The Royal Society elected Barkla to its fellowship in 1912, and in the following year he accepted the professorship of natural philosophy in the University of Edinburgh, which he held until his death.

During the most active period of his life, Barkla's investigations dealt mainly with X-rays and their absorption by matter, and with the emission of secondary radiation. He was the first to show that the secondary emission is of two kinds, one consisting of X-rays scattered unchanged in quality, and the other a 'fluorescent radiation', characteristic of the scattering substance and accompanied by selective absorption of the primary beam. The secondary radiation of the first kind Barkla showed to be polarized, an experimental result of fundamental importance, for it indicated that X-radiation was to be regarded as similar to ordinary light, a point which, up to that time, was thought to be doubtful.

For the discovery of the characteristic radiation and for the explanation of its origin Barkla was most deservedly awarded the Nobel Prize for Physics in the year 1917. His outstanding achievements were also recognized by the Royal Society, which appointed him Bakerian Lecturer for 1916 and awarded him the Hughes Medal in the following year.

Barkla was a successful teacher who inspired many of his pupils with an enthusiasm for research. He was in great request as an examiner in physics, and few excelled him at this work. His long experience of students in three universities, the wide range of his knowledge of physics, his judgment and common sense made him an eminently fair and discriminating examiner. He would re-read with extreme patience (not always shared by his co-examiner) any script of a 'border-line' candidate which he found difficult to assess, and his verdict, when finally delivered, could be accepted with confidence.

While a lecturer at Liverpool, Barkla married Mary Esther, eldest daughter of the late John T. Cowell, receiver-general of the Isle of Man. He leaves two sons and a daughter. Only in the last year was his life clouded by indifferent health; but the family had previously suffered a grievous loss by the death at Carthage in August 1943 of the youngest son, Flight-Lieutenant Michael Barkla, whose achievements at school and at the university had given promise of a career no less brilliant than that of his distinguished father.

Those who were privileged to know Barkla well will treasure the memory of his open-hearted friendliness and personal charm, of the delights of the Hermitage of Braid—his earlier home in Edinburgh—and of the almost idyllic happiness of his domestic life there.

FRANK HORTON.

Prof. G. D. Birkhoff

THE many friends of Prof. G. D. Birkhoff on the eastern side of the Atlantic are deeply grieved to hear of his death on November 12. For a whole generation he had been a commanding figure among mathematicians and a link between American men of science and their colleagues in both western and eastern Europe.

George David Birkhoff was born at Overisel, Michigan, on March 21, 1884; as the name would indicate, his family was originally Dutch, but it has long been settled in the United States. He studied first at Chicago and then at Harvard, returning to Chicago for his doctorate; and, after a short period as instructor in the University of Wisconsin, was appointed assistant professor of mathematics at Princeton in 1909. It was here that he wrote the memoir on the "General Theory of Linear Difference Equations" (*Trans. Amer. Math. Soc.*, 1911) which first brought him into prominence; the "Jahrbuch über die Fortschritte der Mathematik" devoted more than two pages to a notice of it, a rare honour for a young and unknown author. Fundamental solutions of linear difference equations with rational coefficients were obtained for the entire plane of the complex variable by direct matrix methods, and their nature was studied from the functional point of view. Birkhoff showed that there exists a purely Riemannian theory of the equations, and found quantities which play a part like that of the monodromic group constants of an ordinary linear differential equation. His methods were of wide generality, and the paper constituted a striking advance in the subject, to which he made further contributions from time to time, notably in a memoir in *Acta Math.*, **54** (1930).

A closely related branch of mathematics which also owes much to Birkhoff is the theory of linear differential equations, on which he published many memoirs from 1910 onwards (*Proc. Amer. Acad.* and *Trans. Amer. Math. Soc.*); the earlier ones were particularly concerned with the problem of constructing systems of linear differential equations with prescribed singular points of given character and with a given monodromic group.

Birkhoff's interests were shared between pure and applied mathematics, and his work in dynamics was of great value. In an extensive memoir—almost a complete treatise—on "Dynamical Systems with Two Degrees of Freedom" (*Trans. Amer. Math. Soc.*, **18**; 1917), he reduced all problems relating to such systems, even in the 'irreversible' case, to the problem of determining the orbits of a particle constrained to move on a smooth surface which rotates about a fixed axis with uniform angular velocity and which carries with it a conservative field of force; and he showed how the existence of periodic solutions may be directly inferred, and their form determined. This investigation was followed by others, especially on periodic orbits and the problem of three bodies (*Acta Math.*, *Amer. J. Math.* and elsewhere); a connected account of much of his dynamical work appeared in 1927 as one of the American Mathematical Society's Colloquium volumes, under the title "Dynamical Systems".

His two books on relativity, "Relativity and Modern Physics" (1923) and "The Origin, Nature, and Influence of Relativity" (1925) were useful and widely read, and characteristically original in treatment.

In later life, Birkhoff became much occupied with the discovery of mathematical relations in æsthetics. As is well known, more than two thousand years ago Pythagoras founded the scientific theory of music by showing that simple numerical ratios exist between the lengths of the strings the notes of which yield agreeable melodic progressions. Birkhoff's aim was to create a theory of similar character for the fine arts: the results obtained were described in his book "Aesthetic Measure", published in 1933.

