OBITUARY NOTICES OF FELLOWS DECEASED.

George Poulett Scrope. It is scarcely possible at the present day to realize the conditions of that intellectual "reign of terror" which prevailed at the commencement of the present century, as the consequence of the unreasoning prejudice and wild alarm excited by the early progress of geological inquiry. At that period, every attempt to explain the past history of the earth by a reference to the causes still in operation upon it was met, not by argument, but by charges of atheism against its propounder; and thus Hutton's masterly fragment of a 'Theory of the Earth,' Playfair's persuasive 'Illustrations,' and Hall's records of accurate observation and ingenious experiment had come to be inscribed in a social *Index Expurgatorius*, and for a while, indeed, might have seemed to be consigned to total oblivion. Equally injurious suspicions were aroused against the geologist who dared to make allusion to the important part which igneous forces have undoubtedly played in the formation of certain rocks; for the authority of Werner had acquired an almost sacred character; and "Vulcanists" and "Huttonians" were equally objects of aversion and contempt.

To two men who have very recently—and within a few months of one another—passed away from our midst, science is indebted for boldly encountering and successfully overcoming this storm of prejudice. Hutton and his friends lived a generation too soon; and thus it was reserved for Lyell and Scrope to carry out the task which the great Scotch philosopher had failed to accomplish, namely, the removal of geology from the domain of speculation to that of inductive science.

Born in the year 1797, and educated successively at Harrow and Cambridge, George Poulett Thomson enjoyed the advantage of a considerable amount of foreign travel during his earlier years. By the advice of his university friends, Sedgwick and Dr. E. D. Clarke, he soon began to devote much of his attention to the phenomena of volcanos, and between the years 1818 and 1821 carefully studied the principal volcanic districts of Italy. He married in 1822 the heiress of the Scrope family, and having adopted her name, set out on a series of geological explorations in Auvergne, Southern Italy, the Ponza Islands, the Euganean Hills, and subsequently in the Siebengebirge and the Eifel, which occupied him till the close of the year 1823. So marked an effect would appear to have been produced upon his mind by the great Vesuvian eruption of 1822—which he was so fortunate as to witness, and which, indeed, inspired his first contribution to geological literature—that from this time forward he seems to have been confirmed in his devotion to that branch of geological

inquiry which, throughout his after life, he so successfully pursued. The result of Scrope's studies and investigations, thus carried on independently and almost unaided, was to make him an enthusiastic supporter of the Huttonian doctrine, that causes similar in kind to those now in operation were quite competent to have produced all past geological changes, and at the same time a most determined opponent of Werner's teaching concerning the aqueous origin of basalt, and of Von Buch's theory of "elevation-craters."

In 1824 Scrope was elected a Fellow of the Geological Society; and having returned to England, he sought the society of those engaged in similar inquiries with himself, and in Charles Lyell found an earnest fellow-student who was able to understand and sympathize with his geological convictions. Most of the members of the infant Geological Society seem at that time to have come to a tacit agreement to lay aside all consideration of those questions relating to the philosophy of their science, which had, in the case of the generation then passing away, been the means of provoking so much heated and embittered controversy. To three of their number, however, such practical abnegation of their responsibilities was impossible; and it is to the boldness and sagacity of Lyell, Scrope, and De la Beche that geology is indebted for the initiation of its modern advance and development. At the period when Scrope returned from the continent Lyell had long been engaged in that patient collection of facts illustrating the changes produced on the earth's surface by the operations of existing causes, which at a subsequent date enabled him to produce his incomparable 'Principles of Geology'; and between the two thinkers the closest friendship soon became established, attended with a freedom of intercourse which was doubtless of great advantage to both of them in preparing for their joint attack upon the prevailing geological errors.

Scrope wrote several memoirs relating to the geology of the countries he had visited, and in 1825 published his 'Considerations on Volcanos.' The dominant idea in this remarkable work is well illustrated in the passage which follows an enumeration of the effects of atmospheric agencies, of the circulation of water on the earth's surface, and of volcanos and earthquakes in causing the destruction and reproduction of rocks, changes of level, and the transference of new rocks from the earth's interior to its surface. These the author declared to be "changes which in their general characters bear so strong an analogy to those which are suspected to have occurred in the earlier stages of the world's history, that, until the processes which give rise to them have been maturely studied under every shape, and then applied with strict impartiality to explain the appearances in question, and until after a long investigation and with the most liberal allowance for all possible variations, and an unlimited series of ages, they have been found wholly inadequate to the purpose, it would be the height of absurdity to have recourse to any

gratuitous and unexampled hypothesis for the solution of these analogous facts."

It is interesting to notice, too, in this work, published now more than half a century ago, many striking anticipations of later geological discoveries—such as the action of water in producing volcanic eruptions, and in causing the liquidity of lavas; the presence of the same agent in deep-seated rocks, and its influence in the formation of those of granitic character; the effects of pressure in producing cleavage and foliation; and the necessarily more or less *local* character of all geological "formations."

It must be confessed, however, that the 'Considerations on Volcanos was a work little calculated to promote the cause which the author and his friend had so much at heart, namely, the removal of the prejudices which hindered the progress of geological inquiry. Its bold and vigorous attacks on the positions of the "Cataclysmists" roused their most determined opposition, while the numerous and sometimes rather crude speculations into which the author allowed himself to be drawn, in his attempt at "the establishment of a new theory of the earth," afforded only too many opportunities for telling retorts, which were eagerly taken advantage of.

In December 1826 Scrope was elected a Fellow of the Royal Society. That he knew how to profit alike from the judicious criticism of friends and the unsparing ridicule of opponents, was clearly enough shown when in 1827 his second work, 'On the Geology and Extinct Volcanos of Central France,' made its appearance. In this essay, which is still everywhere recognized as one of the classics of geological literature, the author succeeded in demonstrating, even to the most incredulous, the power of rivers to excavate the valleys in which they flow; and his friend Lyell pronounced a just eulogium on it when he said:—"We consider Mr. Scrope's work the most able that has appeared since Playfair's 'Illustrations of the Huttonian Theory,' in support of the doctrine that 'valleys have been shaped out progressively by the action of rivers, or of such floods as may occur in the ordinary course of nature.'"

It was now the turn of Lyell to take the field in the controversy with the Catastrophists, and to bring to the support of the Huttonian doctrines that vast mass of patiently collected facts, that moderation in statement and candour in argument, and that calm, persuasive style—occasionally, but involuntarily, flashing into eloquence—which gave such charm and power to the 'Principles of Geology,' and which still recall so vividly to all who knew him the deep enthusiasm, curbed by sound judgment, which distinguished its author.

During the composition of this great work the two friends were in constant correspondence. Lyell had wisely determined to undermine the positions of his adversaries, rather than to arouse their opposition by

direct attacks; and to his more ardent friend was committed the congenial task of applying and driving home the arguments of the 'Principles' in a series of reviews of the work. The first and second volumes were introduced to the public by appreciative and discriminative notices in the 'Quarterly,' which were written by Scrope; and the completion of the third edition in 1835 was made the occasion of a final article from the same pen.

In these able reviews, which are admitted to have produced a very great effect at the time they were written, and which may be still read with much profit, Scrope took up certain positions somewhat in advance of his friend in geological theory. Thus we find him, even at this early date, demurring to the too absolutely uniformitarian doctrines of Hutton and Lyell, and maintaining views very similar to those developed by Prof. Huxley in his Anniversary Address to the Geological Society in 1869. On the question, too, of the relative influence of subaerial and marine denudation in originating the forms of the earth's surface, Scrope at this early date maintained views which his friend was not prepared to accept till some years later.

Unfortunately, however, for geological science, Scrope had by this time almost forsaken scientific for political labours; but of his useful and honourable public career this is not the place to speak. Nevertheless when, in 1858, he found his friend Lyell again engaged in a controversy with the supporters of the "Theory of Elevation-Craters," he determined once more to bear his part in meeting the new arguments of their old opponents; and the publication of his able memoir "On the formation of Cones and Craters" was the consequence of this resolve. As he now began gradually to withdraw himself from the sphere of politics, Scrope found time to revisit his former haunts, and to prepare new and greatly improved editions of his earlier works; and these have been translated into the principal European languages. During his declining years, which decaying strength and increasing blindness compelled him to spend in almost complete retirement, he followed with interest the progress of thought in connexion with his favourite science, and watched with jealousy its excentric development, contributing from time to time many a suggestive essay or trenchant criticism to the scientific periodicals. Not a few of the younger students of that branch of the science which he had himself so successfully cultivated were indebted to him, during these years of increasing feebleness, when he could no longer take the field, not only for counsel, sympathy, and encouragement, but for friendly aid in pursuing their researches. But the death of Lyell, his early friend and fellow-labourer, with whom to the last he maintained an affectionate correspondence, produced a great shock to his weakened frame; and within a few months thereafter he passed peacefully away.

