OBITUARY NOTICES OF FELLOWS DECEASED

Between 30th Nov. 1864 and 30th Nov. 1865.

John George Appold died August 31, 1865. Mr. Appold was greatly distinguished as an amateur engineer, and for his success in the general application of chemical, physical, and mechanical principles for the purposes of mankind.

He was born on the 14th of April, 1800, at the factory of his father, Christian Appold, in Wilson Street, Finsbury. He was educated at an indifferent school in the vicinity, and at an early age was taken from his studies to assist his father, who was a fur-skin dyer of much celebrity. At the age of 22 his father gave him the business, when his far-seeing mind at once perceived that the power of steam might be advantageously introduced into his factory, and that if he was to hold the first place in his department of manufacture, he must rely upon a knowledge of chemistry and physics. For years he devoted himself to his factory with such success that he improved his art, and in some cases was the sole possessor of a knowledge of the means by which he carried out difficult processes. Through this superior skill he amassed in a few years a handsome fortune, by industry and talent alone, without resorting to speculation of any kind.

From about the year 1844 he bestowed less time on his business, and was thus enabled to apply the knowledge which he had obtained therefrom to a wider range of subjects, whereby he gained the confidence and esteem of the leading engineers of the age.

Mr. Appold was exceedingly modest and distrustful of his own powers, till he found that men of the highest reputation listened to him with respect and commendation, when, fortunately for the public, he became more confident in enforcing his own inventions. He was somewhat irritable in manner, especially when wrongfully contradicted; but was greatly beloved by his men, not only from the kindness of his heart, but from the confidence with which he inspired them when difficulties had to be overcome.

He was married at the age of 25 to Miss Maria Illmann, who during the whole of his life sympathized with his train of thought, calmed his irritability, took the liveliest interest in all his projects, and by a devotion to his comfort and happiness contributed in no small degree to further the inventions which he has given to the world.

Mr. Appold was not a man of extensive reading, and indeed he used books but little; but he was a careful observer of facts, and his mind was well stored with accurate and exact data available for use. His inventions and processes were the result of pure thought. They were but little derived from the analogy of other methods in actual use, but were in great measure creations of his own mind.

Mr. Appold's chemical inventions were confined to his own business; none of them have ever been published, some are still in the possession of

the present proprietors of the factory, but others doubtless will be for ever lost.

In applied electricity Mr. Appold pointed out difficulties in the use of that agent as a motive power for clocks, and attempted to prevent irregularity in their performance, but without, however, attaining the degree of perfection which his exact mind alone could tolerate. His great work in connexion with electricity is of a purely mechanical nature, as he devised a most efficient break to regulate the speed of laying electric cables at the bottom of the sea. From the great value of this apparatus the name of Appold will be ever associated with this department of engineering, as the successful laying of the Atlantic and other cables has in no small degree depended upon this invention, although others have subsequently made improvements upon it. This contrivance is an adaptation of a labour-regulating machine, invented and patented by him some time previously, for use at prisons, so that the labour which every prisoner performs may be exactly apportioned to his strength.

Hydraulic science was a particularly favourite subject with Mr. Appold. His centrifugal pump stands boldly forward as an invaluable instrument for raising large quantities of water to a moderate height. The construction of this pump was a special instance of an invention arrived at by thoughtful investigation. The experiments were made at considerable cost to himself in his factory, and after accurately watching the results, he applied his mind to a right consideration of their bearing, and thus produced a pump which for its particular purposes surpasses every invention which preceded it. In the Great Exhibition of 1851 a centrifugal pump was exhibited, the merits of which are fully described in the Reports of the Jurors, and in the Exhibition of 1862 a much larger one was shown. The Appold centrifugal pump is largely used in Egypt and in the West Indies for the purposes of irrigation. It is also beneficially used for draining tracts of ground lying below the level of the natural outfall; and Whittlesea Mere, and a great portion of the Bridgwater marshes were drained by its instrumentality.

Mr. Appold also devised a pump for raising the thick viscid printing ink used for the 'Times' newspaper, which apparatus has been employed for some time, and well illustrates his success in adapting his contrivances to the requirements of the case.

His wonderful power of intelligent observation was well displayed during the attempts to launch the Great Eastern steamship at Blackwall by means of hydraulic pumps, when his skilled eye detected that the labourers were working irregularly, and sometimes the labour which they apparently gave was a mere sham. He immediately communicated with Mr. Brunel, who gave him leave to fix a test upon each pump to show the work performed. This was highly appreciated by the great engineer.

Mr. Appold was peculiarly happy in devising valves in connexion with large pumps, and many such now in use at the large waterworks were

contrived by him. He also invented a valve for equalizing the flow of water, and thus ensuring the safety of persons using hydraulic lifts by a proper regulation of the speed, irrespective of variation of the weight by difference in the number of persons employing them. This valve is in common use at all the large hotels.

A very pretty contrivance was invented by him for throwing air into water-pipes under great pressure. At the waterworks of the South Essex Company water is pumped 12 miles and raised 400 feet by the direct action of the engine. Under these circumstances the air in the air-vessel was absorbed by the water, and the use of an air-pump caused great heat from the compression of the air. On consideration of all the facts, he immediately contrived an injector, by which a suitable quantity of air was thrown into the air-vessel without the aid of any pump.

He also devised a simple method to avoid the bursting of water-pipes in houses when the water is suddenly shut off at high pressures, and also to prevent the unpleasant noise which occurs under these circumstances. His contrivance consists in soldering a foot of pipe, closed at one end and full of air, vertically near the tap. This acts as an air-vessel, and perfectly prevents the noise or the risk of fracture of the pipe.

The Appold overflow for cisterns is an ingenious application of scientific principles, by which cisterns can be filled with safety to a very short distance of their top. The overflow consists of a funnel-shaped pipe, contracted at the bottom and very large at the top. This is covered with an inverted metallic saucer, so that when the water flows fast the whole pipe is filled, and with the covering constitutes a siphon which powerfully sucks down the water.

Mr. Appold also warmly advocated the use of siphons to carry water over an embankment instead of having culverts through the bank. For this purpose he recommended that one valve only should be used, and that it should be placed at the upper part of the siphon, so that facility of examination may be secured. Mr. Appold also suggested to Messrs. Easton and Amos the arrangement of air-pumps which are employed for the exhaustion of the siphons at Kings Lynn.

Great as Mr. Appold was in his knowledge of hydraulic principles and in his application of them, he was no less fortunate in his successful appreciation of pneumatic science. He was a thorough master of ventilation, and that at a time when the principles of the art were but imperfectly known; his own house was for years regarded as a model of perfection in that way, as fresh air of regulated temperature and moisture, and thoroughly screened from all impurities, was abundantly supplied by a series of most ingenious self-acting contrivances. The Appold motor-hygrometer which Mrs. Appold presented to the Royal Society, whereby a self-acting motive power was obtained under any desired condition of hygrometric moisture, is a very remarkable example of the skill with

which Mr. Appold devised the most delicate apparatus to meet any want. By the use of this instrument the flow of a small stream of water over a warm stove was regulated, and by this means one uniform hygrometric state of the atmosphere was ensured throughout the building. The bellows he applied to prevent the jar of slamming doors is an ingenious and effective apparatus; and the Appold Pneumatic Valve, for preventing down draughts with very feeble currents, acts perfectly.

Mr. Appold's mechanical contrivances were innumerable, and many of them distinguished by their extreme originality. Perhaps the most remarkable is the scrubber, devised to remove deposits from the inside of the water-pipes of a town. This has been used with perfect success at Torquay, but it is to be regretted that he never himself knew that his design answered its expectations. It was a question whether the main pipes of Torquay would not have to be removed, but the action of the scrubber was so perfect, that the deposit was entirely disintegrated and carried away with the flow of water. In his factory many remarkable devices existed. Pumps were curiously arranged to throw on and off as they were required; and air was supplied to the steam-engine fire by self-regulating apparatus.

Besides his more important contrivances he made some for mere amusement; and every part of his house bore testimony to the fertility of his imagination and power of invention. Doors were made to open on approach, and to shut after the person had passed through; others locked themselves afterwards. He had contrivances also by which all the shutters of a room closed by the touch of a spring, and thus, when associated with the regulator of a gas-lamp, caused a change from daylight to gaslight, to the no small amusement of his visitors. All his numerous contrivances acted perfectly, even to the unimportant matter of his self-acting stable-gates, which when once adjusted, were so exact in their mechanism that they remained in use for years without requiring attention.

Shortly before his death he was constructing an apparatus for measuring accurately the pitching and rolling of vessels at sea.

Mr. Appold showed a knowledge of the laws of heat by constructing a thermometer of extreme delicacy for a range of a few degrees. It consisted of a thin plate of zinc and steel rivetted together, and suspended on a knife-edge, so that its bar was unequally balanced. This form of thermometer is difficult to manufacture, otherwise it would doubtless be in general use for sitting-rooms and greenhouses, as it indicates distinctly a variation of a tenth of a degree, which can be read across the room. He also constructed a motor thermometer to regulate the supply of gas to a stove according to the temperature of an apartment at a considerable distance, and this acted in the most efficient manner.

One very curious application of physiological experiment Mr. Appold has left us in connexion with the Daguerreotype. In the early days of stereoscopic photography he conceived the idea that from the superposition in

Wheatstone's stereoscope of two images of the human countenance, one laughing and the other extremely serious, a normal state of countenance would be produced. Accordingly he had two such pictures made of himself, and the effect which is produced by regarding the two images through the stereoscope is so good, that his family and friends consider that it is by far the best likeness which remains, and expresses most accurately his natural condition of countenance.

With but very slight knowledge of the use of figures, Mr. Appold had very considerable power of mental calculation. He made curious and extensive mental calculations which approximated very closely to the truth. In this way he astonished Stephenson and other engineers by suddenly stating how much he could by his own strength deflect the colossal bridge over the Menai Straits. Upon accurate measurement it was found that he really deflected it more than he stated, but then he said he used all his strength, and had been afraid of overstating his case. His mode of calculating appeared to be by a geometric series, continually halving or doubling, as the case required, from a known unit.

During the last twenty years of his life he was always present when any great engineering work was being carried out. He was ever watchful and suggestive when difficulties arose, and contributed his share to the success of the undertaking. In this manner he exercised an important influence, and his loss will be keenly felt wherever new and difficult mechanical operations are attempted.

We thus find that Mr. Appold was the author of inventions of great originality in various departments of practical science. It is interesting to know the manner in which he applied his mind for that purpose It was his habit when a difficulty arose, carefully to consider the exact result he required, and having satisfied himself upon that point, he would direct his attention to the simplest mode by which the end could be attained. With that view he would during the day bring together in his mind all the facts and principles relating to the case, and the solution of the problem usually occurred to him in the early morning after sleep. If the matter was difficult, he would be restless and uneasy during the night; but after repose, when the brain had recovered from fatigue, and when in the quiet of the early morning no external influences distracted his attention, the resultant of all known scientific principles bearing upon the question presented itself to his mind.

Mr. Appold's inventions were essentially practical. They were not mere proposals or paper inventions; and he ever showed that he was a man of action in bringing into successful operation his various designs. Great, however, as were his powers of thoughtful invention he was not distinguished in the study of the higher relations of the physical forces, and he left to others the task of propounding those noble generalizations of modern days which have done so much to simplify and dignify human knowledge; but

he affords a conspicuous example, in his own line, of the benefits that may be conferred on mankind by rightly directed thought, even when unaided by acquired learning. He followed the religion of his country, without associating himself with theological controversies; and his numerous acts of charity and benevolence were bestowed with the utmost care that the giver should remain unknown.

Mr. Appold was afflicted with a painful disease for the last few years of his life, which he bore with heroic fortitude. He was suddenly, however, seized with internal hæmorrhage at Clifton, when he met his death with that calm resignation which marks the true philosopher. To the honour of the inhabitants of the parish in which he lived, a monument has been erected by them to his memory in the Church of St. Leonard, Shoreditch.

His election into the Royal Society took place on the 2nd of June, 1853.

George Boole, by whose death mathematical science has suffered a great loss, was born at Lincoln on the 2nd of November, 1815. His father was a tradesman of very limited means, but held in high esteem by those who knew him. Having nothing to support his family but his daily toil, it was not to be expected that he could expend much on the education of his children; yet they were not neglected. Being himself a man of thoughtful and studious habits, possessed of an active and ingenious mind, and attached to the pursuit of science, particularly of mathematics, he sought to imbue his children with a love of learning, and employed his leisure hours in imparting to them the elements of education. His son George was sent first to the National School, and afterwards to a private Commercial School, conducted by the late Mr. Thomas Bainbridge, Lincoln. From his father he received his principal instruction in the rudiments of mathematics, and from him also he inherited a taste for the construction and adaptation of optical instruments. It was not, however, until a comparatively late period of his earlier studies that his special aptitude for mathematical investigations developed itself. His earlier ambition seems to have pointed to the attainment of proficiency in the ancient classical languages; but his father being unable to assist him in overcoming the first difficulties of this course of study, he was indebted to a neighbouring bookseller (Mr. William Brooke) for instruction in the elements of Latin grammar. To the study of Latin he soon added that of Greek, without any external assistance, and for some years he devoured every Greek and Latin author that came within his reach.

At the age of sixteen he became an assistant in a school at Doncaster; subsequently he occupied a similar post at Waddington, a village about four miles from Lincoln. In these situations, besides prosecuting his studies in the ancient classics, he cultivated an acquaintance with the best English authors, and began to read the German, French, and Italian languages, in all of which he ultimately attained singular proficiency.

Two of his latest mathematical essays were written, one in German, and the other in French. As he had at this time a great wish to take orders in the church, he applied himself for two years to the study of patristic literature by way of preparation for the regular theological course. But the circumstances of his parents and some other difficulties hindered the accomplishment of this design. In his twentieth year he decided on opening a school on his own account in his native city. Henceforward mathematics became his special study.

