have seen of the method, it can scarcely be a modification of the "immune body" treatment, with which, it is maintained, some success has been attained. It appears more likely that we have to deal with some modification of Calmette and Guerin's method, in which the bovine tubercle bacillus is cultivated on a glycerinated medium to which a small proportion of ox-bile has been added. Here, after about forty generations of such culture, the bacillus becomes so far modified that when injected intravenously into the bovine animal it is incapable of setting up an active tuberculous process, and so modifies the tissues and especially the wall of the alimentary canal of the treated animal that an ordinary culture of a virulent "bovine" bacillus is no longer able to retain its position in the tissues of the host, and, consequently, is unable to set up any tuberculous process.

It is, of course, too early to pronounce any definite opinion, either favourable or adverse, on these various methods. It must be realised that a certain proportion of the cases in which there is tuberculous infection recover without any special treatment; that others recover when supplied with plenty of fresh air, good food, and when the hygienic conditions generally are favourable, and that these agencies are called into play by all who are engaged in the intelligent study and treatment of tuberculosis.

SIR GEORGE HOWARD DARWIN, K.C.B., F.R.S.

GEORGE DARWIN, whose decease occurred at Cambridge on Saturday, December 7, came, as is well known, of illustrious scientific lineage, having been born in 1845 at Down, the second son of Charles Darwin, author of "The Origin of Species," and thereby the renovator of the biological sciences. Like many contemporaries who attained to distinction in scientific pursuits, his school education was gained under the Rev. Charles Pritchard, F.R.S., afterwards Savilian professor of astronomy at Oxford. He went up to Trinity College, Cambridge, in 1864, graduated as second wrangler and second Smith's prizeman in 1868, the present Lord Moulton being senior; he was elected a fellow of Trinity the same year, and enjoyed the statutory tenure of ten years. In addition to mathematical subjects, he was interested in economic and political science, and with a view to practical life was called to the Bar in 1874. About this time he wrote a well-known statistical memoir on the marriage of first cousins, an early example of the present exact investigations in cognate biological domains. Considerations of health, however, prompted his return to Cambridge, where he devoted himself to mathematical science, especially in its astronomical aspects. He had already initiated his most striking contributions to the subject of the evolution of the solar system, especially the moon-earth system, and to cosmogony in general, when he was elected to the Plumian chair of astronomy and experimental philosophy in 1883. He was re-elected fellow of Trinity, as professor, in 1884, and his marriage dates from the same year.

If one were asked to name a domain in which the power of mathematical analysis had conspicuously asserted itself over phenomena apparently most complex and fortuitous, the prediction of the tides up to their closest details, by procedure now systematised so that it can be applied almost without technical skill, would surely come to mind. The principles of the application of harmonic analysis to this subject were laid down by Laplace, following up the beginnings established long before by Newton; but it was a far cry from this to actual systematic performance. The outstanding name in this magnificent achievement is that of Lord Kelvin, whose intellectual energy kept the subject to the fore, while his inventive genius originated the machines by which calculations too long and laborious for arithmetical processes were reeled off automatically. But it is very doubtful whether tidal practice, in which British methods dominate the world, or the refinements of tidal theory, would stand in their present completeness if Kelvin had not enjoyed the good fortune, when he was himself getting submerged in other problems, of finding a colleague so imbued with the subject, so expert and tenacious amid the complexities of numerical calculation, as George Darwin proved himself to be. His tribute to Lord Kelvin, to whom he dedicated volume i. of his Collected Scientific Papers, which relates to this subject, gave lively pleasure to his master and colleague:—

> Early in my scientific career it was my good fortune to be brought into close personal relationship with Lord Kelvin. Many visits to Glasgow and to Largs have brought me to look up to him as my master, and I cannot find words to express how much I owe to his friendship and to his inspiration.

The practical developments of tidal theory and prediction were published to the world in a series of reports to the British Association, worked out mainly by Darwin, from the year 1883 onward. In 1879 he had broken ground in another direction, entirely fresh. The recognition of lunar tidal friction as a cause of lengthening of the day goes back to Kant. The problem as to how the tidal loss of energy is divided between the earth's rotation and the lunar orbit had baffled Airy; it had been shown by Purser that the principles of energy and momentum conjointly can lead to its solution; but it remained for Darwin to develop, by aid of graphical representations which have become classical, most striking inferences regarding the remote past history of our satellite. This discovery was the starting point of a series of memoirs in the next subsequent years, which applied similar procedure to the precession of the equinoxes and to other features of the solar system.