PETER ANDREAS HANSEN, born at Tondern in Schleswig, on the 8th of December, 1795, was the son of Nikolai Hansen, a prosperous gold- and silversmith of that town. Young Hansen attended the town school, where he learnt the elements of Latin and French, and showed special aptitude for mathematics and physics.

After his confirmation he chose watch-making for his calling, and went to Flensburg to serve his apprenticeship in that business. He soon distinguished himself by his skill and ingenuity in mechanical construction, and then set to work on his own account at mathematical studies. His circumstances, and also his father's wishes, were opposed to his ardent desire to study at a University; and he therefore at the end of his apprenticeship returned home to his parents, and in the year 1818 began his wanderings. He first passed some months in Berlin, where he found some occupation under a master who was one of a French colony settled there, and in whose family he acquired some familiarity with the French language.

At the end of the year 1819 he returned to Tondern, and settled down in his father's house as a watchmaker. But as early as the spring of 1820 the influence of a physician, Dr. Dirks, who was interested in matters appertaining to mathematics and physics, and who recognized Hansen's talents, gave a decided turn to his course of life. Dirks succeeded in gaining the consent of the father for the young man to go to Altona to join Professor Schumacher, who was there entrusted with the management of the Danish measurement of an arc of a meridian. Schumacher received Hansen very kindly, and exerted himself to obtain for him an appointment in the measurement. He was, however, in the first instance unsuccessful; and Hansen, who had meanwhile begun to work at Astronomy in the Round Tower, then the Copenhagen Observatory, was thinking of going to Göttingen to study under Gauss. Finding that Gauss was prevented by the measuring of an arc of the meridian in Hanover from lecturing, he was at last induced by Schumacher, and with the royal consent, to go at his own expense to Altona (in 1820) to take part in the measurement in Holstein.

After the completion of this task he returned to Tondern, from which place he was recalled to Copenhagen by Schumacher in January 1821. He was employed regularly on the survey.

Before long, through the influence of Schumacher, the king became interested in Hansen, and from that time forth the latter received many personal proofs of appreciation and recognition of his services, of which he always cherished a grateful recollection.

In the summer of 1822 Schumacher sent Hansen to Heligoland to assist in some astronomical observations for the determination of geographical positions in conjunction with some English savants.

Schumacher became more and more intimate with Hansen, and a friendship grew up between them which was only to be dissolved by death.

Before long Hansen's eminent services to science attracted the notice of the astronomical world; and in the year 1825, when Encke left the Seeberg at Gotha to take the superintendence of the Observatory of the Berlin Academy, Hansen was selected to conduct the Observatory on the Seeberg, with the title of Professor, a post which he retained for nearly half a century, namely, to the end of his life. The small salary (of 600 Thalers) attached to this appointment obliged him for a number of years to undertake calculations for Ephemerides for the Danish and English Governments.

He lived in the Observatory itself from the year 1825 to 1839; but as the arrangements and fittings were no longer adapted to the requirements of science, and besides the building itself was too much out of repair to bear much longer the wear and tear of weather, Hansen, with the consent of the Duke, removed to the town of Gotha, and in the southern suburb built himself a house with a little private observatory, in which the meridian circle was set up. Here he worked from the year 1842 to 1857, until the new Ducal Observatory was established, which was fitted up under his superintendence in such a perfect manner, though on a very modest scale, that it has since served as a model to several larger institutions.

The work Hansen accomplished at Gotha embraces almost every branch of practical and theoretical astronomy; and if no regular and comprehensive series of observations has been made under him, the cause of this deficiency lies in the insufficient funds at his disposal, which neither admitted of the payment of assistants nor of the purchase of large instruments. But though Gotha could not in these respects rival other great observatories, it possessed an astronomer who was enabled by his mechanical genius to do much in improving the art of observation by ingenious improvements in the arrangements and use of his instruments. The apparatus and methods which he invented for the investigation of errors of division, for the prevention of flexure, for the registration of observations, for the parallactic motion of telescopes mounted horizontally, as well as numerous original contrivances, such as those which were applied in the building of the present observatory, obtained the general approbation of astronomers. His works on the use of the Fraunhofer Heliometer, the Transit-instrument, and the Equatorial have become classical in spherical astronomy.

But it was especially Hansen's rare mathematical ability that enabled him to carry out the great works which make an epoch in the department of physical astronomy known as the Theory of Perturbations. As early as the first years of his residence on the Seeberg, he published in the 'Astronomische Nachrichten' the main principles of his new theory of perturbations, which in the course of years he employed in the accurate investigation and calculation of the motion of the moon, of the sun, of the greater and lesser planets, and of the comets.

Aided by his remarkable facility in calculation (for four-figure logarithms he scarcely required the aid of the tables), he in 1853, conjointly with Olufsen and with pecuniary assistance from Denmark, at the request of the Society of Sciences at Copenhagen, completed his solar tables; and likewise in 1857 the lunar tables printed by the English Admiralty, for which the Parliament of Great Britain voted him the sum of £1000.

In 1838 he published the theory of the moon's motion in a special work, 'Fundamenta nova investigationis orbitæ veræ quam Luna perlustrat;' the exposition of the theoretical calculation of the perturbations employed in the lunar tables appeared in 1862–64, in two elaborate treatises published in the Transactions of the Royal Society of Sciences in Saxony. An appendix treats of the verification of chronological eclipses. He wrote a series of treatises on the theory of the absolute Perturbations of the Asteroids, to which he appended tables of Egeria.

The comet disturbances he treated in two special works—the one entitled "Ermittelung der absoluten Störungen in Ellipsen von beliebiger Excentricität und Neigung," 1843 (which was translated into French by Mauvais); the other a prize treatise of the French Academy, 'Mémoire sur le calcul des Perturbations qu'éprouvent les comètes.' As examples, he gives the disturbances of Encke's comet by the Earth and Saturn.

For his 'Untersuchungen über die gegenseitigen Störungen des Jupiters und Saturns' he had received in 1830 the prize offered by the Berlin Academy. A further posthumous memoir, "Ueber die Störungen der grossen Planeten, insbesondere des Jupiters," has just been published in the Transactions of the Saxon Society. In the same Transactions he published, amongst other things, very elaborate memoirs on the "Theorie des Aequatoreals" (1855), on "Theorie der Sonnenfinsternisse und verwandten Erscheinungen" (1858), on the "Bestimmung der Sonnenparallaxe durch Venusvorübergänge vor der Sonnenscheibe" (1870), in relation to the Transit of 1874, two memoirs connected with dioptrical researches (1871 and 1874), besides a long series of memoirs on the Calculus of Probabilities and the higher Geodesy (1865–1869), to which he was led by his taking part in the European measurement of an arc of a meridian.

One of his latest memoirs treats of the determination of errors in the division of a graduated rectilinear scale, and was written with a view to the expected photographic measures of the Transit of Venus.

Among the memoirs of the London Astronomical Society we may mention two important papers on the Inequalities of long period in the Moon's motion (1847), and on the Figure of the Moon (1854). In the former he examines the influence of Venus on the mean longitude of the moon, and in the latter he endeavours to show that the centre of the figure of the moon does not coincide with her centre of gravity, but that the latter is about 59 kilometres further from us than the former.

After the death of Schumacher, Hansen shared for some time the editorship of the 'Astronomische Nachrichten' which Schumacher had

founded. Petersen was for a time his companion in this editorial work at Altona. Of the numerous contributions he made to this periodical we need only mention, in addition to those already spoken of on the theory of perturbations, those of early date on the transit-instrument and on the meridian circle, on eclipses and occultations of Stars, on refraction of light, on the determination of the latitude, on the calculus of probabilities and the method of least squares, on different geodetic problems, on the disturbances of Encke's comet by a resisting medium, &c.; and at a later period especially the papers on the calculation of special perturbations by mechanical quadratures and the reduction of places to the ecliptic of the date. An immense number of essays on various subjects of interest have appeared in the Reports of the Transactions of the Mathematical and Physical Class of the Saxon Society; of these we need merely allude to the papers on the solution of a system of linear equations; on spherical harmonics; on ideal coordinates; on Keppler's problem; the ecliptic tables, &c., together with the analysis of the same; on the arrangements of the new Ducal Observatory at Gotha; on the determination of the orbit of a heavenly body from three observations; on the secular variation of the mean longitude of the Moon, and the alteration of the day's length by the gradual decrease of the rate of rotation of the Earth (April 1863); on the computation of triangulations; on the centre of gravity of spherical triangles; on a new telescope-stand; on the application of photography for observing the Transit of Venus, &c.