His earliest papers, written, as he himself incidentally mentions, toward the close of the year 1838, were prepared during his perusal of the 'Mécanique Analytique,' in the form of "Notes on Lagrange." From these notes in the following year he made selections, and wrote out what appears to have been his first paper (though not the first published), entitled "On certain Theorems in the Calculus of Variations," wherein he proposed various improvements on methods of investigation employed by the illustrious French analyst. About the same time his attention was attracted to the transformation of homogeneous functions by linear substitutions, a problem which occupies a very conspicuous place in the writings of Lagrange, and which had also employed the powers of Laplace, Lebesque, Jacobi, and other distinguished continental mathematicians. The manner in which Boole dealt with this important problem showed him at once to be a man of most original and independent thought, and in the course of his investigations he was led to discoveries which may be regarded as the foundation of what has been called the Modern Higher Algebra. His first published paper relates to this subject; and although he afterwards greatly improved and extended his method of analysis, yet his original memoir, entitled "Researches on the Theory of Analytical Transformations, with a Special Application to the Reduction of the General Equation of the Second Order," is interesting as showing how the subject first struck his mind. This memoir he communicated in 1839 to the Cambridge Mathematical Journal. Other papers in rapid succession followed. The generous assistance of the editor, the late Mr. Duncan F. Gregory, in correcting the imperfections of style which naturally resulted from his want of proper early training, Boole remembered with pleasure and thankfulness to the end of his life. His rising reputation led his friends to wish that he should enter himself at Cambridge. This project also he abandoned, and he continued to work amidst the interruptions and anxieties incident to the occupation of a schoolmaster. While applying the doctrine of the separation of symbols to the solution of differential equations with variable coefficients, Mr. Boole was led to devise a *general method in analysis*. The work was too elaborate and weighty for the mathematical journal; and he therefore, by the advice of Mr. Gregory, communicated a paper on the subject to this Society. For this paper, which was printed in the Transactions for 1844, he received the Royal Medal.

In the course of these speculations, and others of a like nature which grew out of them, Mr. Boole was led to consider the possibility of constructing a calculus of deductive reasoning. The severe discipline of his efforts to extend the powers of the analysis had given him not only a complete mastery over its mechanical processes, but also, what was of far greater advantage, a profound insight into its logical principles. In tracing out those principles he discovered that they admitted of an application to other objects of thought than number and quantity; he found, in fact, that logical symbols in general conform to the same fundamental laws which govern the symbols of algebra in particular, while they are subject also to a certain special law. This discovery suggested a variety of inquiries which he seems at different periods to have pursued, but without any intention of publishing his views on the subject. In the spring of the year 1847, however, his attention was drawn to the question then moved between Sir W. Hamilton of Edinburgh and Professor De Morgan, and he "was induced by the interest which it inspired, to resume the almost forgotten thread of former inquiries." His views were embodied in a remarkable essay, entitled "The Mathematical Analysis of Logic," which in the autumn of the year was put on sale in Cambridge and London. Early in the following year (1848) he communicated to the Cambridge and Dublin Mathematical Journal a paper on the "Calculus of Logic," in which, after premising the notation and fundamental positions of his essay, he gave some further developments of his system. From this time forward he applied himself diligently to a course of study and reflection on psychological subjects, with a view to the production of a much more elaborate and exhaustive work than either of those above named. He felt that the inquiry was one of great importance, and that in labouring to perfect his theory he was rendering essential service to science. He meditated deeply on the nature and constitution of the human intellect. The most eminent authorities, both ancient and modern, were consulted; opinions differing widely from each other, and often wholly opposed to his own, were carefully considered; and whatever was likely to help him in the great work which he had undertaken, was eagerly sought. Mental science became his study; mathematics were his recreation. So he has been heard to say; and yet it is a remarkable fact, and one which serves to show the great power and genius of the man, that his most valuable and important mathematical works were produced after he had commenced his psychological investigations.

In 1849 he was appointed to the Mathematical Chair in the newly formed Queen's College at Cork; and when the Queen's Colleges of Belfast, Galway, and Cork were united so as to form the Queen's University of Ireland, he was chosen one of the public examiners for degrees. These offices he filled with the highest reputation. In 1852 the University of Dublin conferred upon him the honorary title of LL.D., in company with

the late Judge Hargreave, "in consideration of their eminent services in the advancement of mathematical science." Late in the year 1853 Dr. Boole brought to its close a labour on which he had bestowed a vast amount of profound and patient thought. His "Mathematical Analysis of Logic" was written hastily, and on this account he afterwards regretted its publication; but the work which he now gave to the world must be regarded as the most carefully matured of all his productions. It is entitled "An Investigation of the Laws of Thought, on which are founded the Mathematical Theories of Logic and Probabilities." The principle on which the investigation proceeds is essentially the same as that enunciated by the author in his earlier logical essays; but, as he himself remarks, "its methods are more general, and its range of applications far wider." This great work was published in 1854.

During the remaining ten years of his life he contributed to various scientific journals papers on Probabilites, on Partial Differential Equations, on the Comparison of Transcendents, and on other high mathematical subjects. He also produced two text-books, one on 'Differential Equations,' and one on 'Finite Differences'—works which display a vast amount of original research as well as an extensive acquaintance with the writings of others. These have become class-books at Cambridge.

In 1855 Dr. Boole was married to Miss Mary Everest, daughter of the late Rev. T. R. Everest, Rector of Wickwar, Gloucestershire, and niece of Colonel Sir George Everest, F.R.S., lately deceased, as also of Dr. Ryall, the Vice-President and Professor of Greek in Queen's College, Cork. The union was one of great mutual happiness, and was blessed with a family of five daughters.

In 1857 Dr. Boole communicated to the Royal Society of Edinburgh a memoir "On the Application of the Theory of Probabilities to the Question of the Combination of Testimonies or Judgments." For this purpose there was awarded to him the Keith Medal, the highest honour in the shape of prize which that Society has at its disposal. In June of the same year he was elected a Fellow of this Society. At the Oxford Commemoration in 1859 he received the honorary degree of D.C.L.

Soon after the publication of his Treatise on Differential Equations, Professor Boole resolved that if a new edition of the work should be called for he would reconstruct it on a more extended scale. For several succeeding years his studies and researches were largely inspired and directed by this object, which, however, he did not live to accomplish. The treatise had been for some time out of print, and he was engaged in preparing a new and enlarged edition when he was suddenly struck by the hand of death.

He had walked from his residence at Ballintemple to the College in Cork, a distance of little more than two miles, in a drenching rain, and lectured in his wet clothes. The result was a feverish cold, which soon

fell upon his lungs and terminated fatally. He died on the 8th of December, 1864.

Dr. Boole was a man of great goodness of heart. By those who knew him intimately he was regarded with a feeling akin to reverence. "Apart from his intellectual superiority," says one of his colleagues, "there was shed around him an atmosphere of purity and moral elevation, which was felt by all who were admitted within its influence. And over all his gifts and graces there was thrown the charm of a true humility, and an apparent total unconsciousness of his own worth and wisdom."

Many illustrations might be given of the versatility of Boole's talent, his love of poetry and music, his fine appreciation of the beauties of external nature, his profound reverence for truth, especially religious truth, and many other qualities of his intellect and heart which have not been so much as touched upon; but the limits within which it is proper that this sketch should be contained forbid any elaborate estimate of his character.

Boole's mathematical researches have exercised a very considerable influence upon the study of the higher branches of the analysis, especially in this country. They have stimulated and directed the efforts of other investigators to an extent that is not perhaps generally known. Out of his theory of linear transformations has grown the more general theory of covariants (due to Professor Cayley), with all its important geometrical and other applications. By his invention of an algebra of non-commutative symbols, a great impulse has been given to the cultivation of the calculus of operations. His general method in analysis is the most powerful instrument which we possess for the integration of differential equations, whether total or partial. To Sir John Herschel is due the high praise of having first applied the method of the separation of symbols to the solution of linear differential equations with constant coefficients. But it was reserved for Duncan F. Gregory and Boole to set the logical principles of that method in a clear and satisfactory light; and to Boole alone belongs the honour of having extended the theory to the solution of equations with variable coefficients. His principal discoveries in this department will be found in his 'Differential Equations,' and the Supplementary volume (edited by Mr. Isaac Todhunter), works which though primarily intended for elementary instruction, may be read with advantage by the advanced mathematical student. Other original investigations will be found in the same volumes, and more especially in those parts which relate to Riccati's equation, to integrating factors, to singular solutions, to the inverse problems of geometry and optics, to partial differential equations, and to the projection of a surface on a plane.

The calculus of logic, upon the invention of which Boole's fame as a philosophical mathematician may be permitted to rest, is most fully developed in his 'Investigation of the Laws of Thought.' The design of this work is—to use the author's own words—"to investigate the fundamental

laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolical language of a Calculus, and upon this foundation to establish the science of logic, and construct its method; to make that method itself the basis of a general method for the application of the mathematical doctrine of Probabilities; and, finally, to collect from the various elements of truth, brought to view in the course of these inquiries, some probable intimations concerning the nature and constitution of the human mind."

Boole has left behind him a considerable quantity of logical manuscripts; these will perhaps be published either in a separate form or in a new edition of the 'Laws of Thought.' His works are his noblest monument, but his friends and admirers have raised other memorials. Of these we may mention in particular, a memorial window in the Cathedral at Lincoln, and another in the College Hall at Cork.

The following is a list of Professor Boole's papers printed in the Philosophical Transactions. "On a General Method in Analysis," 1844, pp. 225–282. "On the Comparison of Transcendents, with certain applications to the Theory of Definite Integrals," 1857, pp. 745–803. "On the Theory of Probabilities," 1862, pp. 225–252. "On Simultaneous Differential Equations of the First Order in which the Number of the Variables exceeds by more than one the Number of the Equations," 1862, pp. 437–454. "On the Differential Equations of Dynamics. A Sequel to a paper on Simultaneous Differential Equations," 1863, pp. 485–501. "On the Differential Equations which determine the form of the Roots of Algebraic Equations," 1864, pp. 733–755.

Samuel Hunter Christie was born in London on the 22nd of March, 1784, and at a very early age showed the talent for mathematical pursuits which afterwards so highly distinguished him. He was entered at Trinity College, Cambridge, in 1801, and, in his third year, obtained a scholarship. In 1805 he took his degree of Bachelor of Arts as Second Wrangler, having a severe struggle with Turton (afterwards Bishop of Ely) for the "Blue Riband" of the University, and being bracketed with him as Smith's-prizeman. In 1806 Mr. Christie was appointed Third Mathematical Master at the Royal Military Academy at Woolwich, and immediately devoted himself to the improvement of the mathematical studies at that College, and persevered in the work with much success, during his lengthened career of forty-eight years in the public service. In 1812 he established the system of competitive examinations, but was unable fully to carry out his views in this and in other respects until his advancement to the post of Professor of Mathematics in 1838. It is not too much to say that no two educational institutions could present a stronger contrast than the Royal Military Academy in 1806, and the same College in 1854 when Mr. Christie resigned the Professor's Chair; and this

change was in great measure due to his unflagging advocacy of an improved system.

It is, however, in Mr. Christie's labours as one of our more distinguished Fellows that the Society is principally interested. Our Transactions are enriched with a number of papers from his hand, and he took an important share in promoting the great advance in both theoretical and experimental knowledge of magnetical science, which received its impulse from the observations made during the Arctic voyages in 1818 and 1819. The leading idea which runs through Mr. Christie's theoretical discussions of his various experimental results, he first stated as an hypothetical law in a paper published in the Cambridge Philosophical Transactions for 1820. In a paper read before the Royal Society in June 1824, he gave an account of some of his experiments for the determination of the effects of temperature upon magnetic forces, and established a correction for temperature in the experimental determination of the magnetic intensity, which had been previously overlooked. Mr. Christie was the first to observe the effect of the slow rotation of iron in producing magnetic polarity, and, at his suggestion, the very interesting series of experiments which he originated, and which are given in detail in a paper published in the Philosophical Transactions for 1825, were repeated by Lieutenant Foster, R.N., during the expedition to the north-west coast of America in 1824, under Captain Parry, with results even more striking than his own, owing to the diminished horizontal component of the magnetic force.

In 1833 a paper by Mr. Christie upon the magneto-electric conduction of various metals was selected by the Council of the Royal Society as the Bakerian Lecture for the year. In this paper he shows, both experimentally and theoretically, that the conducting power of the several metals varies inversely as the length, and directly as the square of the diameter of the conducting wire, thus obeying the same law as that previously discovered by Sir Humphry Davy and Professor Cumming, in the cases of voltaic and thermo-electricity; although his conclusion as to a difference in the order of their conducting powers could not now be maintained His important remark in this paper—that magneto-electricity cannot be developed at the same instant in every part of a system, *and that the action on the remote parts of the wire cannot be absolutely simultaneous* with that on the parts in the immediate neighbourhood of the magnet—appears to have been almost prophetic, now that we are able to submit this vast velocity to a definite measurement, by timing the transmission of effect through a journey of three thousand miles.

The effect of the solar rays upon the magnetic needle very early engaged Mr. Christie's attention, and he showed, by a series of experiments detailed in papers published in the Philosophical Transactions for 1826 and 1828, that the direct effect of the solar rays is definite and not due to any mere calorific influence. He then also threw out the suggestion that terrestrial magnetism is

probably derived from solar influence. On this idea he instituted a series of experiments to determine whether a source of heat applied to two substances of different conducting powers in uniform contact, like the earth and the atmosphere, would produce phenomena corresponding to the diurnal variation, as the source of heat was applied successively to different parts of the combined system. The results he obtained were in accordance with this supposition, but of course their validity as evidence is subject to the question of how far the actual conditions of the earth were truly represented in the ingenious experimental combination which he adopted.

Mr. Christie appears to have been the first to make use of a torsion balance for the determination of the equivalents of magnetic forces; he also devoted himself to the improvement of the construction of both the horizontal needle and the dipping-needle; and he served constantly upon the "Compass Committee" formed to assist the Admiralty in bringing the Compasses of the Royal Navy into some accordance with the advanced knowledge of the day.

