that it is a stable gas and can exist in an uncharged state. In fact, the persistence with which it clings to the walls of the discharge tube and the cathode makes experiments troublesome, as when once the tube has been used for this gas, it will continue, after the gas has been pumped out and replaced by another of a different kind, to show the (3) parabola; long sparking with oxygen in the tube is required to get rid of it.

I made many tests of the chemical properties of this gas and found that under them it behaved like ordinary molecular hydrogen. Thus, for example, it disappeared after vigorous sparking in the presence of oxygen, or when passed slowly over red hot copper oxide; again like hydrogen it can pass through red hot palladium; and there was evidence that when an electric discharge was passed through it, some of its molecules were split up into a positively charged hydrogen molecule and a negatively charged hydrogen atom.

Through the kindness of Lord Rutherford, I have had the opportunity of examining by the positive ray method samples of 80 per cent concentration of heavy hydrogen prepared by recent methods. Very interesting photographs obtained with heavy hydrogen of less concentration have been published by Prof. P. Zeeman. So far as I can see, the heavy hydrogen behaves in just the same way as the form of hydrogen obtained by bombarding solids. With these high concentrations, so much heavy hydrogen adheres to the walls of the tube, that instead of trying to get rid of it by bombarding with oxygen, it saves time to make a new tube for each experiment. Again, with the highly concentrated gas, I found, as Prof. Zeeman had done, parabolas corresponding to H_4 and H_5; in my early experiments a parabola (4) was frequently seen along with H_3. I ascribed it to helium and probably some of it was due to this source, but now I think part of it was due to H_4; on a few occasions, too, I observed a line corresponding to H_5. The evidence seems to me to leave little doubt that the gas I called H_3 more than twenty years ago is the same as that which is now called heavy hydrogen.

I said in "Rays of Positive Electricity" that from my experiments I suspected that there might be two kinds of H_3; this surmise is confirmed by the fact that many chemists who have experimented on tri-atomic hydrogen have come to the conclusion that it has a life of only a minute or so, and can only exist when charged with electricity. So far as I know, they all used hydrogen prepared in the usual way and not that obtained by bombarding solids; there is not the slightest doubt that the H_3 obtained in this way is stable and can exist uncharged.

I think the effect of the solid is due to its adsorbing a mixture of gases including H_2 and H_3, and that when it is bombarded, relatively more H_3 than H_2 comes off from the adsorbed layers. Thus the mixture that comes out is richer in H_3 than the mixture in the gas adsorbed by the solid.

Obituary

Sir William Hardy, F.R.S.

THOSE who enjoyed Hardy's friendship, and even those who could hope for no more than occasional contact with him, will deeply feel the loss of a strong and vital personality radiating an influence which stimulated effort, cured discouragement and could reawaken flagging enthusiasms. Hardy entered into everything he did with zest, and this seems to be the word which adequately describes his own attitude to life. He met each successive experience with fresh interest, and brought his whole nature to the appreciation of whatever it offered of value. His enjoyment of intellectual pleasures was itself almost sensuous, while his delight in the beauties of Nature, or in the appeal of fine pictures and music, was always mingled with—and, for him, intensified by—the intellectual reactions they evoked. Life's minor pleasures appealed to him and he loved a good wine, and a good story, in the telling or the hearing, and he enjoyed both best in good company.

Surpassing Hardy's many other enthusiasms was —as all his friends knew—a passion for the sea and the adventures it provides for all good sailormen like himself. Research stood high among his pleasures; he would literally smack his lips over some happy occurrence in a test tube, but probably the highest note in the gamut of his enjoyment was evoked by a boat with full sails, a spice of danger, and with the good ship answering to his hand on the helm.

Some insistence upon this lusty side of Hardy's temperament is essential to any proper understanding of him as a man; but while he savoured all pleasures so keenly, his outlook was far indeed from that of the mere hedonist; his life was full of serious purpose, and no less full of accomplishment and service.

I myself came first to know Hardy in 1898, when he was in his thirty-fourth year. His scientific training had been that of a biologist, and at this time he was on Michael Foster's staff in the Physiological Laboratory at Cambridge. He was, in particular, responsible for the teaching of histology to the advanced class, and had engaged in histological research. He had published, alone and with others, several papers describing highly original work on wandering-cells, and *inter alia* on the nature of the attack of oxyphil blood cells on bacteria.