Hansen published papers in various other periodicals, as, for instance, in the 'Comptes Rendus' of the Paris Academy, in the Monthly Reports of the Berlin Academy, in the Monthly Notices of the London Astronomical Society, in the Results of the Magnetic Society, in Schumacher's Astronomical Jahrbuch, the Mathematical Works of Jacobi, the Mathematical Journal of Gutten in Wilna (über das Repsold'sche Aequatoreal), the Memoirs of the Naturforschenden Gesellschaft in Danzig (which latter Society awarded him the prize for his treatise, "Theorie der Pendelbewegung mit Rücksicht auf die Gestalt und Umdrehung der Erde," 1853), and so on. In conclusion we may add to this short summary the Memoir on the Fraunhofer Heliometer, 1827, and the 'Commentatio de gradus praecisionis computatione,' written on occasion of Olbers's Jubilee in 1830.

Hansen did not escape controversy. Some of his works and their results have been attacked by German, French, English, and American astronomers; to these attacks such men as Pontécoulant, Lubbock, Encke, Brünnow, Peters, Baeyer, Weingarten, Newcomb, and Delaunay have lent their names. No one more than Hansen regretted the bitterness which is more or less inseparable from such discussions, though he felt it a duty to science to give distinct expression to his convictions.

He received various honorary titles and decorations, and numerous recognitions of his scientific position. Most of the learned societies of Germany and other countries elected him a member. The Royal Society,

of which he was a foreign member, conferred upon him the Copley Medal in 1850. In 1842, and again in 1860, he received the Medal of the Royal Astronomical Society.

A great number of his contemporaries in astronomy and mathematics enjoyed the privilege of his acquaintance and instruction. His pupils retained a grateful sense of the amiability and patience with which he laboured to make them worthy disciples of his science.

Hansen had many offers of other honourable and advantageous appointments; amongst others one at Dorpat as successor to Struve in 1839, one as successor to Bessel in Königsberg in 1847, one at Copenhagen; and in the year 1866 he was offered that of Astronomer to the Berlin Academy.

In the year 1828 he married the eldest daughter of the Oberforstmeister Braun. He retained his vigour of body and mind to a considerable age, and his facility of writing never left him. At times he almost lived at his writing-table, not seeming to feel the need of recreation either of body or mind. Healthy sleep was sufficient for the restoration of his powers. He did not take bodily exercise; and in his latter years was seldom willing to make any excursion or journey. He twice visited England, mainly to promote the publication of his Lunar Tables; and he deeply gratified the Director of the Chief Russian Observatory, Pulkova, by his presence at the 25th anniversary of the founding of that great institution.

His last years were saddened by a disease of the eyes which altogether prevented him from reading, and even rendered writing very difficult. In the last months of his life he had the additional suffering of a liver complaint. His death took place on the 28th of March, 1874. He had in the beginning of that month completed the manuscript paper "On the Determination of errors in the Division of a Rectilinear Scale," and sent it to the printer. The *post mortem* examination of the head showed a finely formed brain with a remarkably thin skull.

The main feature of his character was an ardent love of truth; what he had once recognized as true he maintained with all the energy of conviction, caring little whether others were convinced or not; and he sometimes found it difficult to understand how an opinion contrary to his own could be honestly held. Thus he sometimes considered himself aggrieved when he was opposed in things which he had made his own by conscientious study. But when convinced of the excellence of another view, he would at once give his unqualified adhesion to it.

As Hansen had not studied either at a Gymnasium or a University, and had thus been compelled to forego the systematic training of any high school, he owed all the many-sided learning which he acquired to his own untiring diligence and thirst for knowledge. He improved his acquaintance with the French and Latin languages which he had begun at school, as his French and Latin papers sufficiently show. He had also a fair knowledge of English, and even made some

progress in Russian. In his latter years he often recited from memory passages from Homer and Horace. Hansen's personal appearance was noble and imposing; his tall and stately form with his early grey hair gave him a venerable appearance. His whole demeanour, as well as his expression of countenance, announced a man of intellect, and one whose opinions were the result of matured thought. He took little interest in the commonplaces of society, and thereby gave many people the impression of being reserved, but he was gladly and freely communicative in intercourse with those who took a real interest in scientific questions. He willingly acknowledged any suggestion offered to him on such subjects, and enjoyed on this account especially his personal intercourse with the celebrated mathematician Jacobi, during the stay of the latter at Gotha, and felt deeply the loss caused by his early death.

He had great taste for music, and played both on the piano and the harmonium. Another recreation to which he occasionally resorted was chess. He had not much appreciation of the beauties of nature, owing probably to shortsightedness and the peculiarity of his eyes, he being to a considerable extent colour-blind. Accustomed in early youth to a flat seashore, he felt rather oppressed than attracted by the romantic scenery of the Thuringian forest.

He was an affectionate and devoted husband and father, and in his old age took the greatest delight in the society of his little grandchildren.

His predilection for mechanical contrivances, which was one of his chief sources of recreation after any continuous mental labour, continued in later years; and when his eyesight began to fail him, he with his own hands introduced improvements in a most ingenious and artistic watch, which he had contrived during his residence on the Seeberg, and which, besides other things, indicated the mean time, the apparent solar time, and the sidereal time. He also took a steady interest in the machine factory which his son had erected in Gotha.

For nearly forty years Hansen conducted the Detail Survey of the Gotha domains with untiring zeal and care, and had the satisfaction of completing it before his death. Hansen held the appointment of Commissioner of the Ducal Government, and was for a long period President of the "Permanent Commission," which post he only relinquished at last on account of his health. He was also an efficient President of the Commission appointed by the German Empire for the preparation for observing the Transit of Venus. Both these scientific undertakings gave him an opportunity of making elaborate and valuable theoretical investigations.

His collection of scientific books has been, by the enlightened care of the Grand Ducal Government and with the consent of the Landtag, purchased for the Library of the Observatory. With the most praiseworthy liberality his family have delivered up to the Astronomical Society of Leipzig the whole of his valuable collection of manuscripts, thus affording a further proof of the interest ever taken by Hansen in the labours of that institution, notwithstanding that he was not a member of it.

Sir CHARLES LYELL was the eldest son of Charles Lyell, Esq., of Kinnordy, in Forfarshire, where he was born on the 14th of November, 1797. He inherited from his father a strong taste for natural-history pursuits, and in early boyhood devoted himself to them with enthusiasm in the New Forest, to which his family had removed not long after his birth. Destined for the legal profession, he studied at Exeter College, Oxford, and took his M.A. degree in the year 1821. He was duly called to the bar; but by this time his bias towards the life of a scientific student had grown so decided, that the practice of the law became increasingly irksome to him. He had studied geology under Buckland, whom he had accompanied to the field on those equestrian excursions which the merry Professor used to lead over the surrounding country. We find him already, in February 1824, elected Secretary of the Geological Society of London, and in 1826 he entered the Royal Society. His first geological memoir was on some freshwater marls in his native county of Forfarshire; it was read in December 1824: containing a comparison of the recent with ancient deposits of the same kind, it showed the pathway of inquiry which even then he had deliberately chosen, and along which he was to journey to the end of his life as the great apostle of the doctrine that the Present alone affords the key to the Past.

Having recognized at the beginning of his career that the true progress of geology could best be advanced by a careful collection and discussion of all facts bearing upon the present changes of the earth's surface, he devoted himself for several years to a diligent study of all accessible works of travel from which trustworthy information could be obtained regarding modern geological changes. During this time he seems to have written no scientific memoirs for publication; but by the end of the spring of 1828 he had completed the sketch of his 'Principles of Geology.' In May of that year he accompanied Mr. and Mrs. Murchison to France, and spent some time with them in the scientific circles of Paris, among the volcanic rocks of Auvergne and in the interesting valley of the Rhône. This journey formed the turning-point in his career. Instead of returning to London and resuming his professional work, he wrote to his father stating that after the fullest consideration he had at last decided to give up the law and devote himself to science as the occupation of his life. Having taken this determination, he struck southwards into Italy and Sicily, and was soon immersed in those researches in tertiary geology which formed one of the great features in the scientific work of his life.