In the Report of the British Association for 1833, the portion which refers to the then state of knowledge of the magnetism of the earth was drawn up by Mr. Christie, and he therein again maintained that not only the daily variation, but also the quasi-polarity of the earth is most probably due to the excitation by the solar heat, of electric currents at right angles, or nearly so, to the meridian; and he suggests that the direction of these currents must be influenced by the form, extent, and direction of the continents and seas over which they pass, and also by the height, direction, and geological structure of chains of mountains.

The Letter of Baron Humboldt in 1835 to H.R.H. the Duke of Sussex, P.R.S., on the establishment of permanent magnetic observatories at widely separated stations within the British territories, was referred by H.R.H. the President, to Mr. Christie and Mr. Airy to report upon. Their report was read to the Royal Society in November 1836; and upon a further report to the same effect from the joint Committee of Physics and Meteorology in 1838, the President and Council made a representation in favour of the measure to Her Majesty's Government which was successful.

In connexion with Mr. Christie's career as a teacher, it may be mentioned that he was the author of an 'Elementary Course of Mathematics' for use in the Royal Military Academy. In 1837 Mr. Christie succeeded Mr. Children as one of the Secretaries of the Royal Society, and retained that office until 1854, when he went to reside at Lausanne upon his retirement from the post of Professor of Mathematics at the Royal Military Academy. He was one of the Visitors of the Royal Observatory at Greenwich; a Vice-President of the Royal Astronomical Society; a Corresponding Member of the Academy of Sciences of Palermo, and a member of the Société Philomathique of Paris. He died at Twickenham, where he had resided for some years, on the 24th of January, 1865, having nearly completed his

eighty-first year. The date of his election into the Society is January 12, 1826.

The science of Palæontology has sustained a great loss in the death of Hugh Falconer, M.D. Born at Forres, in the north of Scotland, on the 29th of February, 1808, he received his early education at the Grammar school of that town, and afterwards studied Arts at the University of King's College, Aberdeen, and Medicine at the University of Edinburgh. From the former University he received the degree of A.M.; and from the latter, in 1829, the degree of M.D.

As a boy, he exhibited a decided taste for the study of natural objects, which he eagerly followed up in Edinburgh under the systematic tuition of Professors Graham and Jameson. On visiting London in 1829, he availed himself of the opportunity to assist the late Dr. Nathaniel Wallich in the distribution of his great Indian herbarium, and to study the collection of Indian fossil mammalia from the banks of the Irrawaddi, formed by Mr. John Crawfurd during his mission to Ava, and presented by him to the Geological Society. Both occupations proved of material service in his subsequent career, and in the latter instance it determined the labours to which he afterwards so zealously devoted himself.

In 1830 Dr. Falconer proceeded to India as an Assistant-Surgeon in the H.E.I.C. Service, and arrived in Calcutta in September of that year. Here he at once undertook an examination of fossil bones from Ava, in the possession of the Asiatic Society of Bengal, and published a description of them, which at once gave him a recognized position in the roll of cultivators of science in India, and led to his being appointed in 1832 to succeed Dr. Royle as Superintendent of the Botanic Gardens of Suharunpoor, in the North-western Provinces.

In the same year (1832) he made an excursion to the Sub-Himalayan range, and from the indication of a specimen in the collection of his friend and colleague, Captain, now Sir Proby T. Cautley, the real nature of which had been previously overlooked, he was led to discover vertebrate fossil remains *in situ* in the tertiary strata of the Sewalik Hills. The search was speedily followed up with characteristic energy by Captain Cautley in the Kalowala Pass, by means of blasting, and resulted in the discovery of more perfect remains, including miocene mammalian genera. The finding, therefore, of the fossil fauna of the Sewalik Hills was not fortuitous, but a result led up to by researches suggested by previous special study, and followed out with a definite aim. Early in 1834 Dr. Falconer gave a brief account of the Sewalik Hills, describing their physical features and geological structure, and showing their relation to the Himalayahs (Journ. Asiat. Soc. of Bengal, vol. iii. p. 182). The name "Sewalik" had been vaguely applied before then by Rennell and others to the outer ridges of the true Himalayahs, and the lower elevations towards

the plains. Dr. Falconer restricted the term definitely to the flanking tertiary range, which is commonly separated from the Himalayahs by valleys or *Doons*. The proposed name was not favourably received at the time by geographical authorities in India; but it is now universally adopted in geography and geology as a convenient and well-founded designation. On his first visit to the Sewalik Hills, Dr. Falconer concluded that they did not belong to the "New Red Sandstone," to which they had been referred by Captain Herbert, but that they were of a tertiary age, and analogous to the *Molasse* of Switzerland. Thirty years of subsequent investigation by other geologists have not altered that determination, although our exact knowledge of the formation has been greatly extended.

The researches thus begun were followed about the end of 1834 by the discovery by Lieutenants Baker and Durand of the great ossiferous deposit of the Sewaliks, near the valley of the Markunda, westward of the Jumna, and below Nahun. Captain Cautley and Dr. Falconer were immediately in the field, and by the joint labours of these four officers a subtropical mammalian fossil fauna was brought to light, unexampled for richness and extent in any other region then known. It included the earliest discovered fossil *Quadrumana**, an extraordinary number of *Proboscidia* belonging to *Mastodon, Stegodon,* and *Elephas*; several extinct species of *Rhinoceros*; *Chalicotherium*; two new subgenera of *Hippopotamus,* viz. *Hexaprotodon* and *Merycopotamus*; several species of *Sus* and *Hippohyus,* and of *Equus* and *Hippotherium*; the colossal ruminant *Sivatherium,* together with fossil species of *Camel, Giraffe, Cervus, Antilope, Capra,* and new types of *Bovidæ*; *Carnivora* belonging to the new genera *Sivalarctos* and *Enhydriodon,* and also *Machairodus, Felis, Hyæna, Canis, Gulo, Lutra,* &c.; among the *Aves,* species of *Ostrich, Cranes,* &c. Among the *Reptilia, Monitors,* and *Crocodiles,* of living and extinct species, the enormous tortoise, *Colossochelys Atlas,* with numerous species of *Emys* and *Trionyx*; and among fossil Fish, *Cyprinidæ* and *Siluridæ*. The general facies of the extinct fauna exhibited a congregation of forms participating in European, African, and Asiatic types. Thrown suddenly upon such rich materials, the ordinary means resorted to by men of science for determining them by comparison were wanting. Of palæontological works or osteological collections in that remote quarter of India there were none. But Falconer was not the man to be baffled by such discouragements. He appealed to the living forms abounding in the surrounding forests, rivers, and swamps to supply the want. Skeletons of all kinds were prepared; the extinct forms were compared with their nearest living analogues, and a series of memoirs by Dr. Falconer and Captain Cautley, descriptive of

* Dr. Falconer's first published memoir on the Quadrumana of the Sewalik Hills was dated November 24th, 1836, and it was not until January 16th, 1837, that M. Lartet's memoir on the discovery of the jaw of an Ape in the tertiary freshwater formation of Simorre was presented to the French Academy of Sciences.

the most remarkable of the newly discovered forms, appeared in the 'Asiatic Researches,' the 'Journal of the Asiatic Society of Bengal,' and in the 'Geological Transactions.' The Sewalik explorations soon attracted notice in Europe, and in 1837 the Wollaston Medal, in duplicate, was awarded for their discoveries to Dr. Falconer and Capt. Cautley by the Geological Society.

In 1834 a Commission was appointed by the Bengal Government to inquire into and report on the fitness of India for the growth of the tea-plant of China. Acting on the information and advice supplied by Dr. Falconer (Journ. Asiat. Soc. of Bengal, 1834, iii. p. 182), the Commission recommended a trial. The Government adopted the recommendation; the plants were imported from China, and the experimental researches were placed under Falconer's superintendence in sites selected by him. Tea culture has since then greatly extended in India, and the tea of Bengal bids fair to become one of the most important commercial exports from India, as Falconer long ago predicted.

In 1837 Dr. Falconer was ordered to accompany Burnes's second mission to Caubul, which preceded the Affghan war. Proceeding first westward to Kohat and the lower part of the valley of Bunguish, he examined the Trans-Indus portion of the Salt-range, and then made for Cashmeer, where he passed the winter and spring in examining the natural history of the valley, and in making extensive botanical collections. The following summer (1838) he crossed the mountains to Iskardo, in Bulkistan, and traced the Shiggar branch of the Indus to its source in the glacier, on the southern flank of the Mooztagh range. Having examined the great glaciers of Arindoh and of the Brahldoh valley, he then returned to India *viâ* Cashmeer and the Punjab, towards the close of 1838, to resume charge of his duties at Suharunpoor. His report of this expedition was at the time one of great interest and importance.

In this, as in many other scientific expeditions, Falconer's health suffered greatly from the results of incessant exposure; and in 1842 he was compelled to return to Europe on sick leave, bringing with him the natural history collections amassed by him during ten years of exploration of the Himalayahs, of the plains of India, and of the valley of Cashmeer. They amounted to eighty cases of dried plants, and about fifty large cases of fossil bones, together with geological specimens, illustrative of the Himalayan formations from the Indus to the Gogra, and from the plains of the Punjab across the mountains north to the Mooztagh range. This extensive collection of Indian fossils, together with the still larger collection presented by Capt. Cautley, now forms one of the distinguishing characteristics in the Palæontological Gallery of the British Museum.

From 1843 to 1847 Falconer remained in England. He occupied this time in publishing numerous memoirs on the geology and fossil remains of the Sewalik Hills, which appeared in the Transactions of the Geological

Society, and in the Proceedings of the Zoological Society, and of the Royal Asiatic Society. He also communicated several important papers on botanical subjects to the Linnean Society, of which may be specially mentioned that on *Aucklandia Costus*, the Cashmeer plant which yields the *Kostos* of the ancients; and that on *Narthex Assafœtidæ*, which was the first determination of the plant, long contested among botanists, which yields the assafœtida of commerce. He had found it growing wild in the valley of Astore, one of the affluents of the Indus.

But his main work at this time was the determination and illustration of the Indian Fossil collection presented by Captain Cautley and himself to the British Museum and to the East India Company. The bulk of the specimens were still imbedded in matrix. Sir Robert Peel's Government gave a liberal grant to prepare the materials in the national museum for exhibition in the Palæontological Gallery. Falconer was entrusted with the superintendence of the work, and rooms were assigned to him by the trustees in the British Museum. At his instance and under his superintendence a series of casts of the most remarkable of the Sewalik fossils was prepared and presented by the Court of Directors of the East India Company to the principal museums in Europe. Under the patronage of the Government and of the East India House an illustrated work was also brought out, entitled "Fauna Antiqua Sivalensis." In less than three years there appeared nine parts of this work, each containing twelve folio plates, executed in a style rarely equalled and never surpassed. No fewer than 1123 specimens are figured in these plates; and of many specimens three, four, or five different views are given. Besides the Sewalik fossils proper, the 'Fauna Antiqua' includes illustrations of a very valuable and important series of mammalian remains from the pliocene deposits of the valley of the Nerbudda, together with illustrations of the miocene fauna of the Irrawaddi, and of Perim Island in the Gulf of Cambay. The letter-press of the work did not keep progress with the plates; and at the close of 1847, before the arrears could be brought up, Dr. Falconer was unfortunately compelled, by the expiration of his leave, to return to India, where he found it impossible to continue the work by correspondence at a distance from the specimens. It is hoped, however, that the manuscript notes and memoirs which he has left behind will form a complete key to this great work on Indian Palæontology.

On his return to India in 1848, Dr. Falconer was appointed Superintendent of the Calcutta Botanic Garden, and Professor of Botany in the Medical College. In 1850 he was deputed to the Tenasserim Provinces to examine the teak forests, which were threatened with exhaustion from reckless felling and neglected conservation. His report, suggesting remedial measures, was published by the Bengal Government. In 1852 he published a memoir recommending the introduction into India of the quinine-yielding Cinchonas, and indicating the hilly regions in Bengal and the Neilgherries in Southern India as the most promising situations for experimental nur-

series. Some years afterwards the Cinchona was introduced from South America, and it is now thriving in India. In 1854, assisted by his friend the late Mr. Henry Walker, he undertook a 'Descriptive Catalogue of the Fossil Collections in the Museum of the Asiatic Society of Bengal,' which was published as a distinct work in 1859. In the spring of 1855 he retired from the Indian service.

On his return to England he resumed his palæontological researches, and in 1857 he communicated to the Geological Society two memoirs "On the Species of Mastodon and Elephant occurring in the Fossil state in England." Besides attempting to discriminate with precision the three British fossil elephants, till then confounded under the name of *Elephas primigenius*, Dr. Falconer produced for the first time a Synoptical Table, showing the serial affinities of all the species of *Proboscidia*, fossil and living, then known, of the former of which a large number had been either discovered or determined by himself. In the same year he published an account of the remarkable Purbeck mammalian genus '*Plagiaulax*,' discovered by Mr. Beckles near Swanage. In 1860 he communicated a memoir to the Geological Society "On the Ossiferous Caves of Gower," explored or discovered by his friend Lieut.-Col. Wood. The existence of *Elephas antiquus* and *Rhinoceros hemitœchus* as members of the cave-fauna was then for the first time established, and the age of that fauna precisely defined as posterior to the boulder-clay, or period of the glacial submergence of England. In 1862 Dr. Falconer communicated to the British Association at Cambridge an account of *Elephas melitensis*, the pigmy fossil elephant of Malta, discovered, with other extinct mammals, by his friend Captain Spratt, C.B., in the ossiferous cave of Zebbug. This unexpected form presented the Proboscidia in a new light to naturalists. Further researches on the general questions concerning the same family appeared in a memoir published in the 'Natural History Review' in 1863. Among many notes and papers which never appeared during his life-time may be mentioned a most important memoir "On the European Pliocene and Post-pliocene species of *Rhinoceros*," which, it is hoped, will shortly be published. In this memoir it is shown that there are four distinct pliocene and post-pliocene species of *Rhinoceros*, three of which have long been confounded by Cuvier and other palæontologists under the name of *R. leptorhinus*. One of these, *R. leptorhinus* (*R. megarhinus* of Christol.) has no bony nasal septum; two, *R. Etruscus* (Falc.) and *R. hemitœchus* (Falc.), or *R. leptorhinus* (Owen), have a partial bony nasal septum; while the fourth, *R. antiquitatis* (Blumb.) or *R. tichorhinus* (Cuv. & Fisch.), has a complete bony nasal septum.