Just before I became a member of the Cambridge staff, Hardy had convinced himself that current histological methods were employed with too little discrimination, and that many of the structures supposed to be characteristic of protoplasm were no more than artefacts produced by the action of

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reagents during the preparation of tissues for the microscope. Once assured that this might well be the case, he set himself with characteristic energy to investigate the matter. He was thus led to study aspects of the colloidal state in relations but then little known, and to deal with problems remote from his previous experience. He worked with the simplest of equipments, yet he rapidly brought significant facts to light. I was fortunate enough to occupy a room adjacent to his, and witnessed the progress of his research and the joy it gave him.

In 1899 Hardy published two classical papers "On the Structure of Cell Protoplasm" and "On the Coagulation of Proteid by Electricity". These titles do not convey the full significance of the work they describe. The clarity with which the existence of two types of colloidal dispersion was demonstrated, and the precision the work gave to the relation between electrolytes and colloids with its dependence upon ionic and micellar charges, together with other points of much importance described in these publications, made them extraordinarily influential. They stimulated work by scores of others and greatly accelerated the progress of colloidal chemistry.

Hardy retained to the end of his life an interest in this and kindred aspects of knowledge. He was specially curious as to the nature of the protein equilibrium in blood, and in the precise nature and meaning of the globulin fraction. Had he lived to deliver his address as president of the British Association, I believe that part of it, at least, was to be devoted to the results of his later thought on such questions.

The period of Hardy's researches to which I have been referring was of much significance to him. It led to his general interest in physical chemistry, and determined a direction for much of his later thought and work, his highly original dealings with the influence of chemical constitution on surface tension, for example, and the later developments which followed upon them.

In his earlier days as a physiologist, Hardy did not especially concern himself with metabolic phenomena, or with nutritional questions. The formation and management of the Royal Society Food (War) Committee, which fell to him as the biological secretary of the Society, awakened his interest in such matters and prepared him for the important work he was to do in later years as chairman of the Food Investigation Board.

Hardy's mind was but little trammelled by tradition, or even by the orthodox views of the day. His thought always worked on original lines. He was indeed no industrious reader of current scientific literature, seeking rather for the known facts whenever he wanted them for a specific purpose. This circumstance, and the great variety of his interests, together with his constant choice of the simplest possible technique in research, displayed qualities more often possessed by brilliant amateurs than by professional workers in scientific fields. One of the reasons for the success of his highly personal work was the freshness of mind that he brought to every problem, and the ingenuity with which he contrived his own simple, but adequate, experimental methods.

Hardy's genius had free play in the laboratory, and pure science has doubtless suffered from the fact that his latest years gave but little opportunity of displaying it there. One would be rash indeed, however, to suggest that he should have been spared from the administrative duties which he fulfilled so admirably and so greatly to the advantage of his country.

F. GOWLAND HOPKINS.

BY the death, on January 23, of Sir William Bate Hardy, at his home in Cambridge, in his seventieth year, science has lost a great captain and Great Britain a great public servant.

Hardy was educated at Framlingham and at Gonville and Caius College, Cambridge, where he was elected to a fellowship in 1892. He was Shuttleworth scholar in 1889, and Thurstonian prizeman in 1900. He was first and foremost a biologist, taking zoology in the Tripos, and then turning to physiology, and particularly to histology, a subject which he taught and in which he did research in Michael Foster's laboratory. To the end of his life he never lost his love of the microscope, and it is not many years since that he spent uncomfortable hours at a temperature of $-12°$ C. in one of the cold chambers at the Low Temperature Research Station, following through the microscope the process of freezing in gels.

From histology Hardy passed to the study of the colloidal state, a field then new and one in which he did pioneer work. No event in later life gave him more pleasure than to take part in the meeting at Cambridge in 1930 called by the Faraday Society to discuss the biological aspects of colloidal science. His scientific interests constantly broadened, and turning to the problems involved in action at surfaces, he entered the field of lubrication, and became a recognised authority on boundary conditions, contributing an article on the subject to the "Dictionary of Applied Physics". He was also Chairman of the Lubrication Research Committee of the Department of Scientific and Industrial Research.

The work for which Hardy was best known was, however, that which he did from 1917 onwards in the service of the Department of Scientific and Industrial Research as first chairman of the Food Investigation Board and as Director of Food Investigation. Here he found a new field that gave full scope for the exercise of his truly remarkable powers as leader and inspirer of a team of research workers, as advocate of the need for more science in industry and as apostle of co-operation in research between the members of the British Commonwealth of Nations. It was appropriate that the direction of the work should

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