The first volume of his 'Principles' was published in January 1830. Its appearance at once placed its author in front of the geologists of his day—a position acknowledged even by those who would not admit his doctrine that the present order of nature should be taken as a measure and guide in explaining former geological changes. Before the second volume appeared in January 1832, he had been elected Professor of

Geology in King's College, London—an appointment, however, which he did not long retain. His summers were devoted to excursions through different parts of the British Islands and to tours on the continent, not so much with the view of doing original field-work himself as to see with his own eyes the ground and the rocks described by others, and thus to be better enabled to realize their descriptions and to judge of the relative importance of their contributions to geology. In this way he traversed Europe, from the mountains of Scandinavia to the shores of Sicily, and extended his travels into the Canary Islands. Anxious still further to enlarge his experience, he went to the United States and spent some time in a geological tour there, of which the results were published in 1841 in his volumes of a 'Visit to the United States.' A few years later he again crossed the Atlantic and collected materials, which appeared in 1845 in his 'Second Visit to the United States,' as well as in numerous papers published in various scientific journals.

Though he wrote many minor papers and a few large memoirs on original researches of his own, most of his work appeared from time to time in the successive editions of his 'Principles' and 'Elements.' Among his most important memoirs should be mentioned his paper on the Consolidation of Lava on steep slopes upon Etna, published in the 'Philosophical Transactions' for 1858. This paper may be regarded as having finally exploded the elevation-crater theory of Von Buch, although the admirable memoirs of Scrope had already given that theory its death-blow.

Perhaps the best idea of the solid services rendered by Lyell to geology is obtained by looking back at the condition of the science when he first began to study it, and by contrasting that state with the luminous exposition of the subject in the early editions of his 'Principles.' To men who had been compelled to gain their general view of geology from such works as Daubuisson's 'Traité' or Cuvier's 'Theory of the Earth,' the appearance of Lyell's volumes must have been of the nature of a new revelation. From vague statements about early convulsions and a higher intensity of all terrestrial energy culminating in periodic catastrophes, they were led back, with rare sagacity and eloquence, to the living, moving world around them, and taught to find there, in actual progress now, the analogues of all that they could discover to have been effected in the geological past.

The keynote which Lyell struck at the very outset was, that in geology the past can be understood only through the present, that the forces now in operation are quite powerful enough to produce changes as stupendous as any which have taken place in former times, provided only that they get time enough for their task.

These views were not promulgated for the first time by the author of the 'Principles of Geology.' In cruder form they had been earnestly urged by Hutton, and eloquently illustrated and extended by Playfair; but after much turmoil and conflict of opinion, they had very generally been allowed

to sink out of sight. On the continent, indeed, they had never excited much attention, and were for the most part ignored as mere vague speculation; in this country they had been only partially adopted even by those who professed to belong to the Huttonian school: so that it was, in one sense, as a new doctrine that they were taken up by Lyell, and enforced with a wealth of illustration and cogency of argument which rapidly gained acceptance for them in Britain, and eventually led to their development in every country where the science is cultivated.

In one important respect Lyell's teaching differed from that of his predecessors. Up till his time little had been made of organic remains as monuments of former physical changes as well as records of the history of the progress of life upon the surface of the earth. The stratigraphical labours of William Smith, followed by the palæontological researches of Cuvier and Brongniart, opened fields of inquiry of which their predecessors never dreamed. The old beliefs were being rudely shaken, and in this transition-state of the science there was needed a leisured thinker who could devote a calm judgment and a facile pen to the task of codifying the scattered observations which had accumulated to so vast an extent, and of evolving from them the general principles which they seemed to establish, and which, when clearly announced, could not fail greatly to stimulate and guide the future progress of geology.

Such was the task which Lyell set before himself half a century ago. In its discharge he devoted himself with special ardour to the development of that biological side of geology which owes, if not its existence, at least its rapid and wide spread to his influence. Though not himself, in the strict sense, either a zoologist or botanist, he kept himself throughout his life abreast of the progress of the biological sciences, and on terms of intimate relationship with those by whom that progress was sustained in this country and abroad. He was, in the true meaning of the word, a naturalist. He had in his day few equals in the grasp which he could take of natural-history subjects in their geological bearings. Thus the geographical distribution of plants and animals received more and more ample treatment from him as he advanced in years; the succession of living forms in time gave him a theme for accurate and eloquent description. In fact the breadth of his conception of what geology ought to be was perhaps even more conspicuously marked in this biological side than in that which treated of inorganic operations. He enlisted in his service every branch of natural history which could elucidate the story of the earth and its inhabitants; and not merely the published information on these questions, but many of the floating ideas of discoverers, found their first exposition and illustration in his pages.

Probably no scientific work, except the 'Origin of Species,' has during the lifetime of its author exercised so powerful an influence upon the science which it illustrates as Lyell's 'Principles of Geology.' No fewer than eleven editions appeared, each of them marking a distinct and some-

times a very great advance. At first the descriptive part, relating to the succession of the stratified formations of the earth's crust, was included in the larger work; but this was soon separated, and expanded into an independent volume under the title of 'Elements of Geology,' of which (including the 'Student's Elements') the author lived to edit eight editions. Of these, too, each as it appeared was hailed as the summing-up of a calm and impartial judge of the evidence and arguments in all the disputed stratigraphical questions of the day. When the discussion first arose as to the nature and significance of the worked flints found in the valley of the Somme and elsewhere, Lyell at once put himself in the front by collecting all the available information and publishing it, in 1863, in his 'Antiquity of Man.'

Sir Charles Lyell's position, as a foremost thinker among the geologists of his day, was fully acknowledged during his lifetime. He twice held the Chair of the Geological Society. He presided over the British Association at Bath in 1864. He received the honour of D.C.L. from his own University in 1855. The Royal Society gave him the Copley Medal in 1858. He was chosen a member of the chief learned societies of Europe and America. By his own Sovereign he was knighted in 1848; and, as a further mark of Her Majesty's appreciation, he was raised to the dignity of a Baronet in 1864. He married a daughter of the late Mr. Leonard Horner, F.R.S. Throughout his long and honoured career she joined to the fullest in his labours, accompanying and aiding him in his journeys, assisting him in his literary work, entering into his geological speculations with the heartiest sympathy, and, above all, sharing his friendships and throwing over them, and over the social gatherings at his house, the charm of her genial manner and conversation. She predeceased him in 1873, leaving no children. Sir Charles himself died on the 22nd of February, 1875, and, as a fitting close to his illustrious life, was publicly buried in Westminster Abbey.—A. G.

Dr. Neil Arnott was born at Arbroath, in Scotland, on the 15th May, 1788, and died in London on the 2nd March, 1874. He passed his childhood at Upper Dysart, and began his education partly with his mother, a woman of great energy and ability, and partly in the parochial school of Lunan, near Arbroath. From his earliest years he gave great attention to all natural objects around him, and in after life he often referred to the experience thus acquired as his introduction to the phenomena of the physical world.

Neil Arnott entered the Aberdeen Grammar School in November 1798, and he continued there three years. He went into the Bursary Competition at Marischal College at the beginning of the session of 1801. He was then thirteen, and older than the average of boys at the same stage in the school. He came in sixth, and was entered a student of Marischal College, where he went through the accustomed course of

four sessions, devoting his time to the study of the classics and mathematics, to civil and natural history, as well as chemistry, botany, and zoology.

In the third year of the curriculum he took up the subject of Natural Philosophy, which appears to have had for him an absorbing interest. The Professor in the University was Patrick Copland, a man gifted with remarkable powers of elucidating the phenomena of the science by experiments, and of attracting and fixing the attention of his young pupils. Among these none profited so much by Copland's lectures as the subject of this memoir. In this department Neil Arnott felt himself thoroughly at home, and, aided by the friendly counsel and encouragement of the Professor, he made great and rapid progress. He carried away full notes of these lectures, and turned them to account in his after studies. In other points, too, he benefited greatly by Copland's instructions, *i. e.* in selecting from daily life familiar illustrations of natural phenomena, and in the invention and construction of the most simple forms of apparatus for the purpose of experimental demonstration. After a successful career of study, Neil Arnott obtained his M.A. degree in the year 1805.

He selected the medical profession for his future career, and commenced the study of medicine in Aberdeen, where it was known that he had worked hard in order to qualify himself for entering one of the London Hospital Schools. His wishes in this respect were soon gratified. He arrived in London on the 29th September, 1806, when in his nineteenth year, and entered as a pupil at St. George's Hospital, under Sir Everard Home. Through the influence of Sir Everard he, at a later period, obtained an appointment as surgeon in the East-India Company's medical service. Much of the experience of sea-life which he thereby obtained he afterwards turned to good account in preparing the work by which his name is so well known to the scientific world,—the 'Elements of Physics.' Numerous observations on the waves, currents, tides, winds, and storms, and on the depth and colour of the sea were made by him, and afterwards incorporated in the chapters of this work. He left England on his first voyage to China in 1807, before he had completed his nineteenth year, and after a disastrous course, which took him across the Atlantic to Rio, he landed at the Cape of Good Hope. He there ascended the Table Mountain and made those meteorological observations which are recorded in the 'Physics.' He returned to London in 1809, and made a second voyage to China in 1810.