While exploring the Himalayahs in his early days, Falconer's attention had been closely directed to the physical features which distinguished them from mountain-ranges in temperate regions, and more especially to the general absence from their southern valleys of the great lakes so common in corresponding situations in the Alps. When the hypothesis of the excavation of lake-basins by glacial action was brought forward, he took a

share in the discussion, and combated the view by an appeal to the contradictory evidence furnished by the Himalayahs, the lakes of Lombardy, and the Dead Sea.

For nearly thirty years Dr. Falconer had been engaged more or less with the investigation of a subject which has lately occupied much of the attention both of men of science and of the educated classes generally, viz. the proofs of the remote antiquity of the human race. In 1833, fossil bones procured from a great depth in the ancient alluvium of the valley of the Ganges in Hindostan were erroneously figured and published as human. The subject attracted much attention at the time in India. It was in 1835, while the interest was still fresh, that Dr. Falconer and Captain Cautley discovered the remains of the gigantic miocene fossil tortoise of India, which by its colossal size realized the mythological conception of the tortoise which sustained the elephant and the world together on its back (Geol. Trans. 2nd ser. vol. v. 1837, p. 499). In the same formations as the *Colossochelys* the remains were discovered of a smaller tortoise, identical with the existing *Emys tectum*. About the same time also several species of fossil *Quadrumana* were discovered in the Sewalik Hills, one of which was thought to have exceeded the Ourang-outang, while another was hardly distinguishable from the living "Hoonuman" monkey of the Hindoos. Coupling these facts with the occurrence of the camel, giraffe, horse, crocodiles, &c. in the Sewalik fauna, and with the further important fact that the plains of the valley of the Ganges had undergone no late submergence, and passed through no stage of glacial refrigeration, to interrupt the previous tranquil order of physical conditions, Dr. Falconer was so impressed with the conviction that the human race might have been early inhabitants of India, that he was constantly on the look out for the upturning of the relics of man, or of his works, from the miocene strata of the Sewalik Hills. In April 1844 he wrote thus to his friend Captain Cautley:—"Joining the indication given by the Hindoo mythology with the determined fact of the little *Emys tectum* having survived from the fossil period down to the present day, I have put forward the opinion that the large tortoise may have survived also, and only become extinct within the human period. *This is a most important matter in reference to the history of man.*" The same view was publicly announced at the Zoological Society and the British Association in 1844.

Ten years later Dr. Falconer resumed the subject in India, while investigating the fossil remains of the Jumna. In May 1858, having the same inquiry in view, he communicated a letter to the Council of the Geological Society, which suggested and led to the exploration of the Brixham cave, and the discovery in it of flint-implements of great antiquity associated with the bones of extinct animals. In conjunction with Professor Ramsay and Mr. Pengelly he drew up a report on the subject, which, communicated in the same year to the Councils of the Royal and Geological Societies, excited the interest of men of science in the case. Following up the same object,

he immediately afterwards proceeded to Sicily to examine the ossiferous caves of that island, and there discovered the "Grotta di Maccagnone," in which flint-implements of great antiquity were found adhering to the roof-matrix, mingled with remains of hyænas now extinct in Europe. (Quart. Journ. Geol. Soc. 1859.) Thus in 1859 the subject of the antiquity of the human race, which had previously been generally discredited by men of science, was launched upon fresh evidence. Since then it has been actively followed up by numerous inquirers, and Dr. Falconer himself was contemplating, and had indeed actually commenced, a work 'On Primeval Man.' In 1863 he took an active share in the singularly perplexed discussion concerning the human jaw of Moulin-Quignon; and in the conference of English and French men of science held in France, he expressed doubts as to the authenticity of the specimen, but in that guarded and cautious manner which was characteristic of him. In the spring of 1864 he published a notice on the remarkable works of art by "primeval man," discovered by Messrs. Lartet and Henry Christy in the ossiferous caves of the Dordogne; and in September he accompanied his friend Mr. Busk to Gibraltar, to examine caves in which marvellously well-preserved remains of man and mammals of great antiquity had been discovered. A joint report of this expedition by himself and Mr. Busk was afterwards published.

But his valuable life was drawing to a close. In January 1865 he was seized with a severe attack of acute rheumatism, from which he had formerly suffered in Cashmeer, and which on the 31st of the same month terminated fatally.

At the time of his death Dr. Falconer was a Vice-President of the Royal Society, and Foreign Secretary of the Geological Society; and as a proof of the high esteem in which he was held by his many friends, it may be mentioned that the sum of nearly two thousand pounds has been collected for founding a Fellowship in Natural Science in the University of Edinburgh, to be called "The Falconer Fellowship," and for the execution of a marble bust which has been presented to the Royal Society.

From what has been said, it is obvious that Falconer did enough during his life-time to render his name as a palæontologist immortal in science; but the work which he published was only a fraction of what he accomplished. The amount of scientific knowledge which perished with him was very great, for he was cautious to a fault; he always feared to commit himself to an opinion until he was sure that he was right; and he died in the prime of life and in the fulness of his power. Lovers of science and those who knew him well can best appreciate his fearlessness of opposition when truth was to be evolved, his originality of observation and depth of thought, his penetrating and discriminating judgment, his extraordinary memory, the scrupulous care with which he ascribed to every man his due, and his honest and powerful advocacy of that cause which his strong intellect led him to adopt: they also have occasion to deplore the death of a staid adviser, a genial companion, and a hearty friend.

Vice-Admiral Robert FitzRoy, born at Ampton Hall, Suffolk, July 5, 1805, was youngest son of General Lord Charles FitzRoy by his second wife, Frances Anne, eldest daughter of the first Marquis of Londonderry. He entered the Royal Naval College at Portsmouth in 1818; and from 1819 to 1828 served on board the *Owen Glendower*, *Hind*, *Thetis*, and *Ganges* in the Mediterranean and on the coasts of South America, and became flag-lieutenant at Rio Janeiro.

In the year last mentioned, on the decease of Captain Stokes, who, under Captain King, had been employed in surveying the shores of Patagonia and Tierra del Fuego, Lieutenant FitzRoy was selected by the commander-in-chief on the station, for the command of the *Beagle*, one of the two vessels engaged in the survey. He entered on his new duties with the zeal and conscientiousness which through life characterized his professional and official services. Of the importance of the task even a non-professional reader may judge by a comparison of the charts of the South American coasts published since 1826, with those previously existing. Of the greater portion of the shores, from the La Plata on the east to the north of Peru on the west, especially the broken and intricate outlines of the lower latitudes, little was known, and that was imperfectly laid down on early charts in a way which has been aptly described as "confused." The Chonos Archipelago was completely omitted, and the Spanish charts of Chiloe were twenty-five miles in error.

In the winter of 1829, while surveying the tortuous channels which ramify so bewilderingly in the rugged region to the rear of the Land of Desolation, Lieutenant FitzRoy discovered two large inland seas (Otway Water and Skyring Water) connected by a channel twelve miles in length, to which Captain King gave the name of FitzRoy Passage. During this exploration, Lieutenant FitzRoy with two boats was away from the ship thirty-two days, exposed to the rigours of a severe and stormy climate, yet no opportunity was lost of making observations and taking notes of remarkable objects. At the end of 1830 the two vessels returned to England, "having added charts of the south-western and southern shores of Tierra del Fuego, besides those of a multitude of interior sounds and passages," to the results of the first two years of the survey. Among his specimens of natural history, Lieutenant FitzRoy brought four native Fuegians, and expended largely from his private resources in endeavouring to improve their condition.

At the end of 1831, the *Beagle* having been thoroughly re-equipped, was again commissioned with Lieutenant FitzRoy as commander to renew the survey. On the voyage out a partial examination was made of the Abrolhos Bank, of which a brief account was read before the Royal Geographical Society and published in their Journal. Other papers from his pen are printed in the same periodical, in one of which he sums up in few words the results of the additional survey, accomplished with not less spirit and intelligence than the former. "Beginning," he remarks, "with the

right or southern bank of the wide river Plata, every mile of the coast thence to Cape Horn was closely surveyed, and laid down on a large scale. Each harbour and anchorage was planned; thirty miles of the river Negro, and two hundred of the Santa Cruz, were examined and laid down, and a chart was made of the Falkland Islands .... Westward of Cape Horn, as far as the parallel of 47° S., little has been added to the results of the *Beagle's* first voyage, because nearly enough was then done for the wants of vessels in those dreary regions. But between 47° and the river Guayaquil, the whole coasts of Chile and Peru have been surveyed; no port or roadstead has been omitted."

During this survey (in 1834) Lieutenant FitzRoy was promoted to the rank of Captain. In 1835, while he lay at Valdivia, the great earthquake took place, of which he has given a circumstantial and interesting account. The *Beagle* afterwards sailed for an examination of the Galapagos, and thence for England, touching at fourteen stations from Tahiti to the Azores to measure meridian distances, for which purpose a large number of chronometers had been placed on board. The vessel arrived at Greenwich in November 1836, having, in the course of her lengthened cruise, circumnavigated the globe.

Captain FitzRoy's anxiety to make his work as complete as possible, led him to hire two vessels and purchase a third at his own cost to fill up the details of the survey, and include the Falkland Islands. This outlay, however, involved him in embarrassments which hampered him for many years. The Royal Geographical Society hastened to recognize his merits by awarding him their Gold Medal for 1836, "for the zeal, energy, and liberality shown by him in the conduct of the survey;" and, "acknowledging the importance of the mass of information" which he brought home, declared it to have been "perhaps not exceeded by any expedition since the time of Cook and of Flinders." When we remember that Mr. Charles Darwin was on board the *Beagle* during the whole of her voyage, and there gathered the materials for his 'Journal and Remarks,' and geological works since published, the expedition may, indeed, be regarded as memorable. A full account thereof, written by Captain FitzRoy, was published in three volumes in 1839.

In 1839 Captain FitzRoy was chosen an Elder Brother of the Trinity House; in 1841 he sat in the House of Commons as Member for North Durham; in 1842 he was appointed Acting Conservator of the Mersey; and in the following year he went out to New Zealand as Governor, which post he held for three years. He was elected a Fellow of the Royal Society in 1851; in 1854 he was placed at the head of the Meteorological Department of the Board of Trade; in 1857 he became Rear-Admiral, Vice-Admiral in 1863, and in 1864 the Academy of Sciences of the Institute, Paris, elected him a Corresponding Member of their Section of Geography and Navigation.

In carrying out the duties of his appointment at the Board of Trade,

Admiral FitzRoy displayed the earnestness which had always distinguished him. Indeed the severe attention he bestowed on the details of his function, the originating of storm-signals, the publication of 'Reports' and the 'Weather Book,' brought on a severe mental strain which eventually occasioned his death on the 30th of April, 1865. The manner of his death was a shock felt far beyond the circle of his friends, and to them exceedingly painful. But they remember him as a man of kindly nature, courteous and considerate in no common degree, inspiring those who knew him best with affectionate attachment.

The life of BENJAMIN GOMPERTZ is given at length in the 'Assurance Magazine' for April 1866, a journal in which original investigations on a branch of mathematical application make their first appearance, and which, therefore, must remain accessible to the scientific world. He was of a Dutch Jewish family, of which the original name was Cohen, and his father was a diamond merchant, whose means left several sons in affluence. He was born March 5, 1779. He had an early turn for mathematics, and at the age of eighteen became a member of the old Mathematical Society of Spitalfields, of which he was President when it merged in the Astronomical Society. The ordinary biographical details of his life are very simple. He married (in 1810) the sister of Sir Moses Montefiore, so well known for his benevolent exertions: he had previously started in life on the Stock Exchange. The loss of his only son (in 1823) occasioned his retirement from this pursuit, and produced a depression which made his friends anxious that he should divert his mind by engaging again in business. They persuaded him to take the Actuaryship of the Alliance Office; and common rumour stated that the office itself was founded by his friends to procure him employment. On his retirement in 1848 he continued to apply himself to mathematical subjects, even long after he had fallen into a state of bodily debility. He died on the 14th of July, 1866.

Mr. Gompertz's writings, especially those on imaginary quantities and on mortality, show decided inventive power, and that strong aspiration after rigour which characterizes the old English school. Of this school he may be called the last. We do not except Lord Brougham, an older man and an older mathematician, who is still left to us: his early writings are of the mixed type; they show that combination of the old English and the Continental which was made in Scotland before it was made in England. Mr. Gompertz was the genuine disciple of the 'Ladies' Diary,' the 'Mathematical Companion,' and that tribe of periodicals supported by all grades, from the man of business to the artisan, which were read and written in by many mathematicians of power to whom the Philosophical Transactions were unknown. Mr. Gompertz contracted some marked peculiarities. He was the last of the *fluxionists*: to the day of his death he used the notation of Newton, and he held that respect for Newton's memory demanded this adherence, while at the same time he maintained

the superiority of the system. He never would permit himself the abbreviations log x, sin x, &c.; it was always logarithm of x, sine of x, &c. This, and some other consequences of isolated thought, in the mind of a man who was not thrown among his equals in power until he was an old *student*, will be looked at with interest.

The thing by which Mr. Gompertz will always be remembered, is the discovery of the function which so nearly gives the law of human life, published in our 'Transactions.' His recent developments of his own law are as yet *sub judice*, but they show the continuance of youthful energy to a very late period. Those who know the state of the writer when his last papers were published, will wonder at the vigour of mind which remained untouched by bodily weakness. The law above mentioned stands alone as capable of physiological enunciation: tell a mathematician that it is "the power to oppose decay loses equal proportions in equal times," add that the constants undergo nearly sudden changes, and he will be able to re-establish the whole theory.

In the memoir to which we have alluded will be found a full account of Mr. Gompertz's connexion with the Royal Astronomical Society and other Associations. He became a Fellow of this Society in 1819.

