Strain A (effective) Strain 2027 (very ineffective)
BACTERIA FROM THE CENTRAL TISSUE OF CLOVER NODULES PRODUCED
BY TWO STRAINS OF *Rhizobium*.

bacteria or to maintain it from disintegration. This is certainly the result of a maladaptation between the bacteria and the plant, since individual plants can be found in which a normally effective strain of the bacteria will behave ineffectively, and vice versa. It was found in this Department by P. S. Nutman (unpublished work) that *Trifolium pratense* possesses recessive genes that produce a typical ineffective response with a normally effective strain of *Rhizobium*. Our results suggest that the ineffective response may be related to the induced production by the plant of substances inimical to the bacteria*.

Changes in Effectiveness of Bacterial Strains

The abnormal responses given by plants possessing certain genetical compositions do not produce any lasting change in the bacteria. If these are re-isolated from such abnormal nodules and supplied to a normal plant, they will produce the degree of effectiveness typical of the original bacterial strain. It has been claimed by previous workers that continued passage through the host legume will progressively alter the effectiveness of a bacterial strain. The negative results of Virtanen's attempt to change the effectiveness of a strain in this way are in general agreement with unpublished results obtained here, in which effective and ineffective strains of clover *Rhizobium* showed no progressive changes in effectiveness on plant passage, although they readily developed extreme variants in effectiveness on culture in some sterilized soils as well as under other laboratory conditions.

Infection by Mixed Strains of Nodule Bacteria

Investigations carried out at Rothamsted also have a bearing on those of Virtanen relating to the successive application to the host plant of two strains of *Rhizobium*. H. K. Chen⁵ found that when different strains were supplied singly to the host plant, the number of nodules per gram of root attained a limit that was specific to each bacterial strain, though the genetical analysis referred to above has shown that genes in the host plant *Trifolium* also control the number of nodules formed.

As a consequence of this limit, the nodule-producing capacity of a root system can become so saturated that no more nodules will result from a further supply of bacteria whether of the original or of a different strain of *Rhizobium*⁶. This condition readily obtains with peas and soy beans grown in pots, where the

root system makes most of its growth in the first few weeks. In over, the root system of which continues to grow during a long period, the nodules first formed did not inhibit further nodule formation by the same or by a different strain. No evidence could be found of specific immunization by the nodules of one strain against the entry of a different strain.

When two strains were simultaneously supplied in initially equal numbers to pot-grown peas, acute competition in the root surroundings resulted in the preponderance of one of the strains both outside the roots and in the plant. In similar experiments with clover,

one pair of strains showed this selective competition; but with another pair, neither strain showed a selective advantage, the percentage of nodules produced by each strain being in proportion to the relative number produced respectively by the strains in pure culture.

The factors controlling competition between strains of *Rhizobium* in soil as well as those that limit the number of nodules produced afford interesting problems that are now under investigation.

¹ Virtanen, A. I., *Nature*, **155**, 747 (1945).

² Chen, H. K., and Thornton, H. G., *Proc. Roy. Soc., B*, **129**, 208 (1940).

³ Keilin, D., and Wang, Y. L., *Nature*, **155**, 227 (1945).

⁴ Chen, H. K., Nicol, H., and Thornton, H. G., *Proc. Roy. Soc., B*, **129**, 475 (1940).

⁵ Chen, H. K., *J. Agric. Sci.*, **31**, 479 (1941).

⁶ Nicol, H., and Thornton, H. G., *Proc. Roy. Soc., B*, **130**, 32 (1941).

OBITUARIES

Prof. E. J. Williams, F.R.S.

THE death at the early age of forty-two of Evan James Williams, professor of physics at the University College of Wales, Aberystwyth, has taken from us one of the most brilliant physicists of our generation. When finally compelled by his fatal illness to give up his work at the Admiralty, Williams returned to the village of Llanwenog, near Llanybyther, in the heart of rural Wales, near the border of Cardiganshire and Carmarthenshire, where he and two brothers were born, and where his mother and his father, a master stonemason, still live.

Educated at Llanwenog National School and then at Llandysul County School, as was his elder brother, now Dr. D. Williams, of the Aeronautical Structural Department of the Royal Aircraft Establishment, Farnborough, E. J. Williams quickly showed his brilliant qualities of mind. At the age of sixteen, by chance noticing in the local paper that some scholarships were open to competitive examination on the following day at Swansea, but finding the last train gone, Williams made the fifty-mile journey by pillion on his brother's motor-cycle, and won a £60 scholarship, and so began his academic career. From University College, Swansea, he went to Manchester to work under W. L. Bragg, then to Cambridge to work under Rutherford. After a year in Copenhagen with Niels Bohr, he returned to Manchester, and then went on to Chadwick at Liverpool. In 1938, he was

elected to the chair of physics at Aberystwyth. In 1939, at the age of thirty-six, Williams was elected into the fellowship of the Royal Society.

Williams was distinguished both as an experimental and theoretical physicist. His experimental work was mainly concerned with studies of electronic and atomic collision processes, using the cloud chamber of C. T. R. Wilson. The most striking of his experimental achievements was the direct demonstration in 1940 by the cloud chamber method of the decay of a cosmic ray meson into an electron.