It was during these voyages, and when in charge of troops, that his attention was specially directed to sanitary matters: ventilation, warmth, clothing, food, air, and exercise were subjects which came before him in a practical form, and many ingenious contrivances were resorted to by him in order to restore and maintain in a healthy condition the invalided men who had been placed under his care. He was so successful in these

efforts that he lost during the voyage home only one man who was hopelessly diseased, and on his return he received the thanks of the military authorities.

In 1811 he commenced practice in London, in Hunter Street, Brunswick Square. He was acquainted with the French, Spanish, and Italian languages; and he had among his patients a large number of foreign refugees who resided in that neighbourhood. He obtained the diploma of the College of Surgeons in 1813. Although fully engaged in medical practice, Neil Arnott's mind was still much directed towards chemistry and physics, and in this year he gave at the Burton Rooms a course of lectures on Natural Philosophy applied to Medicine. The novelty and utility of this course rendered it highly attractive to medical men. At a later date (1825), when residing in Bedford Square, he gave two courses of lectures on the same subject, chiefly to members of the medical profession. He declined, however, to continue these courses; and in the year 1827 he published the substance of them in his 'Elements of Physics.'

In 1814 the University of Aberdeen conferred upon him the degree of M.D. He practised for many years as a physician, and held the appointments of physician to the French and Spanish Embassies. As a physician Dr. Arnott placed more confidence in regimen than he did in drugs. He made many useful mechanical suggestions for the treatment of certain diseases, such as hernia, stricture, &c. It was from 1838 to 1855 that he was in the height of his professional career. He then withdrew from practice, and devoted his time almost exclusively to scientific subjects, including also those of a sanitary nature. In this year he published an account of his smokeless grate, a modification of the open fire-grate, but possessing many of the advantages of the stove. This invention included a complete combustion of smoke and a great economy of fuel with a steadiness and endurance of the fire. It was in reference to this invention that in 1854 the Rumford Medal of the Royal Society was awarded to Dr. Arnott.

In 1832 he first made known the use of the Hydrostatic or Water-bed, which has proved of such important service in medical practice. Devoting his attention to sanitary appliances, including the proper methods of warming and ventilating dwelling-houses, hospitals, and infirmaries, he introduced the stoves which are well known by his name. In his essay on "Warming and Ventilation," published in 1838, he gave a full description of his stove. For this and other novel appliances in the treatment of disease and the preservation of public health, the Jurors of the Universal Exposition of Paris, in 1855, awarded to him a Gold Medal, to which the Emperor Napoleon III. added the Cross of the Legion of Honour.

On the foundation of the University of London, in 1836, Dr. Arnott was appointed one of the original Members of the Senate. In 1837 he

was named one of the Physicians Extraordinary to Her Majesty, and in the following year he was elected a Fellow of the Royal Society. In 1854 he was requested by the President of the General Board of Health to become one of the Medical Council; and it was at this period that he devoted a large portion of his time to education and public works.

As the inventor of the "Arnott Stove," the "Arnott Ventilator," and the Water-bed, it is not likely that his name will soon be forgotten; but it deserves to be recorded in his honour that he refused to patent any of his inventions. His great object through life was to benefit others, and not to obtain pecuniary profit. Sir Arthur Helps, in one of his later works, says truly of Dr. Arnott, "His whole life was given to the service of his fellow men. A truer reformer in the best sense of the word never existed." One great secret of Dr. Arnott's success as a writer on natural philosophy was, that from his earliest days he was an acute observer of all that went on around him. Nothing bearing upon physics escaped his notice. In addition to this faculty of observation he possessed happy powers of description. The reader was not only instructed, but made to feel a deep interest in the subject. Instruction was thus rendered a pleasing recreation. His earnest wish was to make the path of learning easy to all; and the reception of his 'Elements of Physics,' the first edition of which appeared in 1827, is a proof of his success in this respect. There are few educated men of the past generation who will not remember the interest with which they read the first volume of this excellent work; and it is not too much to say that the learned and the unlearned, the student and the philosopher, have benefited by its perusal. This work did more for the encouragement of the study of Natural Philosophy than all the works on the subject which had preceded it. Within five years of its publication five large editions were called for, and, although not then complete, it was reprinted in America and translated into several foreign languages. In November 1829 appeared the first part of the second volume. The work underwent six editions during the life of the author, and a posthumous seventh edition has lately appeared.

In 1861 he published his 'Survey of Human Progress,' and this was followed by various monographs on educational subjects.

In 1856 Dr. Arnott married the widow of one of his oldest friends, Mr. Knight. This lady was the daughter of James Hunt Holley, Esq., of Bleckling, in Norfolk. She was an accomplished woman, and the match was in every way suitable. She survived her husband upwards of two years. She had the same philanthropic and educational views, and lived to carry out his intentions in reference to the endowment of the Scotch Universities. The desire of both was to encourage the study of Natural Philosophy. In 1869 Dr. Arnott granted to the University of London £2000, and to each of the four Universities of Scotland (Aberdeen, Edinburgh, Glasgow, and St. Andrews) £1000, while, subsequently to his

death, Mrs. Arnott granted an additional sum of £4000 to be divided among these Universities. Thus within the period of seven years Dr. and Mrs. Arnott had contributed the sum of ten thousand pounds for the promotion of scientific knowledge.

Dr. Arnott was a man of genial disposition, and had a large circle of friends. He took a delight in the society of these friends and in the progress of scientific research, until the infirmities of age compelled him in a great measure to withdraw from social intercourse.

He died in the 86th year of his age, and up to the last year of his life his mind was still actively occupied in devising and maturing new projects or inventions. Among these may be mentioned a chair-bed for the prevention of sea-sickness and a floating breakwater. It was the delight of his life to devise means of ameliorating suffering and adding to human comfort.

Dr. Arnott died in the Roman Catholic faith, and by his own desire his body was buried in the Dean Cemetery, at Edinburgh, in the grave in which the remains of his mother and other members of his family are deposited. An obelisk with an appropriate inscription in commemoration of himself and them has been erected over the grave.

Anders Jonas Ångström was born on the 13th of August, 1814, at the works of Lögdö, in Medelpad (one of the most northerly provinces of Sweden), where his father was chaplain. Although the latter never obtained any advancement in his profession beyond the position of Comminister, he managed to make his scanty income suffice for the educational expenses of his three sons at the secondary school and at the gymnasium of Hernösand. Of these sons, the eldest Johan, now a medical man at Örnsköldsvik, is well known for his botanical researches, and the youngest, Carl Arendt, is Professor of Practical Mechanics at the Polytechnic School of Stockholm. The second son, Anders Jonas, after studying at the University of Upsala, paid special attention to physics and mathematics, but was obliged from time to time to interrupt his studies in order to give private lessons.

In 1839 he took the degree of Doctor of Philosophy, and shortly afterwards was appointed Professeur agrégé of Physical Science at the University of Upsala, the celebrated Rudberg at that time holding the appointment of Professor of Physical Science.

Ångström had a decided predilection for physics, but as, after the death of Rudberg, Adolphe Svanberg was, in 1841, appointed to the professorship of Physics, he saw no prospect of advancement for himself in that department at Upsala. He therefore accepted the appointment of Assistant Professor of Astronomy. In order to gain practice in making astronomical observations, he passed the year 1842 at the Observatory of Stockholm; but after his return to Upsala he occupied himself chiefly with the theoretical branches of the science, because at that time it was almost

impossible, owing to the want of a suitable observatory in Upsala, to make really accurate observations there.

Ångström's published works on astronomy are not numerous. The most important among them are that entitled 'Ad theoriam Cometarum additamenta' (which he published as an evidence of his competency for the post of Assistant Professor), and another, first published, in 1862, in the 'Transactions' of the Society of Sciences of Upsala.

This latter memoir illustrates Ångström's power of arriving at his end by a more direct process, but which others could only attain by long calculation. Both papers show considerable originality of thought. Thus, for instance, he never approved of the explanation generally adopted of the retardation of Encke's comet by the resistance of the cosmic ether; but his opinion was that it depended on the perturbations of the little planets situated between Mars and Jupiter. There is a note of his on this subject in the 'Comptes Rendus' of the Academy of Sciences of Stockholm for the year 1854. He considered that, as a rule, modern astronomers collect too many observations, gaining from them very few new results in comparison to the number and to the immense amount of labour expended.