Sir Benjamin Heywood, Bart., born the 12th of December, 1793, of an ancient Lancashire family, was the eldest son of Nathaniel Heywood, banker in Manchester. His mother was the daughter of Thomas Percival, M.D., elected in 1765, at the age of twenty-five, a Fellow of the Royal Society, and the author of 'Medical Ethics.'

After receiving a good school education, Benjamin Heywood completed his studies in the University of Glasgow, where he distinguished himself in the Logic Class of Professor Jardine, as well as in the Moral Philosophy Class of Professor Mylne. In 1811 he entered on his hereditary calling the bank at Manchester. He married in 1816 the daughter of the late Thomas Robinson, Esq. Of this marriage, six sons and two daughters survive him.

The Manchester Mechanics' Institution was founded in 1824 by the active exertions of Mr. Heywood, who for twenty years held the office of President, and on his retirement from the presidential chair, the Directors, impressed with the suggestive and practical character of his addresses, collected and published them.

Scientific pursuits were always encouraged in the Institution by Mr. Heywood. In 1838, after a conversation with Mr. Leonard Horner, F.R.S., he recommended certificates of proficiency to be granted to meritorious students when they had completed an allotted course of study. This plan was subsequently adopted with benefit to the Institution.

In 1831 a large majority of the inhabitants of Lancashire were greatly nterested in the Reform Bill, which conferred on many of their towns the right of representation in parliament. At the general election of that

year, Mr. Heywood was chosen without opposition one of the members for the county of Lancaster to support the government measure of reform. His courtesy, integrity, and determined adherence to principle, gained for him general confidence, but parliamentary life did not suit his health, and on the dissolution of parliament, after the passing of the Reform Act in 1832, he retired from the arduous duties of a public career.

Statistics were always an interesting science to Mr. Heywood. He earnestly supported the formation of the Manchester Statistical Society, conducted a valuable inquiry into the condition of the working classes in Manchester, and as one of the officers of the Statistical Section, presented the results of this investigation (in 1834) at the Edinburgh Meeting of the British Association for the Advancement of Science.

In 1838, at the accession of Her Majesty Queen Victoria, Lord Melbourne being Prime Minister, Mr. Heywood was created a baronet. In 1843 he was elected a Fellow of the Royal Society, and twice held the office of a Vice-President of the British Association, on the successive visits of that body to Manchester. He died on the 11th of August, 1865.

Sir William Jackson Hooker was born at Norwich on the 6th of July, 1785. He was descended of a family which aforetime had given birth to men of eminence, and among them the author of the 'Ecclesiastical Polity.' Born to affluence, and educated at a school of reputation, he as a young man was enabled to devote his life to science, without the need of following a special calling. Circumstances brought him early into relation with some distinguished naturalists, and among the rest Sir James Edward Smith, the most eminent British botanist of his day; and the influence of this acquaintanceship combining with his own taste, no doubt, helped to decide his choice of a pursuit. In 1809, through the encouragement of Sir Joseph Banks, to whom he had become known, young Hooker visited Iceland, which he extensively explored, making large collections in all branches of Natural History; but these, together with all his notes and drawings, were totally lost on his way home, through the burning of the ship in which he was returning. His escape, by the opportune arrival of another vessel in mid-ocean, was almost miraculous. An account of it will be found in the modest narrative called 'Recollections of Iceland.'

In 1810–11 he made preparations for accompanying Sir Robert Brownrigg, who had been appointed Governor of Ceylon, to that island, then but little known to naturalists. With this design, he disposed of his estates, and invested the proceeds in securities, which were unfortunately ill-chosen, and afterwards much decreased in value. As an illustration of the zeal with which he prepared for his enterprise, the fact is recorded that he made pen-and-ink copies of the plates and descriptions of the entire manuscript series of Roxburgh's Indian plants, preserved in the India House. His plans, however, were frustrated by the intestine troubles in the island followed by the Candian war which soon afterwards broke out.

In 1814 he made a botanizing expedition into France, Switzerland, and the north of Italy, which extended over a period of nine months, and in the course of which he became acquainted, at Paris and elsewhere, with the principal botanists of Europe; thus laying the foundation of a scientific intercourse and correspondence which lasted until his death.

In 1815 he married the eldest daughter of Mr. Dawson Turner, a banker in Yarmouth, and settled at Halesworth, in Suffolk, where his house at once became the rendezvous of British and foreign botanists, and where he commenced the formation of that great Herbarium which is now the finest in the world.

His first botanical work was that on the British Jungermanniæ, which was completed in 1816. This, which is a model of skilful microscopic dissection and accurate description, is illustrated by engravings after drawings by his own exquisite pencil. The 'Muscologia Britannica' was published in conjunction with Dr. Taylor, in 1817, and was followed by the 'Musci Exotici.' These and other works, added to an increasing home and foreign correspondence, fully occupied his time for the next five years of his life. Meanwhile his property had been rapidly deteriorating, and with an increasing family he found it necessary to look out for some remunerative scientific employment. He therefore accepted the Regius Professorship of Botany in the University of Glasgow, at that time vacant, and removed to that city in 1820.

His life at Glasgow was entirely devoted to botany; he rose early, and went late to bed; he visited but little, and devoted the whole powers of his mind and his pencil to his favourite science. He was a most popular lecturer, his class being sometimes attended by as many volunteers as collegians; he encouraged his students in the pursuit, by taking them on excursions, by giving them rare plants from his duplicates, and by furnishing them with letters of introduction to all parts of the world when they went abroad. He kept up a close connexion with the authorities of the Admiralty, Treasury, Foreign, and Colonial Offices; and it was mainly through his exertions that botanists were so frequently appointed to the various Government expeditions of that period.

During the twenty years he resided at Glasgow he published his 'Flora Scotica,' in which the plants of a great part of the British Isles were for the first time arranged according to the natural method; the 'Flora Exotica,' and (in conjunction with Dr. Greville) the 'Icones Filicum;' also the 'Botanical Miscellany,' the 'Journal of Botany,' the 'Icones Plantarum,' the 'British Flora,' the 'Botany of Ross's, Parry's, Franklin's, Back's, and other Arctic Expeditions;' the 'Flora Boreali-Americana,' and (in conjunction with Dr. Walker Arnott) the 'Botany of Beechey's Voyage,' and various other works of standard authority. In 1826 he commenced the authorship of the 'Botanical Magazine,' which he carried on for nearly forty years. His Herbarium in the meantime was constantly receiving accessions, mainly owing to the indefatigable correspondence he

kept up with all parts of the world, and to the number of trained Scotch medical students who, when seeking their fortunes in foreign countries, continued to send him plants, even up to the day of his death.

During his residence in Glasgow he was twice offered knighthood, which he accepted from William the Fourth in the year 1836; this honour being bestowed on him in consideration of his scientific labours, and the great services he had rendered to botany. His connexion with Scotland as a Professor terminated in 1841, when he was appointed to the Directorship of the Royal Gardens at Kew.

It is worthy of being recorded that Sir William Hooker, who from the commencement of his botanical career felt a strong interest in Kew, had never abandoned the secret idea that the time might come when these Gardens should be made over to the nation, and become the head-quarters of botanical science for England, as well as its colonies and dependencies in all parts of the world, and that it might be his fortune to be a chief instrument in bringing about this end, and in rendering Kew an establishment worthy of the country. The idea of devoting the Gardens at Kew to this great national and scientific purpose had been keenly cherished by John Duke of Bedford, himself an ardent horticulturist. With that nobleman Sir William Hooker was on terms of friendship and correspondence; and the Duke did not fail to urge upon those in political power the fulfilment of what was with Sir William himself a favourite project. Upon the Duke's death, his son, the late Duke of Bedford, zealously carried out his father's wishes; but it was upon the present Earl Russell, then Lord John, that the chief weight of the transaction fell; and it is to him that the nation owes these magnificent gardens.

In 1841 Mr. Aiton, for fifty years the Director of the Royal Gardens, resigned his post at Kew, and was succeeded by Sir William Hooker, who entered upon his duties in command of resources for the development of the Gardens, such as had never been combined in any other person. Single of purpose and straightforward in action, by his honest zeal, and singular tact in making his plans clear and obviously advantageous to the public, he at once won the confidence of that branch of the Government under which he worked. Another means which he at once brought to bear on the work in hand, was his extensive foreign and colonial correspondence, especially that with students whom he had imbued with a love of botany, and who, scattered over the most remote countries of the globe, gladly availed themselves of their opportunities of contributing to the scientific resources of the establishment. His views were further greatly facilitated by his friendly intercourse with the Foreign and Colonial Offices, the Admiralty, and the East India Company; to all of whom he had been the means of rendering service, by his judicious recommendation of former pupils to posts in their employment, and by publishing the botanical results of the expeditions they sent out. Nor can we omit to mention here the late curator of the Royal Gardens, Mr. John Smith, an officer of un-

usual botanical and horticultural knowledge, by whom he was zealously seconded in all his plans.

To describe the various improvements which have resulted in the present establishment,—including, as it does, a botanic garden of 75 acres, and a pleasure-ground or arboretum of 270 acres, three museums, stored with many thousand specimens of vegetable products, and a magnificent Library and Herbarium (for the greater part the private property of Sir William), placed in the late King of Hanover's house on one side of Kew Green, and adjoining the Gardens,—would rather be to give a history of the Gardens than to sketch the life of their Director; it will suffice, therefore, to record the following dates of the more interesting events which have marked their progress.

The first step was the opening of the Gardens to the public on week-days, which followed immediately upon Sir William entering upon the Directorship. Rather more than 9000 persons visited them during the first year of their being thrown open, and the number has steadily increased. In 1864 the number of visitors amounted to 473,307.

About 1843 the Queen granted from the contiguous pleasure-ground an addition of 47 acres, including a piece of water, by the side of which the Palm stove was afterwards erected.

In 1846 the Royal Kitchen and Forcing Gardens, which ran along the side of the Richmond-road, were added. Upon this piece of ground stood an old fruit-house, since memorable as the origin of the first Museum of Economic Botany that ever existed. Sir William requested that thi building might not be pulled down, but that it might be fitted up to receiv specimens of vegetable products illustrative of the nature and uses of plants, and the whole thrown open to the public. Through the exertions of the indefatigable Director, aided by Mr. Smith, the Economic Collection has now become important and well known.

In 1861 was commenced the large Temperate House in the pleasure-grounds, often called the Winter Garden; the last building wanting to complete the establishment as representing horticulture. This beautiful building, which is not yet completed, was designed by Mr. Decimus Burton, and is admirably adapted to its purpose; the interior arrangement of the beds, and of the plants in them, which have been so much admired, is, however, wholly due to Sir William's judgment and taste.

It might be supposed that the twenty-four years spent at Kew in contriving and directing these public improvements, added to the daily correspondence and superintendence of the Gardens, would have left but little time and energy for scientific pursuits; such, however, was far from being the case. By keeping up the active habits of his early life, Sir William was enabled to get through a greater amount of scientific work than any other botanist of his age. The 'British Flora,' which has now reached the 12th edition, he made over to his successor in the Glasgow chair, Dr. Walker Arnott; but his monthly 'Journal of Botany' was recommenced; first ap-

pearing as the 'London,' and afterwards as the 'Kew Journal of Botany;' which together extended to seventeen annual volumes, and was enriched with papers of his own; with letters from his correspondents in all parts of the world; with reviews of botanical works; with contributions on physiological, structural, and systematic botany; and with notices of the progress of the science everywhere. With the exception of carrying on the 'Botanical Magazine,' for the last fifteen years of his life most of his leisure was devoted to the study of Ferns, and on this subject he published two works of standard value, the fruit of great labour—the 'Genera Filicum,' with illustrations by the late Mr. Francis Bauer, and the 'Species Filicum,' commenced in the year 1846, and finished only last year. This work, which is in five volumes, and contains the only complete systematic description of the vast tribe of plants to which it is devoted, would of itself have been sufficient to establish a botanical reputation, and is regarded as a standard authority upon the subject. During the last few years of his life, he also published his 'Garden Ferns,' 'Exotic Ferns,' and 'British Ferns;' all beautifully illustrated, and with descriptions from his own pen. At the date of his death he was engaged upon a 'Synopsis Filicum,' of which one number only has appeared.

In connexion with the scientific labours of Sir William Hooker, there are two names which should be prominently mentioned. The one is that of Lady Hooker, who for forty years was his able amanuensis and assistant in literary work, and the other that of Mr. Walter Fitch, now one of the most distinguished botanical artists in Europe. Up to about 1835, Sir William made the drawings for his works with his own hand; but about that time he was fortunate in having the skill of this artist brought before him, whose talents he encouraged, and whose services he eventually secured for the illustration of his works. Most faithfully has Mr. Fitch seconded his early patron and friend in his labours. Of their extent some idea may be formed from the fact that Mr. Fitch has executed in the last thirty years upwards of 4000 drawings of plants, all of which have been published by Sir William.

Of Sir William Hooker it may be said, that an almost unbounded liberality was one of his most prominent features; and scientific Botany is more indebted to him than to any individual since Sir Joseph Banks, for the progress it has made within the last half century. In his dealings with the nation his conduct was as liberal as it was towards his fellow-botanists. For the first twelve years of his residence at Kew, his Herbarium and Library were not only kept up at his own expense for the use and benefit of the Royal Gardens, but were open to every botanist who applied at his house to make use of them. To him we are indebted for the appointment not only of botanists but naturalists to the majority of the Government expeditions of discovery, survey, and research, which have been sent out during the last thirty years; and it has been mainly through his energy that funds have been forthcoming from Government to meet the after expenses of publishing

their results. To young botanists he was especially kind and helpful; indeed there are few cultivators of this science in Europe or America who have not borne cordial testimony to his generosity and encouragement. Amongst his latest efforts has been the inducing of the Home and Colonial Governments to grant the necessary funds for the publication of the Floras of their possessions; and within the two last years of his life he prevailed upon Sir Charles Wood, the President of the Indian Board, in like manner to support the publication of the Flora of British India; while, through the influence of his steady friend Earl Russell, he has also procured a grant for the publication of the Flora of tropical Africa.