In the later years of last century, during Lord Kelvin's meteoric visits to Cambridge to attend the annual meetings of the Fellows of Peterhouse, and to absorb whatever of scientific interest was going on, he was certain to find his way to Newnham Grange, to compare impressions on tidal and cosmical theory and to concert plans for future action. So thoroughly was Darwin from the first immersed in and a partner of Kelvin's work on these subjects, that the necessary rewriting, for the second edition, of the large section of Thomson and Tait's "Natural Philosophy" which deals with tides and their cosmical relations, was confided entirely to his hands.

In 1898 he supplemented this work by publishing a non-mathematical treatise on the tides and kindred phenomena in the solar system, which was developed from a course of Lowell lectures delivered at Boston, and has taken rank with the semi-popular writings of Helmholtz and Kelvin as a model of what is possible in the exposition of a scientific subject; it has accordingly been translated into many foreign languages. The preparation of a new edition of this book, expanded and in part rewritten to include recent developments, was one of the last works of his life.

His studies in astronomical evolution necessarily required him to push the history of the motions of the planetary bodies back into the past, far beyond the times for which the usual practical approximations of gravitational astronomy are suitable or valid. To this end he began to apply a process of step-by-step plotting to the determination of orbits in the classical problem of three bodies,—essayed in simpler cases by Lord Kelvin, but in its adequate use laborious, and demanding skill in arrangement of arithmetical processes; this work culminated in an extensive memoir in "Acta Mathematica" in 1896. The maps of families of orbits there published attracted the attention of other mathematicians. In particular, Poincaré—utilising the general mode of discrimination and classification which he had already employed with signal success in Lord Kelvin's and George Darwin's problem of the forms possible for fluid rotating planets—pointed out the necessary existence of some intermediate classes that had escaped the analysis. And S. S. Hough, H.M. Astronomer at the Cape, who had in his Cambridge days collaborated with Darwin in tidal theory, followed with a memoir devoted to fuller developments. This fascinating subject continued to occupy Darwin's attention up to the end of his life; one of his last public appearances in London was to communicate a paper on it to the Royal Astronomical Society.

His thorough familiarity with the methods of reducing to mathematical order the tangled data of tidal observation marked out Darwin as a desirable expert guide in the national meteorological service; for much was hoped for meteorology thirty years ago from the practical application of harmonic analysis to the voluminous records of barometer and thermometer. Accordingly the Royal Society, which then had control of the service, nominated him a member of the Meteorological Council soon after his return to Cambridge. When that Council was rearranged as a Committee under the Treasury a few years ago, he became one of the two representatives whom the Royal Society was requested to nominate to the new body; and he continued to render valuable service in this capacity until the end.

The earliest of topographic surveys, the model which other national surveys adopted and improved upon, was the Ordnance Survey of the United Kingdom. But the great trigonometrical survey of India, started nearly a century ago, and steadily carried on since that time by officers of the Royal Engineers, is still the most important contribution to the science of the figure of the earth, though the vast geodetic operations in the United States are now following it closely. The gravitational and other complexities incident on surveying among the great mountain masses of the Himalayas early demanded the highest mathematical assistance. The problems originally attacked in India by Archdeacon Pratt were afterwards virtually taken over by the Royal Society, and its secretary, Sir George Stokes, of Cambridge, became from 1864 onwards the adviser and referee of the survey as regards its scientific enterprises. On the retirement of Sir George Stokes, this position fell very largely to Sir George Darwin, whose relations with the India Office on this and other affairs remained close, and very highly appreciated, throughout the rest of his life.

The results of the Indian survey have been of the highest importance for the general science of geodesy, and well-deserved tributes have been paid to them by Helmert, of Berlin, and other chief exponents of the science. It came to be felt that closer cooperation between different countries was essential to practical progress and to coordination of the work of overlapping surveys. Accordingly, about fifteen years ago the International Geodetic Association was established, through scientific and diplomatic influences, to take cognisance of all problems of refined surveys and triangulations, and other investigations relating to the form of the earth, in which international cooperation is essential to complete results. Sir George Darwin was appointed by the Foreign Office, on the advice of the Royal Society, as the British representative on this important international body; and its work was henceforth one of the main interests of his life. It came to the turn of England to receive the triennial assembly in the year 1909, and a very successful meeting at London and Cambridge was organised mainly by his care. He was preparing to go to the meeting of the association in Hamburg last September when his fatal illness supervened.

An important public service has been rendered in this country for many years by the Cambridge University Press, through the application of its resources to the publication in definitive collected form of the works of the great men of science whom this nation has produced, thereby sustaining the national credit in a way which in other countries is promoted mainly by Government subsidy. The collected papers of Sir George Stokes, Arthur Cayley, James Clerk Maxwell, Lord Kelvin, J. J. Sylvester, J. C. Adams, P. G. Tait, J. Hopkinson, and other men of science have in this way been garnered, and have taken their permanent place among the national possessions. It came as a great gratification to George Darwin when, in 1907, the syndics of the University Press signified to him their desire to become responsible for a collected edition of his scientific memoirs, to be prepared under his own supervision. In May, 1911, the last of the four substantial royal octavo volumes in which his work is thus arranged for future generations was published.