Skilful though he was as an experimenter, Williams' distinction lay perhaps even more in his rare gift of analysing in detail the mechanisms of complicated physical processes, using a minimum of mathematical analysis and a maximum of physical understanding. In this quality of mind he had something in common with Niels Bohr, in whose institute in Copenhagen Williams did some of his best work. In a series of papers on collision processes, chiefly in the *Proceedings of the Royal Society*, and particularly in a brilliant but little-known paper, "Correlation of Certain Collision Problems with Radiation Theory", published in Denmark in 1935, Williams showed these rare powers to the full. The development of what is now generally known as the Williams-Weiszäcker method of impact parameters, for the approximate treatment of atomic collision problems, has the valuable quality of revealing the underlying physical mechanisms, which are often obscured by the heavy mathematical machinery of more rigorous methods. A particularly fertile application of these ideas was made by Williams to predict the later verified logarithmic rise of ionization with the energy of a very fast particle. As applied to the simpler collision processes, the impact parameter method was at first sometimes thought of as only giving an approximate answer and a visualizable picture of what could be calculated exactly by orthodox quantum mechanical methods. However, in recent years it is coming to be more and more used in solving the very complicated problems of the collision of fast neutrons, protons and mesons; this is so just because the complexities of the problems have made solution by more rigorous methods either very difficult or nearly impossible.

During the War, Williams turned his powerful analytic mind to many of the most important problems of the U-boat war, and made contributions of decisive importance to the winning of the campaign. His first work in this field, made during the summer of 1941, lay in the analysis of the process of attack on U-boats by aircraft. Simple but penetrating arguments, based on the actual observed facts of such attacks and on theoretical reasoning about these facts, showed that certain changes in the depth-setting and spacing of the depth charges should lead to a striking improvement in the number of U-boats sunk. The changes were made and the predicted results were attained, thus revolutionizing the attacking power of Coastal Command aircraft.

During 1942 Williams, who was then head of the Operational Research Section of Coastal Command, studied in great detail the tactics of harassing the U-boats by aircraft during their passage through the Bay of Biscay on their way from their bases to their hunting grounds. It was largely due to Williams' keen analysis and powerful advocacy that an augmented and improved 'Bay Offensive' was staged in early 1943. The results, in terms of U-boats sunk, were not only in startling agreement with his pre-

dictions, but also were one of the important factors that led to the defeat of the U-boat campaign in the summer of 1943, and so made possible the serious planning of the invasion of Europe.

Part of the story of the technical battle of wits—particularly in the field of radar—the victory in which made this 'Bay Offensive' successful, has already been told. The tactical battle of wits, waged by Coastal Command and the Admiralty staffs against the U-boat command, were analysed with great insight by Williams, working in close collaboration with the Naval and Air Anti-U-boat Staffs. Some day, perhaps, it may be possible to tell much more of this fascinating story.

During the last months of his illness, when Williams took up again his favourite subject of the quantum theory of atomic collision processes, he confessed that he still found the subtle intricacies of the U-boat war of comparable intellectual interest.

Scientific men of all lands will mourn the loss of this brilliant young Welshman. His death, coming so soon after that of R. H. Fowler, means a sad weakening of the none too wide ranks of British theoretical physicists.

P. M. S. BLACKETT.

Prof. Marc Tiffeneau

MARC TIFFENEAU was born at Mouy on November 5, 1873. After leaving school he was apprenticed to a druggist in Sainte-Maxence for a year, after which he went to Paris, where he continued his training for two years longer. Then he studied at the *École supérieure de Pharmacie*, where at the same time as his friends Valeur and Blaise he came under the influence of Béhal. After an academic career of exceptional brilliance, he acted for five years as a demonstrator in the department. By this time he had qualified as a pharmacist, and in this capacity was attached for many years first to the *Hôpital Boucicaut* and later to the *Hôtel Dieu*. In both those hospitals he had the good fortune to find ample facilities for research, of which he took full advantage, for in due course he shared his enthusiasm for chemistry with a large band of ardent workers, among whom Orékhoff and Mlle. Lévy were outstanding.

Tiffeneau was a man with wide interests, and the scientific aspect of medicine made a special appeal to him. It is characteristic of his versatility that he worked in Richet's laboratory and also at the Pasteur Institute, where it was at the suggestion of Roux that he decided to qualify in medicine. In 1907 he obtained his doctorate in science, and in 1910 his doctorate in medicine. He was elected to a chair of chemistry at the *Hôtel Dieu* in 1924, and to a chair of pharmacology and materia medica at the Sorbonne in 1926; for a man to have held at the same time those two important chairs, and to have achieved distinction in each, is surely exceptional. In 1937 he was Dean of the Faculty of Medicine of the University of Paris. He was honoured by his election into the *Académie de Médecine* in 1927 and by his selection as member of the *Institut de France* in 1939 in succession to Urbain. He was also an *Officier de la Légion d'honneur*. At the time of his death on May 20, 1945, he was president of the French Chemical Society. His wife, a sister of Prof. Fournéau, survives him with two sons.

After Fittig discovered the pinacol transformation in 1859, the mechanism of this action as well as that of the dehydration of glycols of various types