Sir William was in person tall, athletic, and active; in features remarkably good-looking, animated, and cheerful; his conversation had the charm of intellectual cultivation and refinement, and he had a ready power of conveying clear information. As a scientific correspondent he was unrivalled; promptly answering every letter with his own hand; encouraging those who first addressed him, and stimulating those who flagged. Indeed he was wont to attribute his success in the creation of the National Gardens and the accompanying Museums to his habit of thanking every contributor at once, answering all their questions at whatever trouble, naming the plants they sent, and applying personally to residents in every part of the world for such plants or their products as he desired to have in the Gardens.

He was an LL.D. of Glasgow, D.C.L. of Oxford; a Fellow of the Royal Societies of London and Edinburgh, the Linnean, Antiquarian, Geographical, and other Societies; a Knight of Hanover, Companion of the Legion of Honour, a Correspondent of the Academy of France, and a member of almost every other learned Academy in Europe and America. The date of his election into the Royal Society was January 9, 1812.

He died at Kew on the 12th of August, 1865, in the 81st year of his age, after a very short illness, of a complaint in the throat, then epidemic at that place.

He leaves a widow, two married daughters, and one son, Dr. Joseph Dalton Hooker, F.R.S., now Director of the Royal Gardens.

John Lindley was the son of a nurseryman of considerable ability, who was the author of a manual of horticulture. He was born at Catton, near Norwich, on the 5th of February, 1799, and was educated at the Grammar School of Norwich under Dr. Valpy. He left school at the age of sixteen, and was employed for three or four years in his father's nursery, devoting all his leisure time to the study of botany and horticulture with that remarkable energy and untiring perseverance which characterized his whole life. His father failing in business shortly before he came of age, young Lindley was thrown on his own resources, not only for his own support, but for the discharge of his father's debts, which he took upon himself. Proceeding to London in 1819, he obtained from Sir Joseph Banks

(to whom he was introduced by Sir William (then Mr.) Hooker, his earliest scientific friend) the position of his assistant librarian, and at this early age began the long series of works with which his name will be for ever identified by the publication of a translation of Richard's 'Analyse du Fruit,' made at Mr. Hooker's house at Halesworth in Suffolk at one sitting, which, however, lasted two days and three nights.

In 1822 Lindley became Garden Assistant Secretary to the Horticultural Society, an appointment which influenced his whole career, as he remained connected with that Society, in one capacity or other, throughout his whole working life. The gardens at Chiswick were at that time in process of formation, and to their development he devoted all his energy. In 1826 he became sole Assistant Secretary, conducting, under the Honorary Secretaries Joseph Sabine, Bentham, Henderson, Gowen, and Royle, all the proceedings of that active Society, which has for so long a time taken a prominent part in advancing horticulture to the position it now holds in this country both as a science and an art.

Not satisfied with these laborious duties, which would have tasked all the energies of a man of ordinary capacity for work, Lindley became in 1829 Professor of Botany in University College, an appointment which he held for upwards of thirty years. He was a remarkably exact, clear and impressive lecturer, possessed an admirable faculty of lucid exposition, and was most copious in illustration. He never read his lectures, but they were always carefully studied beforehand.

Nor were these various occupations enough for his ever active mind. Thoroughly versed in the literature of Botany and its kindred sciences, he found time to prepare a series of general works on almost every branch of the science, all of great value, and many of them still standard books of reference in the hands of students. Beginning his career as a naturalist at the time when the natural system of Botany was acquiring its highest development in France, though known only to a few in England, where the Linnean system was still universally taught, Lindley brought all the weight of his teaching and all the force of his controversial powers to the support of the new system, and was, if not the leader, at least the most prominent advocate of a change now universal. His 'Synopsis of the British Flora,' published in 1829, was followed by an 'Introduction to the Natural System of Botany' in 1830, which passed through a second edition in 1836, and took the form of 'The Vegetable Kingdom,' probably the best known of all his works, in 1846. To Medical Botany he contributed an excellent Flora Medica, to Palæontology the well-known Fossil Flora, in which Mr. Hutton was his coadjutor, and to Horticultural Science a work on the Theory and Practice of Horticulture, which he himself regarded as perhaps his most important work, probably because it contained the greatest amount of original matter.

To these general works must be added a long series of monographs and isolated descriptions of plants in a great many periodicals. From his posi-

tion at the Horticultural Society he had the earliest opportunity of seeing novelties, and made it his business to describe all that came before him. He edited for a long series of years the 'Botanical Register,' a periodical devoted to figures and descriptions of new or rare plants of general interest, and contributed a large portion of many other serial works. His earliest monograph was that on Roses, published in 1820 in his twenty-first year. This was followed in 1821 by 'Collectanea Botanica,' an illustrated work published at the expense of Mr. Cattley, an eminent amateur cultivator. Soon after he became connected with the Horticultural Society he began to devote himself specially to the study of Orchideæ, a family the investigation of which is extremely difficult unless from living plants, and which from the multiplicity of its forms and the minuteness and intricacy of its flowers, tasks to the utmost the powers of observation of the naturalist. With this family his name will be for ever associated, not only as the describer of a very great number of new genera and species, but as the author of a series of general works, the last of which, 'Folia Orchidacea,' to the regret of all naturalists, was left unfinished at his death. It was with special reference to the important service he rendered to science by these great works that the Royal Medal of the Society was awarded to him in 1857, though the value of his other labours was also duly recognized.

Till he was past fifty, Dr. Lindley was wont to say that he never knew what it was to feel tired either in body or mind. His first illness was the result of his arduous duties as a juror of the Great Exhibition of 1851, but a few months' rest seemed to restore him to his usual health. Unfortunately, much against the wish of his family, he undertook the charge of the Colonial Department of the Exhibition of 1862, and though constantly ailing he refused to abandon his post, and carried its duties successfully to a close. The effort was too great. His mental and physical powers received a shock from which they never recovered. He was compelled to relinquish all active employment, though his bodily health remained good till the 1st of November in 1865, when he was carried off by apoplexy in his sixty-seventh year. The date of his election into the Royal Society is January 17, 1828.

John William Lubbock was born March 26, 1803. His father, the second baronet of his name, was at the head of the banking and mercantile firm of Lubbock and Co. The son, though of a tender constitution, was partly educated at Eton, and was then placed under the care of Dr. (afterwards Bishop) Maltby. Here he might have made progress in the classics, but his turn had been towards exact science from his earliest years. His father had intended him for Oxford, but, at his own earnest request, he was placed at Trinity College, Cambridge, in 1821. The continental mathematics had been recently introduced into general study, and Mr. Lubbock, perceiving their superior power as means of investigation, spent his first long vacation at Paris, and became a confirmed follower of that

school. Even in his own path, his reading was very much directed to the subjects of his subsequent career; and he had no motive to seek university honours as a means of success in life. Accordingly, in the Tripos of 1825, he obtained no higher place than that of first of the senior Optimes, though his power and reading as a mathematician were well known *. This commencement was of a character which lasted. Sir John Lubbock was throughout life engaged in following up a special scientific pursuit, which was his main business as an investigator, as it had been his main study at the University.

On leaving college he spent a short time in travelling, and on his return commenced a life of business as a partner in his father's house, and a life of scientific inquiry. He joined the Astronomical Society in 1828, and our Society in 1829. In this year he was also a member of the committee for the Diffusion of Useful Knowledge, on which he worked for many years. The establishment of the 'British Almanac' in 1827 owed much to his superintendence; and this work stimulated his attention to the theory of the tides. In the 'Companion' for 1830 appears his first scientific writing, a descriptive memoir on the tides. It is the most precise account of the existing state of the subject; its history has dates, and its explanations have formulæ. Mr. Lubbock was the colleague of Whewell and others in calling attention to the necessity of observation of the tides. In 1834 the Royal Medal was awarded to him for his researches on the subject.

In 1833 he married a daughter of Lieut.-Col. Hotham. He was the first Vice-Chancellor of the University of London, a Treasurer of the Great Exhibition of 1851, a Visitor of the Greenwich Observatory, and a member of various scientific commissions. He was Treasurer and Vice-President of the Royal Society from 1830 to 1835, and again from 1838 to 1845. At his father's death he was left the only working partner; and his reign of sole management included the panics of 1847 and 1857. His entrance into the house was marked by the panic of 1825, in which the firm weathered with honour a run of unprecedented severity; the severest competitive examination, says one of the journals, which a bank ever stood. Sir J. Lubbock never liked business, but he attended to it with perfect regularity. His early mornings and evenings were devoted to science, but not without exciting remark. In the day which has gone by, a man of business, or a professional man, was required to abstain from everything useful in private life or ornamental in society. He might spend leisure in sporting, in cards, in smoking, in eating and drinking, or in talking politics; but not in promoting science, nor in any unselfish addition to social pleasure. He might listen to music, but woe to the banker or the physician who should sing or play the violin in company. Sir J. Lubbock is one of an eminent band who have driven this paltry prejudice

* It is necessary to explain to those who are not connected with Cambridge that this triple superlative, *First Senior Optime*, means the head of the *second* class of university honours.

out of society. There is extant a letter of his (Oct. 30, 1840) to a business associate, who had remonstrated in the usual way. "There is," he says, "one circumstance which gave me much pain in a letter you wrote to my late father some time since. You alluded to my position as Treasurer and Vice-President of the Royal Society . . . But if by rising early and late taking rest, or if in hours which others devote to society or sports of the field, I choose to investigate questions in astronomy, or in any other science, I do not consider that any of the correspondents of the house are warranted in addressing to me any reproach. I submit these remarks to your friendly consideration."

After his father's death he withdrew almost entirely from society, and resided at High Elms, in Kent. Here he showed that there was time left from the wants both of business and of science. He was a farmer, and his southdowns and shorthorns (in which Lord Althorp himself did not take more pride than he) carried off many prizes. He planted choice shrubs and trees, especially conifers ; he kept up three village schools ; and he instructed his own children in mathematics. The old man of (nothing but) business might shake his head and say, Ah! that house will never stand what it stood under old Sir John : but, nevertheless, it kept up both credit and confidence, and joined another old bank in 1860. The firm of Robarts, Lubbock, and Co. has fully answered all expectations. By this junction Sir J. Lubbock had intended to give himself comparative leisure ; for fifteen years he had never been away from business for three consecutive days. The leisure was gained, but the power of using it was gone ; the work of two lives was a run upon the strength of one which ended in failure. He became a sufferer from gout, and the last five years of his life were marked by increasing debility. He died January 20, 1865, the immediate cause being valvular disease in the heart. He often said he had done his work and was quite ready to go. He leaves behind him the memory of an upright and benevolent man, utterly free from selfseeking, and devoted to high pursuits by high moral motives and strong intellectual impulses.

Sir J. Lubbock's researches in the lunar and planetary theories date from the year 1832 ; his separate work, ' On the Theory of theMoon and on the Perturbations of the Planets,' was published, the principal portion, during the years 1834 to 1838, but there are supplementary parts up to 1850.

In the lunar theory, as originally established by Clairaut, the true longitude of the moon is taken as the independent variable ; and Laplace was of opinion that, on account of the magnitude of the lunar inequalities, this was, in fact, the only safe course ; it was accordingly adopted by him in his own researches, and also in Damoiseau's memoir, in the unpublished memoir of Carlini and Plana, and in Plana's great work on the lunar theory. The time or mean longitude of the moon, and the radius vector and latitude, are in the first instance obtained in terms of the true longitude of the moon, and then by reversion of series, the true longitude, the radius vector, and the latitude are expressed in terms of the time.

But in the theories of Laplace and Damoiseau, the coefficients of the several inequalities are presented in an unreduced form, involving denominators and auxiliary quantities, which it is assumed are to be calculated numerically, and by means of them the final numerical values of the coefficients are obtained. In Plana's work, on the contrary, the coefficients are presented completely developed in powers and products of e, e', y, m (the excentricities of the two orbits, the tangent of the inclination, and the ratio of the mean motions) with coefficients, which are, of course, absolutely determinate numbers.

The results so presented constitute, to the degree of approximation preserved, a complete algebraical solution of the problem; they are determinate results, in no wise dependent for their truth on the convergency of the series, and they are of course absolutely independent of the particular process made use of for obtaining them. They are consequently results obtainable by the adoption of the time as the independent variable; and this is, in fact, the course followed by Lubbock—viz., taking the time as the independent variable, he obtains directly the expressions of the true longitude, latitude, and radius vector in terms of the time; expressions strictly comparable with those of Plana, and which, but for the different significations of the e and y in the two theories, would be identical therewith. The advantage of Lubbock's method is its directness; the expressions for the solar coordinates are in both theories given in the first instance by the elliptical theory in terms of the time, and in Lubbock's theory they are used in that form; whereas, in the theory of Clairaut, they have to be transformed into functions of the true longitude of the moon, and the so transformed expressions are used in the calculation of the time and the radius vector and latitude of the moon in terms of the true longitude; and there is, finally, the laborious reversion of series whereby the co-ordinates of the moon are expressed in terms of the time.

The researches on the tides are not easily described. They consist in the main of the application of the existing theory to masses of observation. Sir J. Lubbock was the first who introduced to the fullest extent the plan of consolidating the results of all the observations: Laplace took chiefly those made at the times when the irregularity under investigation was near its maximum. A clear account of Lubbock's mode of proceeding is given by Mr. Airy in his article on the tides (§ 489–491) in the 'Encyclopædia Metropolitana.' We may mention that the man of business was in this matter a valuable colleague of the man of science. Mr. Lubbock's relations with the late Mr. Solly, Chairman of the London Dock Company, procured him access to the observations made at the docks through a golden number of years (1808–1826). We should rather say, procured him the knowledge of the existence of the observations. Mr. Solly, we are sure from knowledge, would gladly have communicated his information to any inquirer; and the Board would have given hearty assent. But

many investigators might have passed a life in the subject without arriving at the fact that the observations existed.

