Obituary

Photograph by Henry Grant

J. D. Bernal 1901-1971

With the death of J. D. Bernal, X-ray crystallography has lost one of that great generation of pioneers who followed von Laue and the Braggs. Born in Ireland in 1901, he was a student at Cambridge and in 1923 went to the Royal Institution, London, where he worked under W. H. Bragg. In 1927 he returned to Cambridge, where he remained until 1937, when he was appointed to the Chair of Physics at Birkbeck College, University of London, which he held until 1963. From that year until his retirement in 1968 he headed the newly established Department of Crystallography in the same college. He was elected a Fellow of the Royal Society in 1937, was awarded a Royal Medal of the Royal Society in 1945, and received high honours from a number of foreign scientific academies.

Bernal's first major contributions were in experimental technique and the immediate stages of interpretation of X-ray diffraction photographs. About these it need only be said that the goniometer which he designed in 1927 is still in wide use today with only minor changes, and that his procedure for interpreting rotation photographs is in continual use in every X-ray crystallographic laboratory. He soon turned, however, from developments in technique to pioneer applications of X-ray crystallography in key fields, especially ones relating to biologically important substances. During the early and middle thirties, he and his students made the first significant X-ray studies on amino-acids, sterols and other steroids, protein single crystals, and viruses. Their work on the sterols showed that the then accepted Windaus–Wieland structure must be wrong and led to the adoption of the now accepted structure. Their pioneer work on proteins and plant viruses, starting with those of tobacco mosaic and tomato bushy stunt, laid the foundation for many well-known successes of the past decade. It was characteristic of Bernal that he rarely followed up such studies, but left the opportunities they provided for others. Two crystallographers later to become Nobel Prize winners for their work on biologically important substances, D. C. Hodgkin and M. Perutz, began their work in this field as students in Bernal's laboratory.

Outside the biological field, Bernal and his students in this same period made pioneer contributions in such diverse fields as the structures of liquids, liquid crystals, hydrogen-bonded substances, and topotaxy. His paper with H. D. Megaw on hydrogen bonding in metal hydroxides and related substances, published in 1935, is still widely quoted today. His interest in the structure of liquids arose from his recognition of the essential part played by water in the constitution of living materials. His work in this field began with the classic paper, written jointly with R. H. Fowler in 1933, on the structure of water. In this paper, it was shown how the now universally accepted concept of a tetrahedral charge distribution in the water molecule could account for many important properties of water and aqueous solutions. Twenty-five years later he followed it up with his general theory of liquids, which will be mentioned later.

During the Second World War, Bernal devoted himself to operational research, to which he made significant contributions. He was Scientific Advisor, first to the British Ministry of Home Security, and afterwards to the Chief of Combined Operations. In 1945 he was awarded the U.S. Medal of Freedom. With the end of the war, he divided his scientific interests mainly between proteins and cements. His influence in inducing people to work in profitable fields is illustrated by an example from this period. By about 1950, the initial period of rapid advance in the determination and systematics of silicate structures had stopped; it seemed to most people that the key principles had been found, and that all that remained was to fit any new structures into a well-established framework. Bernal saw the weakness in this view, and his current interest in cements led him to recognize the particular importance of determining some of the calcium silicate structures, such as that of wollastonite (β-$CaSiO_3$). His frequent emphasis on the importance of this problem was undoubtedly the main factor responsible for the fact that wollastonite and several closely related structures were solved independently during the middle fifties in four different and widely separated laboratories. Typically, Bernal neither solved any of them himself, nor apparently felt any pique because others had done this. These structures proved to be as important as he had suspected, and led directly to the major advances in knowledge of the principles of silicate structures that have since occurred.

In 1958 Bernal's interests returned to the structure of liquids. He started from the hypothesis that a liquid (assumed for this purpose to be composed of spherical, nonpolar molecules) had an instantaneous structure similar to that of a heap of solid spheres that had been formed without any conditions, such as lying on a plane surface, that would tend to produce regularity of packing. He thus saw a liquid as a substance that was coherent, homogeneous, and essentially irregular, and which contained no holes large enough to admit another molecule, and emphasized that the hypothesis differed in principle from some earlier concepts advanced by himself and others, according to which the instantaneous structure of a liquid was seen as resembling some kind of highly imperfect crystalline solid. Bernal was working out the consequences of his hypothesis when his productive life was tragically cut short by a series of severe cerebral haemorrhages, which began in 1963. It says much for his determination that he continued to work for a further five years. Once again, he left leads for others to follow up.

Bernal was remarkable for the great breadth of his scientific knowledge and interests, which extended to many fields. One might mention his interests in the origin of life, geochemistry, the history and philosophy of science and its social implications, and in scientific documentation. His deep interest in the social implications of science and his concern for world peace caused him to take decided stands on many political issues; he was awarded a Lenin Peace Prize in 1953. His writings on the history and philosophy of science and its social implications exceeded in volume those on natural science and he will be widely remembered for some of his books, such as *The Social Function of Science* (1938) and *Science in History* (1954). Whether or not one agreed with his views, his humanity, sincerity, and intensity of feeling could not be doubted. His breadth of interest and his willingness to make a stand on matters outside natural science carried on a tradition of the past that is perhaps too rarely followed today.

How should Bernal he remembered as a scientist? For his personal contributions, especially those made in the thirties, no doubt, but I believe even more for his ability to draw out the creative talents in others. His boundless energy and enthusiasm, the generosity with which he gave out ideas, both to those working under him and to the crystallographic community at large, and his complete unselfishness over matters of publication, should be recorded and remembered. The scientific world would be the richer for more of his like.

H. F. W. TAYLOR