In the affairs of the University of which he was an ornament, Sir George Darwin made a substantial mark, though it cannot be said that he possessed the patience in discussion that is sometimes a necessary condition to taking share in its administration. But his wide acquaintance and friendships among the statesmen and men of affairs of the time, dating often from undergraduate days, gave him openings for usefulness on a wider plane. Thus at a time when residents were bewailing even more than usual the inadequacy of the resources of the University for the great expansion which the scientific progess of the age demanded, it was largely on his initiative that, by a departure from all precedent, an unofficial body was constituted in 1899 under the name of the Cambridge University Association, to promote the further endowment of the University by interesting its graduates throughout the Empire in its progress and its more pressing needs. This important body, which was organised under the strong lead of the late Duke of Devonshire, then Chancellor, comprises as active members most of the public men who owe allegiance to Cambridge, and has already by its interest and help powerfully stimulated the expansion of the University into new fields of national work; though it has not yet achieved financial support on anything like the scale to which American seats of learning are accustomed. Another important body in the foundation and development of which Sir George Darwin took an active part is the Cambridge Appointments Board, which, by bringing trained graduates into connection with the leaders of the commerce and industry of the nation, has worked with notable success for their mutual advantage.

Sir George Darwin's last public appearance was as president of the fifth International Congress of Mathematicians, which met at Cambridge on August 22–28 of this year. The time for England to receive the congress having obviously arrived, a movement was initiated at Cambridge, with the concurrence of Oxford mathematicians, to send an invitation to the fourth congress held at Rome in 1908. The proposal was cordially accepted, and Sir George Darwin, as *doyen* of the mathematical school at Cambridge, became chairman of the organising committee, and was subsequently elected by the congress to be their president. Though obviously unwell during part of the meeting, he managed to discharge the delicate duties of the chair with conspicuous success, and guided with great *verve* the deliberations of the final assembly of what turned out to be a most successful meeting of that important body. But this improvement was only temporary; on their return to Cambridge a month later his friends were most deeply grieved to find that, after some weeks of illness, an exploring operation had strengthened the fears of malignant disease which had not been absent from his own mind for some time.

In the previous year there had come to him what he naturally regarded as the crowning honour of a life devoted to scientific pursuits, the award by the Royal Society in October, 1911, of their highest distinction, the Copley medal for the year. He had himself strongly advocated the claims of his kinsman, Sir Francis Galton, who was the medallist of the preceding year, unconscious that his own name had been standing on the list for consideration. Galton died within a year of the award, and his life, written by Darwin for the Dictionary of National Biography, appeared last October. The Royal Society has thus the melancholy satisfaction of having been just in time in two successive years in conferring her highest mark of distinction on the achievements of two of her distinguished sons.

J. L.

MR. S. A. SAUNDER.

IT is with deep regret that we have to record the death, on Sunday night, December 8, of Mr. S. A. Saunder, at sixty years of age. In Mr. Saunder astronomical science has lost a devoted and conscientious worker who gave himself whole-heartedly to a line of study requiring much ability, and involving immense labour, but offering no prospect of startling results.

Mr. Saunder was an assistant master at Wellington College. He became a Fellow of the Royal Astronomical Society in 1894, and from 1907 to February last he was one of the most active and hard-working of honorary secretaries. A few years ago he was appointed Gresham Professor of Astronomy in the City of London. He gave his last course of lectures (on the tides and tidal friction) early in November, but the fatal illness was then upon him, and it was with great difficulty and pain that he brought the lectures to a conclusion.

Mr. Saunder's scientific work lay especially in the domain of selenography, in which he achieved well-deserved distinction. His paper in the Monthly Notices of the Royal Astronomical Society for January, 1900, on the determination of selenographic positions and the measurement of lunar photographs, was the first of a series of similar papers. In the fourth paper of the series he gave a first attempt to determine the figure of the moon. In the Memoirs of the R.A.S., vol. 59, he published the results of measures of four negatives taken at Paris by Loewy and Puiseaux, with a catalogue of 1433 measured points on the lunar surface. All the positions were carefully reduced to mean libration, and their places given in rectangular co-ordinates. A still more extensive work was published in the R.A.S. Memoirs, vol. 60: Results of measures of two Yerkes negatives by Mr. G. W. Ritchey. The catalogue contains