In a separate work on the heat of vapours and on refraction (1840), the assumption is that the absolute heat of a gas may be represented by A + B × (temperature). A relation between pressure and temperature is then deduced, the constants of which can be determined by joint observations of pressure and temperature. The observations of Arago and Dulong (Mém. Inst. x. 231), and of Ure (Phil. Trans. 1818), are thus satisfied. Employing the observations of Gay-Lussac (Conn. des Temps, 1841), he deduces a formula for the calculation of heights by barometrical observation, and then proceeds to the subject of refraction. In this matter, to a great extent, he follows Ivory. The investigation is nevertheless new and peculiar, and the conclusions are remarkable. The results of Lubbock's theory and Bessel's Tables are almost identical. Down to 65° of zenith distance the difference is not 0″·01; nor from thence to 87° does it ever amount to 1″·0; at 88° it is 4″·0. It would require a very large number of observations to discriminate between them. It appears therefore that, from the assumption that the differences of absolute heat in a gas are directly proportional to the difference of temperature, Lubbock has built up a theory agreeing with observation, all his constants, with the exception of one, being determined independently of astronomical observations. His theory also gives a value of the horizontal refraction agreeing closely with the best determinations of that quantity. His atmosphere is a limited one of about twenty-two miles.

About the year 1830 Mr. Lubbock, jointly with Mr. Drinkwater (Bethune), wrote a tract of thirty-two pages on 'Probability' in the Library of Useful Knowledge. This most excellent little work ranks as the earliest, and, its size considered, the best of the modern English introductions to the subject. Of late years it has become almost a rule, in citing this work, to insist on the authorship. A binder put Mr. De Morgan's name on the outside of a large issue; and though for more than fifteen years every channel of publicity, from the 'Times' newspaper downwards, has been employed to correct the mistake, entire success has not yet been obtained. This work, though perfectly elementary, has that taste of the higher methods which those who are familiar with them can infuse into common algebra. Mr. Lubbock showed his familiarity with Laplace, before any one in Britain, by two papers in the Cambridge Transactions (vol. iii. part 1), on the calculation of annuities, and on comparison of tables. At the time of publication there was no actuary, except Mr. Benjamin Gompertz, who could have read them: the state of things is now different, and the papers have been reprinted in the Assurance Magazine (vol. ix.). In the same volume is an illustration of the way in which the doctrine of probability applies in every subject. It is a paper contributed by Sir J. Lubbock, on the clearing of the London bankers.

By observation it was ascertained that the daily difference at the clearing-house, the money actually wanted to balance the demands of those who are to receive and those who are to pay, is only, one day with another, £29,000. To meet daily contingencies, the banks keep in the Bank of England balances which amount to from $2\frac{1}{2}$ to 3 millions. Sir J. Lubbock recommends that the clearing balance should be paid out of a common fund, which would put the banks so far in the position of being one concern, and would enable them to employ a large part of the sums they must now leave idle. The goodness of the advice is manifest. This paper, the last we believe of Sir J. Lubbock's writings, begins with

> Atque equidem, extremo ni jam sub fine laborum
> Vela traham, et terris festinem advertere proram, &c. &c.,

and ends with a similar prediction in English. For some years he had begun to feel that his end was approaching; and though it turned out that his life was to be preserved to his family and his friends for a few years longer, the prophecy was but too well founded as to his scientific career.

JOHN RICHARDSON was born on the 5th of November, 1787, in Dumfries, of which town his father, Gabriel Richardson, was an influential and highly respected inhabitant. This gentleman was a Magistrate of the county and several times Provost of Dumfries.

A great philosophical poet has said,

> "The child is father of the man."

The sentiment, judging from what is recorded of young Richardson, is peculiarly appropriate to him.

The influences by which he was surrounded in infancy were all of a happy kind, and well adapted to the development of those qualities for which in his varied and adventurous life he was distinguished. Some of these may be briefly adverted to.

The rough sports and exercises of schoolboys tending to invigorate the frame, and in which he was preeminent for activity and enterprise, may have conduced to that bodily strength and power of endurance which served him so well in manhood,—so well, indeed, that even beyond the middle term of life he had been known to say he scarcely knew fatigue.

Of the higher influences, those affecting the mind, the moral character, the chief, no doubt, were such as were exercised over him by his nearest relations: of these, his mother and maternal grandmother, women of notable worth and ability, may deserve the first mention, they being his earliest instructors. The latter lived at a charming spot, Rosebank, in the neighbourhood of the town. There as a schoolboy he was always glad to go on a holiday; and there his love of the beautiful in nature appears to have been formed. Early he had been heard to express a hope that there, where he had so much enjoyment, he might, if spared, be able to retire and end his days.

A great living example of high and fervid intellect cannot but affect the mind of youth. Such was Burns to him: Burns was often at Mr. Richardson's house, a welcome guest, both whilst he lived in Nithsdale and later in Dumfries, till his death in 1796. It happened that his eldest son, Robert, a boy of great intellectual promise, and young Richardson, both of the same age, were entered at the grammar school on the same day, and it is remembered that the Poet on that occasion said playfully, "I wonder which of the two will be the greatest man." It was during his school-period that young Richardson first read the 'Faerie Queene,' and it was of Burns that he borrowed the book. Half a century later he was present at the National Festival held in honour of the Poet in Edinburgh in 1859; and he then expressed the great pleasure he had in his recollections of him, particularizing how on one of the Sunday evenings Burns, when at his father's house, called his attention to some of the paraphrases in his Bible which he most admired, two of which he requested the boy to get by heart and repeat to him: of these, one was forgotten, the other was the 66th, beginning "How bright these glorious spirits shine."

Early he gave proof of a quick and precocious mind. He could read well, it is reported, at the age of four. He was then placed at a preparatory school, and two years later at the grammar school, taught by Mr. Gray, better known afterwards as a man of letters in Edinburgh, and one of the Masters there of the High School. This was in 1793. In 1801, when only fourteen, he was sent to the University of Edinburgh, where thus early he began his Medical Studies, which were continued during two years, and then, when only sixteen, he received the appointment of House Surgeon in the Infirmary of his native town, the duties of which he performed for nearly two years. He now returned to Edinburgh, and shortly after passed an examination before the College of Surgeons and received the diploma of Surgeon. In the following year, having just reached his eighteenth year, he entered the Royal Navy as Assistant Surgeon. The war at that time was raging in all its intensity, and promotion then rapidly rewarded merit. In a year he was advanced to a Surgeoncy. This was after he had been employed in a boat night attack, for which he had volunteered, on a French brig of war in the Tagus. During the remainder of the war his services were various—in the Baltic in the second expedition against Copenhagen, on the western coast of Africa, in the Mediterranean, on the western coast of Spain, in the North Sea, and again in the Baltic, on the coast of America, on the Canadian Lakes; and lastly, during the short war with the United States in 1814, he was present, attached to a marine battalion, at the taking of Cumberland Island and the town of St. Mary's in Georgia.

Shortly after the peace he retired on half-pay, and engaged in private practice at Leith, where (in 1818) he married the second daughter of W. Stiven, Esq., of that town. The leisure he had there, and the vicinity of

Leith to Edinburgh, enabled him to continue his medical and other allied studies, of which Botany was especially a favourite. In 1817 he passed his examinations and took the degree of M.D. Two years later, when an expedition was fitted out by Government to explore by land the northern coast of America, under the command of Lieut. Franklin, R.N., he volunteered his services, and received the appointment of Surgeon and Naturalist to the party.

This was the beginning of that career in which he so distinguished himself; and it was also the beginning of that friendship with Sir John Franklin, of which, twenty-nine years afterwards, he gave such a chivalrous proof in taking the command, at his own request, of the overland expedition, at that time fitted out by the Government, to go in quest of the 'Erebus' and 'Terror,' the melancholy history of which ships, of their gallant crews, and heroical commander can never be forgotten.

The account of the first Expedition, under the title of "Narrative of a Journey to the Polar Sea in the years 1819, 1820, 1821, 1822," by Franklin, amply shows what an important part Richardson took in it: and the indebtedness of its commander to him for the manner in which he performed his duties and afforded his Chief assistance is most amply acknowledged. Apart from the varied, valuable, and curious information collected relative to regions and tribes of people before little known, much of the narrative, especially that pathetic portion descriptive of privations and sufferings, and that part contributed by Richardson relative to the stern duty of depriving a fellow creature of life, who, there was the strongest proof, had forfeited it by the murder of an officer of the party, with a further design on the lives of others, cannot be read without a feeling of emotion blended with admiration for what was endured and done.

During the remainder of his long period of service as a Naval Medical Officer, terminating in his retirement in 1855, he never was employed afloat. He had first charge of the Melville Hospital at Chatham, and afterwards, when promoted to the rank of Inspector of Naval Hospitals and Fleets, that of Haslar Hospital. His position now was peculiarly favourable; first, in affording facilities for prosecuting his studies—he was always a student—especially in natural history; and secondly, as contributing to his comfort, and probably health; for he was the victim of sea-sickness, a malady from which he had increase of suffering with advancing age, latterly even to the endangering of life. Always remarkable for industry and power of application, these qualities were strikingly displayed whilst in medical charge of each of those hospitals. His special duties were not a little onerous, yet by making the most of his time, he was able to contribute largely to the advancement of science in its natural history and geographical departments, of which his successive publications afford the best proof—those publications for which a Royal Medal was awarded him by the Council of this Society in 1856, ten years after he had received the honour of Knighthood conferred on him by the Queen in acknowledgment of his

distinguished service; he had previously, viz., in 1851, had the honour conferred on him of Commander of the Bath. It would be out of place here to dilate on his professional attainments; but it should not be passed over, as showing how he blended science and medicine, that to him chiefly the Medical Department of the Navy is indebted for the Museum which is established at Haslar, and to which he largely contributed.

If fortunate in his position, he was not less so in the estimation in which he was held by the authorities in power. Hence, when Sir John Franklin had to prepare for his second expedition to the shores of the Polar Sea, he again received the appointment which he had in the first. In consequence moreover of the great confidence placed in him, he was entrusted with a separate and important charge, that of exploring the coast between the Mackenzie and Copper Mine rivers, and later, with the sole command of the party sent to the same region in quest of his friend on the occasion of Sir John Franklin's last and fatal exploring enterprise. A just appreciation of what he accomplished in both instances can be formed only by the perusal of the two works in which these Expeditions are described; one, "The Narrative of a second Expedition to the Shores of the Polar Sea in the years 1825, 1826, and 1827;" the other entitled "Arctic Searching Expedition: A Journal of a boat's voyage through Rupert's Land and the Arctic Sea in search of the Discovery Ships under the command of Sir John Franklin, with an Appendix on the Physical Geography of North America." Both which works, one by Franklin, the other by Richardson, were published by authority.

This second expedition, under the command of Sir John Franklin, affords a remarkable contrast to the first,—that so disastrous in its results as regards human suffering and loss of life, this so successful, at least in these relations and the amount of information obtained,—mainly owing to the better arrangements made for the provisioning and conveyance of the party, forewarned by the experience gained in the first; during the whole time not a life was lost, nor was there any amount of privation experienced even temporarily endangering health*.

In his last expedition in quest of his friend, in which greater difficulties and dangers were encountered than in the preceding, the same good fortune as to the preservation of health and life was experienced. The engaging in this undertaking by Richardson was, indeed, as before said, a chivalrous act and the strongest proof that could be given of devoted friendship. It should be remembered that he was then entering his sixty-first year, that he separated himself from a happy home and from children he tenderly loved, and this, let it not be forgotten, with the entire sanction of his wife, she fully entering into and appreciating his noble sense of duty. That the Government should have accepted his offered services was what might be expected; for whom could they have selected for zeal and knowledge

* After Franklin had left his party, on his return he was informed of the death of one man belonging to it from accident, and of another from pulmonary consumption.

better qualified for the search?—resting on the belief they had come to, that Franklin, according to his instructions, would, as was afterwards proved (proved by the relics discovered, and as Richardson was confident), attempt the North-west Passage by Lancaster Sound—that passage which, *after* Franklin, was more happily accomplished first by Sir Robert M'Clure, and then by Sir Leopold M'Clintock—this the crowning reward of the vast efforts which for a series of years and at an enormous cost had been so heroically made, to the enduring credit of our country, for determining the great geographical problem of the Northwest Passage.

The account of this search, as published in two volumes in 1851, is, in accordance with its title of Journal, minute in details, and, from its minuteness, very instructive and deserving of study, abounding, as it does, in varied information in relation to the geology of the country passed through, its natural productions and inhabitants—a model, in brief, of the journal of a scientific traveller well trained by laborious experience, and of which the value must increase as the regions it treats of, especially the Lake Districts of Canada and the territory of the old Hudson's Bay Company, become, as they deserve, more resorted to and colonized.

On his return from this expedition he resumed his duties at Haslar Hospital, where he continued until he tendered his resignation in 1855. He then retired with his family to the Lake District of Westmoreland, where, at Lancrigg, in Easedale, in the neighbourhood of Grasmere,—a spot surpassing even in beauty the longed for retreat, Rosebank, the aspiration of his boyish days,—he passed the remaining years of his life, which, when he was apparently in perfect health, was suddenly terminated, by what was inferred to have been apoplexy, on the 6th of June, 1865, in his 77th year. He was buried in Grasmere churchyard, the burying-place of the greatest of the Lake Poets, Wordsworth.

This period of his retirement, the complement of his distinguished career, was one of almost unchequered enjoyment, and would have been completely so, but for the loss of one of his children, his eldest daughter. Active as ever with unimpaired faculties, whilst he recreated himself with gardening, he devoted much of his time to his favourite pursuits, natural history, and latterly philology, for which he had always a predilection. Here he edited Yarrell's 'British Fishes,' the last edition, which he enriched with many additions; and here he wrote his history of Arctic and Antarctic research, bearing the title of "The Polar Regions," a work especially remarkable for erudition, candour, and mastery of the subject, and for undertaking which he was so eminently prepared and qualified by the experience he had gained in his three exploring expeditions. Though so occupied, he seemed always to have leisure and time at command; he was always ready to give his professional aid to any of the poor people in the neighbourhood wanting medical advice; and having been appointed a magistrate of the county, he performed the required duties in his habitual conscientious and zealous manner.