Birkhoff was professor of mathematics in Harvard University from 1919 onwards, president of the American Mathematical Society during 1924–26, president of the American Association for the Advancement of Science during 1936–37; an honorary doctor of many American universities and of St. Andrews, Poitiers, Paris, Athens and Sofia;

a foreign member of many European academies (including the Institut de France, the Lincei and the Pontifical Academy) and mathematical societies, and an Officier de la Legion d'honneur. His last years were gladdened by the knowledge that his brilliant son Garrett was steadily advancing towards a position in the world of mathematics not inferior to his own.

E. T. WHITTAKER.

Dr. O. F. Bloch

OLAF BLOCH was a man of remarkable energy largely applied to the progress of photographic science and in furthering the application of photography as a tool in many branches of science and technology. He received his earliest scientific training at the Finsbury Technical Institute under Prof. H. E. Armstrong, and having spent some years in the Davy Faraday Laboratory and in chemical manufacture, he joined the staff of Ilford, Ltd., in 1910. Little can be written of his very successful work over many years to produce improved light-sensitive materials, for much of it was made known only to his closest associates and publication in this field is rare; but mention may be made of important work with F. F. Renwick on the optical properties of photographic layers, and early attempts, with Miss F. M. Hamer, to relate the chemical structure of cyanine dyes with their sensitizing properties.

As secretary of the Scientific and Technical Group of the Royal Photographic Society in the years following the War of 1914–18, Bloch took a leading part in organizing an attack on the problem of the sensitometric testing of photographic materials, leading to recommendations to the Sixth International Congress of Photography in Paris in 1925.

Bloch became chief chemist of Ilford, Ltd., in 1930, and his devoted work for the Royal Photographic Society was recognized by his election to the presidency in the following year. His ready wit and wide knowledge made him a most popular lecturer, and he addressed many of the learned societies in Great Britain. He will be particularly remembered for his accounts of the many applications of infra-red photography, just then made really practicable by the discovery and application of thiatricarbocyanines. Later he turned to demonstrating the importance of photography as an indispensable tool in many branches of science and industry, and in these lectures Bloch referred always to his conviction that photography is grossly neglected by British universities as a subject for teaching and research. The foundation of a chair of photographic science at a university in Britain was a cause very dear to him, so that he found particular pleasure in helping academic scientific workers in their photographic problems. Thus by collaboration with Dr. F. W. Aston he produced plates especially designed for recording atomic particles of low penetration, and these were used in the classical investigation of isotopes. A range of materials of special characteristics and spectral sensitivities was prepared for use in astronomy and related sciences. More recently, Bloch eagerly accepted opportunities to collaborate with atomic physicists to evolve photographic emulsion layers of value in recording tracks produced by penetrating atomic particles.

These and other services to scientific investigation were recognized by the University of Aberdeen by the award of the honorary degree of LL.D. He received the Progress Medal of the Royal Photographic Society, and, appropriately, was chosen to preside at the commemoration of the centenary of photography at the Royal Society of Arts in 1939.

Away from his work, Bloch had a remarkable range of interests; he was deeply appreciative of literature and the arts, and was a keen gardener with an encyclopædic knowledge of garden plants. Taking up alpine mountaineering with characteristic enthusiasm when more than fifty years old, he qualified for membership of the Alpine Club. He died on October 19 at the age of seventy-two years.

C. WALLER.

WE regret to announce the following deaths:

Sir John Fox, C.B., O.B.E., F.R.S., Government chemist, on November 28, aged seventy.

Sir Percy Nunn, first director of the Institute of Education, University of London, on December 12, aged seventy-four.

NEWS and VIEWS

Ethics of Scientific Investigation

IN his address "Human Nature in Science" to the Section on Geology and Geography of the American Association for the Advancement of Science, delivered at Cleveland on September 13, 1944 (*Science*, **100**, 299; 1944), Dr. J. K. Wright gave a highly stimulating discussion of some relations between human nature and science as they might be set forth in such a manual for science as Macchiavelli wrote for princes. Analysing first the personal qualities that influence scientific research, especially originality, open-mindedness, precision and scientific consciousness or the ability to discriminate between motives, Dr. Wright indicates the dangers which may attend excess of any one of these qualities. He surveyed next the motives for scientific research; these are first classified as pro-scientific, anti-scientific or non-scientific, according to whether they promote, retard or have no effect on the advancement of science; and again as personal, group or disinterested motives, depending on whether they spring from a desire to serve individual, group or no particular interests. In this analysis, Dr. Wright has wise and stimulating words about opinions or judgments of the relative worth of scientific investigations. Qualitative judgments are fairer than formal judgments, for they take account of the degree of good sense, originality, accuracy and open-mindedness to which the study bears witness, as well as of the suitability of the form and substance to the solution of the problem in hand. The preliminary work required before scientific laws can be formulated may be quite as scientific as the subsequent processes of interpretation to which it leads; and an economic law may be fully as scientific as the law of eclipses, provided all available evidence is used in developing the economic law—and used with the same degree of rationality as that attained in developing the astronomical law.