flaws and chemical segregation are excluded from consideration, are evidently of great importance. There is general agreement on all sides that this background is due to movement of the atoms or molecules of the crystal from their positions of perfect geometrical alinement. The differences of interpretation arise in assigning the cause of the movement and in the mechanism of X-ray scattering. In Great Britain and in the United States, the whole effect is ascribed to the thermal vibrations of the crystal lattice. Just as the Laue and Bragg reflexions are a picture of the static geometry of the crystal, so the diffuse background is a picture of the dynamic vibrations of the crystal. The undisturbed crystal can be regarded as a medium in which the density varies periodically in space, and the effect of the temperature vibrations is to superimpose a spectrum of much longer elastic waves on the natural periodicity of the crystal. The whole crystal then diffracts as a unit and the resulting pattern consists of the usual Laue reflexions plus a background due to the motion of the atoms.

The point of view adopted by the Bangalore group of physicists is rather different. In places I find it obscure and can only hope that the following brief paraphrase of their views does them no injustice. To begin with, the quantum aspect of the interaction of X-rays with the atoms of the crystal is emphasized. The radiation scattered from an oscillating atom is stated to consist of three components, the amplitudes of which depend on the amplitude of oscillation of the atom, and which differ in frequency. The first component, which gives rise to the normal reflexions, has the frequency ν of the primary X-ray beam, while the other two have frequencies $\nu \pm \nu'$, where ν' is the frequency of the atomic oscillation. The frequency change is unfortunately too small to be measured directly.

The atomic oscillations which produce the frequency modulation are supposed, according to Raman, either to arise as a result of direct excitation by the incident beam or to be present as thermal vibrations. The existence of the latter does not seem to be essential; it is sufficient that the atoms are capable of being set in motion by absorbing energy from the X-ray beam—the interaction of the primary X-ray beam with the oscillating atoms then produces the effect. The character of the possible atomic movements is classified into two essentially different parts falling in the infra-red and the elastic ranges of frequency respectively. Raman imagines the elastic low-frequency vibrations of the crystal lattice to arise from the displacement of the lattice cell as a whole from its equilibrium position. Interaction between these vibrations and the X-ray beam gives a background of diffuse scattering of low intensity proportional to the number of lattice cells irradiated. The scattered energy is spread over a wide range of angles so that the elastic waves, it is stated, cannot produce a sharp reflexion.

To the infra-red modes of vibration is ascribed the principal role in producing the observed reflexions, with intensities proportional to the square of the number of lattice cells. These modes of vibration are supposed to arise from the movements of the atoms within the cells of the lattice. There is a difficulty here: the classification of the vibrations will hold for molecular crystals such as benzil, say. In these we might suppose the (infra-red) vibrations of atoms within one molecule to be controlled by forces different from those which control the vibration of

the molecules as a whole (elastic waves). But in metal crystals we can choose a cell containing but one atom, and there is no distinction to be drawn between the vibrations of the atoms as a whole and those of the lattice. The metals aluminium, sodium and lead all show, however, pronounced diffuse reflexions, although the elastic waves are not supposed to be capable of producing such an effect. Moreover, Raman explicitly assumes, as a limiting case it is true, that the infra-red vibrations have identically the same frequency, amplitude and phase in all the lattice cells of the crystal: in order that the centre of gravity of the cell may remain fixed, some atoms must move in opposite directions to others, an idea that leads to difficulties as the number of atoms in the cell diminishes.

When the assumption just mentioned as to the identity of phase of the infra-red vibrations in all lattice cells is abandoned, it is assumed that the phase varies slowly from place to place in the crystal. We are then presented with the difficulty that the variation of phase is propagated through the crystal, a process which must involve the elastic properties of the lattice; yet these are supposed to be without effect in producing the most salient features of the X-ray pattern.

It seems unlikely that the quantum hypothesis as set out by Raman can be reconciled with the elastic wave explanation unless one or other hypothesis is radically altered. Although Sir C. V. Raman is confident that his quantum mechanism is essential, it must be admitted that the "thermal-elastic" theory does give a reasonably accurate account of the observed facts.

OBITUARIES

Prof. L. J. Henderson

BY the death of Lawrence Joseph Henderson, the U.S. National Academy has lost its foreign secretary, Harvard University a notable personality, and the United States an outstanding man of science.

Henderson was born in 1878. He graduated at Harvard in arts and medicine. A couple of years were spent in Strassburg, principally in Hoffmeister's laboratory, but he spent some time acquiring technique in organic chemistry in Thiele's institute, and his mind at that time was in close contact with that of Faust and the work of Schmiedeberg's laboratory. On returning to Harvard, Henderson was made lecturer in biological chemistry; in 1910 he became assistant professor, and in 1919 professor.

A remarkable range of knowledge enabled Henderson to contribute in ways not open to those whose intellectual background is more restricted. Versed in the disciplines of mathematics, science, and philosophy, he could place a physiological problem either in a more mathematical or a more philosophical frame than could most of his contemporary biologists. On the other hand, the manipulative aspect of experimental science made little appeal to him, and probably the particular satisfaction of 'bringing off' a difficult experiment was something which he was content to leave to others.