If one quality more than another predominated in the well-balanced faculties of this excellent man, it was his modesty with freedom from pretension. This is strikingly displayed in words of his own, written down, but never spoken, on the occasion of his receiving the Royal Medal awarded him, as already mentioned, in 1856. We give them with the hope that they may serve as an incitement to others, who think humbly of themselves, to follow his example.

"More than the usual period allotted to one generation has long passed away since, through the circumstance of my being appointed Surgeon to a small body of Arctic explorers, I had to travel over a country reaching from the great American lakes to the islands of the Arctic Sea, and embracing more than the fourth of the distance from the equator to the pole, which had never before been visited by a professed naturalist. I perceived at once the magnitude of the field, and comprehended at a glance that it was far beyond my grasp. The only previous training I had was the little natural science that I had learnt at my northern Alma Mater as a collateral branch of my medical education, but I thought that I could at least record what I saw; and I determined so to do as intelligently as I could and without exaggeration, hoping in this way to furnish facts on which the leaders of science might reason, and thus promote the progress of Natural History to the extent of my limited ability. This was the rule I followed during the eight years that I passed in those countries actually engaged in the several expeditions." His concluding words, too, we are tempted to give, distinctive as they are of a quality of his illustrious friend, Sir John Franklin, which, with other gracious ones, gained him the regard of all who had the happiness of serving under him.

"I cannot forbear adding one word to my thanks for the very high honour which I have appeared before you to receive—it is an expression of mournful regret that your late member, my old and dear friend and commanding officer in the Expeditions of Discovery, does not survive to witness this day. He would have rejoiced with unmixed satisfaction at your appreciation of my labours. From him I received every assistance in collecting specimens that was in his power to give; his sympathy encouraged me, and his claims which, as commanding officer, he might have to the reputation of whatever was done by one of his subordinates, he honourably and cheerfully ceded to him who did the work, in my case as in others. So that contributions were made to science, no personal interests were allowed to interfere."

Besides the works already mentioned, he was the author of the 'Fauna Boreali-Americana,' of Zoological Appendices to the Voyages of Parry, Ross, and Back, of Zoological Reports and Contributions to the British Association for the Advancement of Science, of which Association he was an old member and a regular attendant at its meetings, and the article "Ichthyology" in the last edition of the Encyclopædia Britannica.

He was elected a Fellow of the Royal Society in 1825; he received the

honorary degree of Doctor of Civil Law from the University of Dublin at the time of the Meeting of the British Association in that city in 1857; he was an honorary Fellow of the Royal Society of Edinburgh, and he belonged to many foreign Societies, European and American.

He was three times married, first, as already related, to the daughter of Wm. Stiven, Esq., who died in 1831; secondly, to the only daughter of John Booth, Esq,, the niece of Sir John Franklin; she died in 1845, leaving him five children, of whom three are surviving, a daughter, married since his decease to Charles Reynolds, Esq., and two sons, one, the eldest, a Captain in the Royal Artillery, the other a Lieutenant in the Royal Engineers; thirdly, to the youngest daughter of Archibald Fletcher, Esq., Advocate, of Edinburgh, in 1847, his surviving widow, to whom the place of his retirement belonged, and where she still resides.

The life of Admiral William Henry Smyth comprises such a field of arduous labour and successful result, that we must confine ourselves to the merest synopsis. Forty years a member of our Society (from June 15, 1826), and all that time engaged in works which brought high reputation, his connexion with the Society was confined for the most part to personal exertion on the Council. The benefits which he conferred on the naval service, on astronomy, on geography, and on archæology, must be recorded in detail in more appropriate places than this record.

He was born January 21, 1788. His father was an American loyalist, and a descendant of Captain John Smith, the colonizer of Virginia. He entered the Navy in 1805, and was actively engaged until 1815 in the Indian seas, and on the coasts of Spain and Italy. Here he had his full share of adventure and of danger; and it was during this first period that his love of surveying developed itself, and attracted the notice of the Admiralty. From 1817 to 1824 he was engaged in that great survey of the Mediterranean—the greatest scientific survey ever planned and completed by one individual—which is now recorded in two hundred charts, and is the admiration of the naval world. By this unexampled result of intelligence and industry he won high reputation and the approbation of the Government, shown by grant of permission to accept a foreign order. This was the only public acknowledgement which he ever received, so far as we can learn.

His naval career ended in 1824; but for many years he was employed in the completion of his charts. In 1828 he settled at Bedford, and from thence until 1842, either at Bedford or Cardiff, he varied his pursuits by close attention to the astronomy of double stars and other extra-meridional pursuits. His well-known "Cycle" has done much to quicken a taste for astronomy among naval men.

The last years of his life were passed near Aylesbury. His friend the late Dr. Lee had purchased his instruments, and had attached a small observatory to Hartwell House. Admiral Smyth's residence, St. John's

Lodge, was within a short walk of this observatory; and to the end of his life (September 9, 1865) he was engaged in occasional observation. His long list of scientific titles might be supported by as long a list of published works, independently of scientific memoirs. His books on Sicily and Sardinia, his life of Captain Beaver, his accounts of his own cabinet of Roman coins and of that of the Duke of Northumberland, his works on the antiquities of Hartwell, his account of the Mediterranean, and others, are read with pleasure and profit. But perhaps the most remarkable, as the most professional and the most characteristic, is the long series of articles which he contributed to the United Service Journal. In this series, running over more than twenty years, he has discussed almost every possible nautical subject. He was eminently a collector; and a Nautical Dictionary, of a very wide character, is now in the press under the care of a lady who was for fifty years his scientific colleague as well as his devoted wife.

An extended account contained in the last annual report of the Royal Astronomical Society will render further detail unnecessary. We give a few words to the personal qualities of our subject. Admiral Smyth was one of those men who are the cement of all the associations to which they belong. His genial manners, and the full reliance which all placed on his good faith, his kindness, and his activity, did much to promote unity and, when such a thing arose, to prevent misunderstanding from becoming serious disagreement. The compound of the jolly seaman—no other word will do—the educated scholar, and the kind-hearted gentleman, which appeared in Admiral Smyth is far beyond any character-painting but that of the dramatist or the novelist. A man is known by his associates; and when persons of the most different dispositions and temperaments are united through life in pursuit of good objects, there must be a *something* which keeps them together; and that something must contain benevolence of feeling in large measure. If the world were searched, it would hardly be possible to produce four specimens of mankind so very different as Francis Baily, Richard Sheepshanks, John Lee, and William Henry Smyth, and it would be as difficult to produce four men who lived in more cordial intimacy and friendship broken only by death.

Johann Franz Encke, For. Memb. R.S., was born on the 23rd of September, 1791, at Hamburg, where his father was pastor of St. James's Church. After passing through the Gymnasium of Hamburg, he entered the University of Göttingen in the autumn of 1811. Here he remained pursuing his studies under the direction of Gauss till the spring of 1813, when his patriotism impelled him to take part in the war. He served in Hamburg till the place fell, and afterwards in Mecklenburg, as Sergeant-Major in the Horse Artillery of the Hanseatic Legion, in which he remained till June 1814. He then resumed his studies in Göttingen, but was again called away by the events of 1815. He now entered the Prussian service, holding a commision as Second Lieutenant in the Artillery, and during the

greater part of the time he remained in it was stationed in the fortress of Thorn. He quitted the Prussian service in March 1816, and in the following July became assistant to von Lindenau in the Observatory of Seeberg.

He was appointed Vice-Director of the Observatory in 1820, and Director on the retirement of von Lindenau in July 1822. His works on the transits of Venus of 1761 and 1769 were published in 1822 and 1824 respectively. A supplement to the latter, rendered necessary by the discovery made by von Littrow, that Hell had tampered with the original observations made by himself at Wardhus, appeared in the Transactions of the Berlin Academy for 1835. In 1819 he published his identification of the comets observed by Mechain and Messier on the 17th of January, 1786, by Miss Herschel on the 17th November, 1795, by Pons on the 20th of October, 1805, and again by Pons on the 26th of November, 1818. This comet, to which Encke's name has been given, having a periodic time of about 1207 days, was observed on the 3rd of June, 1822, at Paramatta by Rümker. The discussion of all the observations led Encke to the conclusion that the only way of reconciling them was by the supposition of a resisting medium by which the times of its revolutions are successively lessened. One of the Royal Medals of the Society for the year 1828 was awarded to him for this investigation. He had already (in 1825) been elected a Foreign Member.

In 1825 he was called to Berlin as Professor of Astronomy in the University and Director of the Observatory. In his hands the Berlin Ephemeris received many improvements, of which he gave an account in the Transactions of the Berlin Academy for 1827. He superintended the publication of this work from the volume for 1830 to that for 1852, when he was assisted by Professor Wolfers till the publication of the volume for 1863, after which the latter became sole editor. The volumes contain numerous supplements by Encke on the perturbations of planets, the method of least squares, mechanical quadratures, the solution of numerical equations, the form and dimensions of the earth, and many papers on the correction of the errors of astronomical instruments.

The Observatory, a tower dating from 1711, being unsuitable for the reception of fixed instruments, and in a bad situation, at von Humboldt's suggestion a new Observatory was erected on a plan approved of by Encke; and on the 11th of October, 1835, he observed the position of Halley's comet with the large equatoreal mounted in its place in the new Observatory. The observations made here were published in four quarto volumes between the years 1840 and 1857. He is the author of upwards of one hundred separate works and memoirs dating from 1812 to 1860. The latter are contained chiefly in the 'Zeitschrift' of von Lindenau and Bohnenberger, von Zach's 'Correspondance Astronomique,' Bode's and Encke's 'Jahrbücher,' the 'Astronomische Nachrichten,' and the 'Sitzungsberichte' and 'Abhandlungen' of the Berlin Academy.

In 1859 he suffered from an apoplectic attack, brought on, it is supposed,

by excessive mental exertion. He obtained leave of absence from the Observatory in the spring of 1863, and resigned his post as Director early in 1864. He passed the remainder of his life in the midst of his family at Spandau. His judgment and memory remained unimpaired till within a few weeks of his end. He died on the 26th of August, 1865.

Adolf Theodor von Kupffer, For. Memb. R.S., was born at Mitau, in Courland, where his father was a merchant, on the 6th of January (Old Style), 1799. At the age of sixteen he entered the University of Dorpat as a medical student, but remained there only a few months. In 1816 he entered the University of Berlin, also as a medical student, but the study of medicine becoming distasteful to him, he applied himself to the mathematical and physical sciences, and to mineralogy, under the direction of Weiss. In 1819 he went to the University of Göttingen, and in 1820 to Paris, where he attended Haüy's lectures on Mineralogy. He established himself in St. Petersburg, where he lectured on mineralogy in the winter of 1821–1822. In the spring of 1822 he was appointed Professor of Physics, Chemistry and Mineralogy in the University of Kasan, and at the same time commissioned to visit Paris for the purpose of procuring a collection of physical instruments. While there he competed successfully for a prize proposed by the Academy of Berlin for an essay on the measurement of the angles of crystals. In concert with Arago he planned a series of observations on the daily variation of the magnetic declination, and the disturbances of the declination, at Kasan. He entered upon the duties of his Professorship in June 1823, devoting the time not occupied in teaching to crystallography and magnetism. In April 1828 he was sent on a scientific mission to the Ural, the results of which were published in 1834. They consist mainly of geological observations, the discovery of new localities of some scarce minerals, and of many determinations of the temperature of the soil, made conjointly with Adolf Erman.

Having been elected a member of the Imperial Academy of Sciences, he went to reside in St. Petersburg in August 1828. Early in 1829 he suggested to the Academy the erection of a small magnetic observatory. The project was warmly supported by von Humboldt, who happened to be in St. Petersburg on his way to the Ural and Altai. It was approved of by the Academy, and the building commenced before the end of the year. In the summer of 1829 he was placed at the head of a scientific party engaged in exploring a part of the Caucasus near Mount Elbrus, into which no European had ever penetrated before, and where, for the protection of the travellers against the native tribes, they were accompanied by a strong escort of troops under the command of General Immanuel, the General in command of the Caucasus, who had planned the expedition.

At this period he lectured at the School of Civil Engineering, the Pädagogische Institut, and the Academy for Naval Officers, and was engaged in writing his 'Handbuch der rechnenden Krystallometrie,' which appeared

in 1831. In 1835, Count Cancrien, the Minister of Finance, at Kupffer's suggestion, consented to the establishment of small magnetic observatories at Catherinenburg, Barnaul, Nertschinsk, Sitka, and Helsingfors, subsequently at Tiflis and Moscow, and lastly at Pekin. The observations for the years 1835–1846 were published in the 'Annuaire magnétique et météorologique du corps des Ingénieurs des mines de Russie.' All these observatories were placed in 1843 under the direction of a central institution, the Physical Observatory of St. Petersburg, where the various observations were reduced and edited, and magnetical and meteorological instruments were kept for the use of members of scientific expeditions. Kupffer was placed at the head of this establishment, and ceased to lecture, in order that he might devote all his energies to the duties of his new office. The collected observations for the years 1847–1858 have been published in the 'Annales de l'Observatoire physique central de Russie.' During the latter years of his life he was actively engaged in establishing telegraphic communication with foreign observatories, for the purpose of giving storm-signals at stations on the coasts of the Russian empire.

In 1841 he edited an account of the labours of a Commission, of which he was a member, appointed to fix the standards of measure and weight of the Russian empire. Besides comparing the standards of Russia with those of many other countries, the commissioners redetermined the weight of a given volume of water, one of the most important constants of nature, with a precision, in all probability, hitherto unequalled.

The first volume of his researches on the elasticity of metals (Étude expérimentale de la flexion et des oscillations transversales des lames élastiques) was published in 1860. The second volume, containing experiments on metals produced in the Russian furnaces, and the third, on the elasticity of torsion and rotatory oscillation, are, it is believed, still unpublished. He was elected a Foreign Member of the Royal Society in 1846.

A chill, caused by exposure to cold while superintending the erection of a self-recording anemometer on the roof of the Physical Observatory, brought on an attack of typhoid fever, of which he died on the 4th of June 1865.