The observations on the phenomena of magnetism set on foot by Gauss were originally considered as belonging to the domain of astronomy, an opinion still held by some persons. Gustave Svanberg had, as early as 1836, established at Upsala magnetometers which he had procured from Göttingen. Ångström became much interested in the observations made with the aid of these instruments after his engagement at the Observatory; and in the course of a tour abroad, which he made in 1843, he visited the Observatory of Bogenhausen, near Munich, in order to study the new magnetic apparatus which Lamont had constructed. It was more particularly the apparatus to be employed in travelling which attracted Ångström's attention. He obtained at Munich some of these instruments, and used them assiduously during the remainder of his journey, making magnetic observations at Göttingen, Paris, Brussels, and other places. Between the years 1850 and 1870 he made a large number of observations on magnetic intensity and inclination in different parts of Sweden, but they were never published.

Ångström was commissioned by the Academy of Sciences of Stockholm to work out the magnetic observations which had been made between the years 1851 and 1853, during the voyage round the world of the Swedish frigate 'Eugénie.' The observer, M. Johannson, had died shortly after the return of that expedition, and Ångström was considered to be the person most competent for calculating out these observations, because the English instruments employed by M. Johannson were very similar to those which Ångström was then using for his own obser vations.

The determinations of constants were executed between the years

1854–56, partly according to methods devised by Ångström. But the fact that the observer had sometimes neglected to determine some corrections which had to be applied to the observations, gave rise to scruples in the mind of the calculator, in consequence of which the work advanced so slowly that it was not finished and published until a short time before his death in 1874.

The report of these labours of Ångström forms part of the work published by the Academy of Sciences of Stockholm, 'A Voyage Round the World in the frigate 'Eugénie.''

In the year 1852 the King of Sweden granted new statutes to the Universities of the kingdom. Hitherto the duties of the assistant professors had not been clearly defined; but by these new statutes they were obliged to give regular public instruction. During the next few years Ångström held the professorship of analytical mechanics. Subsequently when, in consequence of enfeebled health, Professor Adolph Svanberg needed a temporary holiday, Ångström from time to time performed the duties of the Professor of Physics; and on the death of Adolph Svanberg he was appointed Professor of Physics at Upsala, and was at last free to devote all his energies to his favourite studies.

Ångström's most important papers are those on optics and on the theory of heat. His first treatise, published on the occasion of his being made Doctor of Philosophy, was on conic refraction, and that which he published when candidate for the office of Professeur agrégé bore the title 'De theoria lucis calorisque dissertatio.' Both treatises show his great erudition in these subjects. He had an extraordinary fertility of ideas and power of coordination. These intellectual qualities are conspicuous in his suggestive dissertation, 'Essay on a Mathematical Theory of Heat.' This paper was, however, never completed; and Ångström considered that it required to be completely recast.

Closely connected with this last treatise was the note he published in 1842, on the occasion of the Meeting of the Scandinavian Naturalists at Stockholm, and which appeared in Poggendorff's 'Annalen,' vol. viii., "Einige Beobachtungen in Betreff der Wärme und deren Theorie," as well as his researches on the transmission of the heat of one metal to another published, in 1860, in the Transactions of the Society of Sciences at Upsala.

To the theory of heat he contributed another important memoir, 'On the Temperature of the Earth at different depths,' for which he had calculated and worked out the observations on the temperature of the Earth made by Rudberg at Upsala between the years 1837 and 1846.

This work, and the ideas gained from his own previous experiments, doubtless formed the basis of the new method of determining the conducting-power of bodies for heat which he applied to solids in 1861, and which he extended to fluids in 1862. This method has attracted

much attention from physicists, from the fact that the determination of the conducting-power is made independently of their radiating-power.

Ångström's first treatise of any length on optics was that 'On Rectilinear Polarization and on the Double Refraction of Crystals with Three Oblique Axes,' by which he has contributed to the explanation of the optical properties of those crystals. With this Memoir is connected his note 'On the Molecular Constants of Monoclinic Crystals.' He also wrote on the question of the principal properties of the plane of polarization, and made experiments on the capacity of absorption of chlorophyl.

Ångström's important work, 'Optical Researches,' was presented to the Academy of Sciences of Stockholm in 1853. In this work he has shown that the spectrum of the electric spark is formed by the superposition of two spectra—one of them due to the metallic pole, the other to the medium through which the spark passes. Following up the observations made by Wheatstone and Masson, he found that the spectrum obtained from an alloy of two metals chemically combined with one another contains the spectrum of each of the two metals.

In the same memoir, Ångström propounds the theory that the only luminous rays which a vapour or gas can absorb are those which it emits when highly incandescent. It was apropos of this theory that Sir Edward Sabine, in his discourse to the Royal Society on the occasion of the election of M. Ångström as a Foreign Member, remarked that the memoir contains the fundamental principles of all subsequent progress in spectrum-analysis.

The continuation of the spectrum researches, published at short intervals by Ångström between the years 1860 and 1870, are well known to physicists. These are:—in 1861, a memoir on the lines of the solar spectrum; in 1863, a new determination of the lengths of the luminous waves; and in 1865, a memoir, published jointly by Ångström and Thalen, on the violet part of the solar spectrum, which paved the way for the great work which Ångström published in 1868, 'Researches on the Solar Spectrum,' containing the determinations, founded on exact measurements, of the length of waves for the different lines of Fraunhofer. His intention was also to treat in this manner the question of the double spectra of bodies; but death interrupted his labours, leaving him only time to discuss, in the 'Comptes Rendus' of the French Academy of Sciences, some ideas put forth by M. Wüllner.

Another work of the same sort, on the Spectra of the Metalloids, had been begun by Ångström some years previously, and was partly printed before his death. Its publication was completed in 1875 by Thalen, in the Transactions of the Society of Sciences of Upsala. A note of his on the Spectrum of the Aurora Borealis, which he was the first to examine,

is contained in the collection of Memoirs published on the occasion of Poggendorff's Jubilee in 1874.

It is much to be regretted that Ångström, in consequence of his great clearness of mind and facility in business matters, was, during his last years, so much occupied with the administration of the University and with other duties totally unconnected with his scientific work. He was Rector of the University of Upsala in 1870 and 1871, President of the Council of Economic Administration of the University from the year 1869 until his death, Secretary of the Society of Science of Upsala from 1867 also until his death, and a Member of the Administrative Council of the city of Upsala from 1868 to 1873.

Ångström did not for many years receive much recognition of his scientific work; but with time distinctions accumulated. In 1850 he was elected a Member of the Royal Academy of Science of Stockholm, in 1851 of the Royal Society of Science of Upsala, of the Royal Physiographical Society of Lund in 1866, of the Société des Sciences Naturelles de Cherbourg in 1867, of the Royal Academy of Science of Berlin also in 1867, Foreign Member of the Royal Society in 1870, of the Royal Society of Science in Copenhagen in 1873, and Corresponding Member of the French Institute in 1873.

Before becoming a Member of the Upsala Society of Science he received from that learned body pecuniary remuneration for researches communicated to them. Several prizes were awarded to him by the Academy of Science of Stockholm, and in 1870 the Royal Society conferred on him the Rumford Medal.

Ångström regularly attended all the meetings of the Scandinavian naturalists. He visited England and France in 1843–44, in 1859, 1866, and 1867. He was a Knight of the Order of the Polar Star, made Commander of the Vasa of the first class in 1873, and Commander of the Italian Order of the Crown. He had a vigorous constitution, and it was only during the last few years of his life that he often complained of violent headache. On the 21st of June, 1874, he died of pachymeningitis, after an illness of three weeks, leaving a widow, one son, and one daughter.

Jean Louis Rodolph Agassiz was born on the 28th of May, 1807, at the village of Motier in the Canton of Freyburg in Switzerland. His father was pastor of Motier, and his ancestors had followed the same profession for six generations. At 10 years of age Jean Louis Rodolph was sent to the Academy of Biel, where he gave evidence of unusual ability. He early showed a strong taste for Natural History, and whilst at Biel began to collect insects; and later on he pursued a systematic study of the plants in the neighbourhood of Orbe near the Jura, to which place his father had moved.

