stone age at Mur-de-Barrez, Aveyron, by M. E. Cartailhac. —Concluding remarks on the waterspouts observed at Villefranche-sur-Mer, Maritime Alps, during the month of October, 1883, by M. J. Jeannel.—Note on the effects produced by lightning during a thunderstorm at Rambouillet on November 10, by M. A. Laugier.

CONTENTS

PAGE