About the time when Henderson graduated, the buffering of fluids was one of the growing points both of physical and biological science, and Henderson's first notable work dealt with that subject (for example,

"Das Gleichgewicht zwischen Basen und Säuren im tierischen Organismus", *Ergeb. der Physiol.*, 8, 254). The milestone which marks that phase is the "Henderson-Hasselbalch equation", stating that the hydrogen ion concentration of a solution containing carbonate, bicarbonate, and carbon dioxide is proportional to the ratio of the free to the combined carbonic acids. Perhaps his greatest contribution was his description of blood as a physico-chemical system. He described the red corpuscles in terms of the concentrations of eight components so connected that the alteration of any one equilibrium invoked a consequential alteration in all the others. This doctrine Henderson elaborated in his classical book "Blood"—the written record of his Silliman Lectures—in which, both for normal blood and that characteristic of certain diseases, the consequential inter-relations of the various factors involved were set forth in more than one hundred nomograms.

To such a mind as Henderson's, it was possible to treat of this great field without acquiring any mastery of the precise experimental techniques by which the data were obtained. It sufficed for him if the data which he plotted were reliable. He therefore, in collaboration with van Slyke, organized a large circle of extremely able experimenters, some in New York, some in Boston, and some farther afield, who undertook the necessary analyses.

It was not possible, however, for Henderson to treat of the physico-chemical blood picture, or rather blood kaleidoscope, without being intensely interested in the philosophical relation of environment to the change which it wrought in the blood of the organism. This interest was responsible for two books, "The Fitness of Environment", and "The Order of Nature". So the study of environment at once locates Henderson's veneration for Claude Bernard, and the name of Claude Bernard leads to Henderson's love of France. He particularly enjoyed the tenure of exchange professorships at Paris and Grenoble. He held the Legion of Honour, and was a foreign member of the Académie de Médecine (Paris). He travelled on French ships, and enjoyed French wines and French cookery. Henderson was no mean cook himself; indeed, during the war years of 1917-18 he was a constituted American authority on the properties of gluten and the science of baking. Other books were "The Fitness of Environment, and "Pareto's Sociology".

Henderson was a wonderful friend and a wonderful host, particularly perhaps at his summer camp, at Morgan's Center in Vermont. He loved to entertain his friends, and so did his wife. Morgan's Center is in hilly country—country which had once been in cultivation, but now has relapsed to a birch wood. Here on the edge of the lake, the very edge (so that you can dive in from the verandah), was the central cottage where one ate and smoked; the premises expanded on what Henderson called the 'village system', which meant that he bought some window frames from a Chicago stores, and the local carpenter built a hut of perhaps a couple of sleeping rooms around the windows.

The nineteen-twenties were prosperous years in the United States, and the loyalty of her sons saw to it that Harvard participated in full measure. Under the wise guidance of President Lowell it was a time of great expansion on both the scholastic and social sides. In the planning of this expansion Henderson took a very important part—a part for which his wide academic outlook on one hand, and his great social

gifts on the other, made him peculiarly valuable. Chairs were created, departments came into being on a basis of wide culture; among these must be mentioned the Fatigue Laboratory of the Harvard School of Business Administration, which dealt largely with muscular fatigue, in its widest sense, and the establishment of a human base-line in such matters; this was Henderson's peculiar *pied-de-terre*. On the social side the expansion took the direction of an endeavour to incorporate into Harvard what was socially desirable in the older English universities while in no wise doing violence to Harvard itself. While, therefore, Harvard still remained Harvard, new houses of residence sprang up, each presided over by a Master, and named after great Harvard men of former times. Thus there was a considerable increase in the number of men—as we would say—"in College". But among the other new features of the Harvard constitution was one particularly precious to Henderson, one for which he was largely responsible, and one of which he was himself chairman, "The Society of Fellows"*.

This tribute would be incomplete without a reference to Henderson's intense desire to knit more closely British and American science, and probably he did much more than appears in successfully accomplishing this. Yet his work was a broader one; it was to knit British and American culture, indeed to knit Britain and America themselves, not perhaps formally, but none the less really. It is significant that only illness prevented his giving the Pilgrim Lecture in London.

Lawrence Henderson received many foreign recognitions of his work, including an honorary Sc.D. in Cambridge. He married Edith Lawrence Thayer in 1910 and leaves one son.

A few weeks ago Sir Charles Sherrington passed a photograph of Lawrence Henderson hanging in the Laboratory. He glanced at it and said, half to himself, "A great man, that."

J. BARCROFT.

* The term 'fellow' is used in at least three senses at Harvard. (1) The charter of 1650 vested "sundry giftes legacies landes and Revenewes in the President and Fellows". Now, the Corporation consists of the President, five fellows and a treasurer, who in the last resort act subject to the Board of Overseers elected by the graduates. (2) The Society of Fellows, consisting of nine senior fellows, of whom the President of the University and the Deans of the Faculties of Arts and Sciences are *ex-officio*, while the chairman (lately Lawrence Henderson) and six fellows are elected by the Corporation and confirmed by the Board of Overseers. The senior fellows select junior fellows and recommend them to the Corporation for appointment. "These men are selected for their promise of notable contribution to knowledge and thought. . . ." A junior fellow has free board-residence in a house and an annual emolument of 1,250-1,500 dollars. (3) Numerous fellowships also exist in connexion with the faculties which are of the nature of senior studentships.

Prof. Walter Nernst, For. Mem. R.S.

IN the passing of Walter Nernst, Nobel laureate, physical chemistry has lost a notable leader. From 1894 he was professor at Göttingen, from 1905 in Berlin, afterwards, until 1924, director of the Reichsanstalt, and from 1925 until his retirement director of the Physical Institute in Berlin. After training as a physicist he became assistant in Ostwald's laboratory in Leipzig, where he was additional professor in 1891, and his earlier work was concerned with the broadening and deepening of what was then the 'new' physical chemistry, which centred around the theory of electrolytic dissociation and was so enthusiastically received and developed in the Leipzig school. Ostwald turned more and more from the atomic and molecular conceptions then