He studied Classics at the Lausanne Academy, and in his 18th year entered on the study of Medicine. He spent two years at Zürich, and thence went to Heidelberg, where he studied Anatomy under Tiedemann, Botany and Zoology under Bischoff and Leuckart. He went in the following year to the University of Munich, where there were at that time many distinguished professors, among them Oken.

At Munich his inclination for the study of Embryology was fostered by his residence in the house of Döllinger. Even at this early period of his career Agassiz showed the strong leaning towards a combination of Natural History and Metaphysics which was his characteristic through life; and whilst studying medicine with a view of making it his profession, he still found time to attend Schelling's course of Mental Philosophy for four consecutive years.

Of his teachers at Munich he has since said,—"Our professors were themselves original investigators, daily contributing to the sum of human knowledge. They were not only our teachers, but our friends. The best spirit prevailed among professors and students. We were often companions of their walks, often present at their discussions; and when we met for conversation or to give lectures among ourselves, as we constantly did, our professors were often among our listeners, cheering and stimulating us in all our efforts after independent research. My room was our meeting-place, bed-room, study, museum, library, lecture-room, fencing-room, all in one: students used to call it 'The Little Academy.'"

At the age of 21 his reputation at the University of Munich was such that Martius entrusted to him the task of describing the fishes collected in Brazil by Spix. This work was published in 1829, under the title "Selecta genera et species Piscium, quos in itinere per Brasiliam peracto collegit et pingendos curavit Dr. J. B. de Spix: digessit, descripsit et observationibus illustravit Dr. L. Agassiz."

Agassiz had already taken the degree of Doctor of Philosophy, and during the following year he passed examinations in Medicine and Surgery.

His work for Martius had led him to make a special study of Ichthyology; and before long he extended his researches from living species to fossil, and entered on that vast field which was to yield him so rich a harvest.

On leaving Munich he resided for a time in Paris, where he acquired the friendship of Cuvier and improved his acquaintance with Humboldt, who became from that time his friend and counsellor for life.

In 1832 he began his career as a teacher. He applied to M. Louis Coulon to obtain for him a position as Professor of Natural History in the Gymnasium of Neufchâtel. No professorship of the kind then existed there; but M. Coulon set to work and raised money enough to guarantee a salary of 2000 francs for three years, and Agassiz was installed as the Professor. There being neither Museum nor Lecture-room, Agassiz

was forced to give his lectures in the Town Hall; but in spite of defective appliances he soon raised his subject to the first rank among those taught in the Gymnasium. He sent for all the specimens he had collected in Germany, constantly added new ones, and by-and-by had a large collection for use. He worked hard at original investigations, constantly employing two artists, Weber and Dinkel, and a painter, Jacques Burkhardt, an old fellow-student at Munich, who became his life-long friend and companion. Stahl, afterwards known as the best modeller at the Jardin des Plantes, was then employed at Neufchâtel; Hercule Nicolet was persuaded to set up there a large lithographic establishment, where were published the last plates of the 'Poissons Fossiles,' those of the 'Poissons d'eau douce,' of the embryology of *Coregonus*, of the works on the Glaciers, and of the Echinoderms.

In 1832, the Société des Sciences Naturelles à Neufchâtel, of which the "Little Academy" at Munich may be said to have been the germ, was founded. The first meeting was held in December, when Louis Coulon was chosen as President and Agassiz as Secretary of the Natural-History Section.

Agassiz held his professorship at Neufchâtel from 1832 until 1846, and during that period got through an enormous amount of work. His work for Martius had led him into palæontology; and the result of his extensive study of fossil fishes was the discovery that the scales of fishes correspond by four kinds of structure to four large natural divisions, which he called Ganoids, Placoids, Cycloids, and Ctenoids. With this basis and with the aid of his intimate knowledge of the skeleton he was enabled to tabulate all the known fossil species to the number of 1000, and these results he published as 'Recherches sur les Poissons Fossiles,' in 5 vols., with about 400 excellent plates. This work occupied ten years in going through the press. It contains the germs of many of the theories he subsequently advocated so zealously in his public lectures. In the preface is found the first notice of his theory of the correspondence between geological succession and embryological development.

The preparation of this book involved an immense amount of work. He had to travel with an artist in order to examine and copy the specimens which could not be sent to Neufchâtel. The expense also was so far beyond his means, that he incurred heavy debts which hampered him for many years. They were not discharged until he had spent many years in the United States, travelling from place to place, giving public lectures on Natural History. At last, finding that this constant travelling interfered too much with his duties at Harvard, he established at Cambridge a school for young ladies, he himself teaching botany, physiology, and geology. This proved eminently successful, and relieved him from all his embarrassments.

After the publication of his work on 'Poissons Fossiles' he came to England to study the fossils of this country, and in 1844 published an

elaborate account of those discovered in the Old Red Sandstone of the Devonian system.

In the midst of all this heavy work he entered on other investigations. He had already turned his attention to the vast ice-masses which furrow the sides of the Swiss mountains, and in 1834 made a report on the observations of Hugi concerning the structure of glaciers. In 1837 he had as President to give the opening discourse to the members of the Helvetic Society of Natural History assembled at Neufchâtel. It was the celebrated "Discours sur l'ancienne Extension des Glaciers." In this discourse he carried to their logical conclusion the facts already observed by Venetz and Charpentier, that boulders are transported and rocks scratched and polished by glacial action; and inasmuch as Switzerland is strewn with these boulders, and exhibits in many places the scratchings and polishing of rock surfaces, he boldly asserted that the whole of Switzerland and also the northern parts of Europe had been covered in former ages by a sheet of ice of vast thickness. This heresy fell like a thunderbolt on the Assembly. Leopold von Buch, the greatest geologist of that time, lost all control over himself, and severely denounced the new theory. When shown the scratched surfaces near Neufchâtel, he replied that the slides of the schoolboys had made them; and he retired at last exclaiming, "O Sancte de Saussure, ora pro nobis." This violent opposition only spurred Agassiz to fresh exertions; and for eight successive seasons he made a series of explorations in the neighbourhood of Mont Blanc and in the Bernese Oberland. With the determination of ascertaining the intimate structure and the movements of ice formations, he established himself in the summer of 1840 on the Median Moraine of the Aar Glacier, and lodged his party, consisting of Desor, Vogt, Burkhardt, and Celestin Nicolet, under a large block of gneiss. This comfortless abode, which was invaded by frost at night and by trickling water in the daytime, was facetiously called "L'hôtel des Neufchâtelais." In 1842 a hut was built on the bank which overhangs the left side of the glacier, and this served as a shelter during the remainder of their visits.

In 1840 and 1841 Agassiz published in French and German his 'Études sur les Glaciers,' accompanied by fine plates. His 'Système Glaciaire,' with its maps and illustrations, did not appear until 1847.

In the midst of these geological and palæontological studies Agassiz found time for a series of careful experiments in moulding. In 1839 his paper appeared, "Sur les Moules de Mollusques vivans et fossiles." In this paper he showed that the soft parts of Mollusca impress their form on the interior of the shell, which form can be reproduced by a cast whose inequalities will represent those of the original animal; so that the casts of mollusks found in great numbers in certain formations could no longer be considered worthless. He first made interior casts of living shells, studied them side by side with the animals, and applied the knowledge of

the animals thus obtained to the fossil casts. This essay was followed by his 'Études critiques sur les Mollusques fossiles.'

At about the same period his attention was attracted to the study of the Radiata and of Embryology. Under his direction experiments were conducted through several seasons on artificially fecundated eggs of the Swiss White-Fish, *Coregonus palcæa*, by Karl Vogt; and in 1842 the account was published as a part of the 'Poissons d'eau douce.' It is worth noting that the Government of Neufchâtel in that same year issued directions to fishermen for the impregnation of fish eggs.

Agassiz had turned his attention to Echinoderms almost as early as to Fishes. In 1834 he had published a paper, "Ueber die äussere Organisation der Echinodermen," in the 'Isis;' and in 1839 he published an admirable anatomical essay on *Astrophyton*. He prosecuted these investigations with extraordinary zeal, and was aided by Desor. Between the years 1838 and 1842 appeared his "Monographies d'Echinodermes vivans et fossiles." From the beginning of his studies he felt the need of having a systematic record of what specialists in palæontology and zoology were doing. He commenced an index, arranged alphabetically and zoologically, of all the generic names introduced into science from the time of Linnæus; this was accompanied by the proper bibliographical references, and formed the commencement of the reform in zoological nomenclature, which was becoming entirely unmanageable. The work was revised and enlarged by 22 of his colleagues, each of whom took a group. The whole was completed in 1846, under the name of "Nomenclator Zoologicus." The bibliographical part was subsequently published by the Ray Society; it was edited by the late Mr. Strickland.

In 1845, on the suggestion of Lyell, Agassiz had been invited by Mr. John A. Lowell to come to Boston and deliver lectures before the Lowell Institute. About the same time, the King of Prussia had been persuaded by Humboldt to present him with a sum of money in aid of a Scientific Mission to America. Agassiz was thus induced to cross the Atlantic Ocean in 1846; and when in 1847 Mr. Abbot Lawrence offered to found for him a professorship of Zoology and Geology in the Scientific School at Harvard College, he obtained his release from his engagements in Europe and accepted the position.

In 1848 he explored Lake Superior, and his account of the observations made there was edited by Mr. J. Elliot Cabot. At the request of Prof. Bache, of the Coast Survey, he passed the winter of 1850 among the Florida Reefs, where he determined the law of growth by which that peninsula has gradually extended southwards by the successive formation of reefs, keys, and mudflats.

In 1852 he was appointed Professor of Comparative Anatomy at the Medical College of Charleston. This appointment did not interfere with his duties at Cambridge, his lectures at Charleston being delivered during the winter vacations of Harvard College. He remained there for only

two terms, when he was compelled by the state of his health to give up the appointment.

In 1853 he published a paper on the newly discovered viviparous fishes of California, and also began to work up the vast amount of materials which he had collected in America. The publications of the American Academy of Boston, of the Boston Society of Natural History, and of the American Association for the Advancement of Science contain a large number of papers on the Natural History of the United States. He was also for many years an active contributor to the pages of the 'American Journal of Arts and Sciences.' He sketched out a series of essays, which were to be entitled "Contributions to the Natural History of the United States." 2500 names appeared on the subscription list of this work. He hoped to publish ten volumes of this series, but only actually published four, leaving a fifth unfinished. These four are:—An Essay on Classification; North-American Testudinata; the Embryology of Turtles; and 'The Acalephs,' under which were included Monographs of the Ctenophoræ, Discophoræ, and Hydroidæ, and an essay on the Homologies of the Radiata. His chief assistant in their preparation was the late Prof. H. J. Clark. These books were illustrated by first-rate lithographic plates, the best of which were drawn by Sonrel.

The 'Essay on Classification' is the crowning work of Agassiz. The erudition displayed in this work is remarkable, and the grasp of facts, intricate and numerous in their relations, is quite amazing. In nothing is this better exhibited than in his celebrated demonstration of embryological, geological, and zoological succession. He shows that in many orders the species which first appear in the older beds resemble the embryo of the highest species now living; and, moreover, that this fossil and this embryo have characteristics in common with the living species that stand lower in the zoological scale. Thus, among living Crustacea, the Brachyurans stand highest; but the embryo of the Brachyuran has a long tail like the Macrurans, which are characteristic of the middle geological periods, and the living forms of which are zoologically inferior to the Brachyurans.

The last years of Agassiz's life were devoted to founding a large museum arranged to show his views of the relations of living animals among themselves, and their connexions in the geological and embryological successions.

His own collections, which had gradually outgrown the means of a single individual, formed the nucleus of a Museum of Comparative Zoology. An endowment-fund was commenced by the generosity of one of his friends, Mr. F. C. Gray, the cooperation of Harvard College and the State of Massachusetts adding to its means at different times. On the death of Agassiz a "Memorial Fund" was raised by subscription, ample enough, it is hoped, to carry out some at least of his cherished ideas.

This Museum has been the nursery for nearly all the Professors of

Natural History in the United States, most of whom are pupils of Agassiz. He did more than any one man to break down the old curriculum of the public schools, and to force the introduction of the teaching of science. His own lectures introduced popular scientific disquisitions into the Lyceum courses, so universal in America. He was an admirable lecturer, fascinating to his audience, and carrying them along by his own enthusiasm; and few even of the public men of America had such a deep hold upon the community as Agassiz. His management of the State Legislature, upon whom he long depended for the support of the museum, was as simple as it was effective. Farmers, merchants, lawyers, and business men, who cared very little for Natural History, freely gave to Agassiz, whose motives were always unselfish, and whose sole aim was the advancement of science.

His wish was to leave this museum as a legacy to the people of America. He gradually gave less time to special investigations and more to the museum, which was to show the forms of life in a connected order.

He brought back a vast collection of specimens from his expedition to Brazil, the results of which expedition are described by Agassiz and his wife in the work 'A Journey to Brazil.' This expedition was undertaken at the cost of Mr. Nathaniel Thayer, who unasked, offered to defray all the expenses, personal and scientific, of six assistants; and eventually did even more than he had promised, continuing to meet all the expenses that were incurred until the last specimen was stored in the Cambridge University. But not even the sight of familiar fishes, that reminded him of old times at Munich and of Spix and Martius, could turn Agassiz again to special studies. He worked on as indefatigably as ever, keeping up his relations with the public, his interest in education, his voluminous correspondence, and giving popular lectures.

But the strain of all this was too great, and in 1869 he was seized with a cerebral attack. He, however, recovered from this, and in the year 1871 joined an exploring-expedition under the direction of the Coast Survey. The steamer 'Hassler' was fitted out expressly to make deep-sea dredgings along the coasts of South America and the west coast of North America. Agassiz had become deeply interested in the results of the deep-sea dredgings he made in 1866 and 1867 in the Straits of Florida, during an expedition under the direction of the Coast Survey, in which he was accompanied by Count Pourtalès. Although the plans of the 'Hassler' Expedition were most carefully matured, it was not a success as far as dredging-operations were concerned. He submitted cheerfully to all the hardships of the voyage round Cape Horn to California, and came back laden with fresh collections. In the course of this expedition a careful exploration was made of the Sargasso Sea, and a nest-building fish discovered, and other important contributions made to Natural Science. His life ended happily; he saw his Museum well supplied with funds and rapidly progressing in size and order. By the aid of the gift of

the Island of Penikese and of a large sum of money, he was enabled to found a summer school of Natural History. The school started with about fifty pupils, and Agassiz had the gratification of founding the first school of the kind in the world. This additional strain on his powers at a season when Agassiz had usually taken a holiday from his ordinary work was too much for his already enfeebled health. On Tuesday, December 2nd, four days before he was attacked with his last illness, he gave an address before the Massachusetts State Board of Agriculture, at Fitchburgh, where he lectured not only with ease but with an unwonted energy, an evidence, no doubt, of cerebral disturbance. This over-exertion was so apparent that, by order of his physicians, he gave up an engagement to lecture at New Haven on the 8th. On the 5th he met his students, and on the 6th, while at work in the Museum of Comparative Zoology, he was taken suddenly ill and retired immediately to his house and bed, never to leave them alive.

His family physician, Dr. Morril Wyman, and his old friend Dr. Brown-Séquard were almost constantly with him during his last illness. He died on the 14th December, 1873.

His funeral was attended at Appleton Chapel, Harvard University, by a vast assembly of mourning friends from Boston and many other towns far and near. The flags of the Municipality of Boston were hung half-mast high, and the bells were tolled during the obsequies. To the solemn music of the "Dead March in Saul" the family and a few near friends, with the University Authorities, left the Chapel for Mount Auburn Cemetery, where now rest the remains of L. J. R. Agassiz.

At the time of his death Agassiz was engaged in his discussion of the "Evolution of Types," the first paper of which appeared in the 'Atlantic Monthly' for December.

Agassiz was much opposed to the theories of Darwin. His old scientific friends, who, one after another, joined the evolutionists, never could understand how he, who had so early in his career pointed the way to what is now one of the strongest proofs of evolution, could resist his own arguments. As a matter of history, it is an interesting record to turn to the pages of his German edition of Buckland's 'Mineralogy and Geology,' and read the notes, many of which would pass as the work of the most advanced evolutionist. But in his later years he was eminently a theistic philosopher. His argument against the doctrine of evolution has been thus described :—

1. There is order and system in organic nature, such as indicates thought. 2. The evolution of species of plants and animals one from another by natural causation is tantamount to a denial of this. 3. Therefore doctrines of evolution are untrue.

Agassiz received the Monthyon and Cuvier prizes and the Copley and Wollaston Medals. He was a Foreign Member of the Royal and Linnean Societies, a Foreign Associate of the French Academy of Sciences, and a member of most other learned Societies and Academies.

Agassiz early married a gifted sister of Professor Alexander Braun, by whom he had three children, who survived him—two daughters, and a son, who has made numerous valuable contributions to our knowledge of Comparative Anatomy and Embryology. His second wife (née Cary), the ever helpful companion and associate in voyage and travel and in literary and scientific work, survives him.