added. *Tribolium* and *Ptinus* developed normally on wholemeal flour. In many insects symbiotic bacteria or fungi are enclosed in special organs called 'mycetomes'. Microscopic examination of Fraenkel and Blewett's beetles showed that the former two species which could do without the B-vitamins possessed mycetomes containing symbiotic yeast-like organisms while the latter two species did not. Fraenkel and Blewett, therefore, supposed that *Lasioderma* and *Sitodrepa* were dependent on their symbionts for their supplies of essential water-soluble vitamins. They proved the truth of their hypothesis by showing that in the absence of their symbionts, *Lasioderma* and *Sitodrepa* lose their power of living on a diet lacking certain members of the B-complex. They also showed that, when freed from symbionts by being hatched from sterilized eggs, *Lasioderma* and *Sitodrepa* behaved in much the same way as did *Tribolium* and *Ptinus* when subjected to diets deficient in certain members of the B-complex.

To summarize these observations on symbiosis and nutrition, it may be said that examples of symbiosis which have long been known have, by morphological and biochemical researches, been raised in some cases to examples of what we may call mutualism.

The fixation of nitrogen by *Rhizobium radicicola* living in the roots of legumes proves this symbiosis to be a case of mutualism.

While mycorrhiza is essential to the normal development of the orchid, it is not essential to the life of the fungus producing it, for the latter lives quite successfully as a saprophyte in dead pine needles, or even when grown in a simple synthetic medium with dextrose and mineral salts. In those orchids which are devoid of chlorophyll, the mycorrhizal condition is associated with a completely saprophytic habit, and the dependence of the orchid on the fungus is obvious.

The manner of establishment of mycorrhiza varies in different plant orders for, while orchid seeds are shed quite free from fungus, the grains of the ryegrass *Lolium* are regularly infected. The mechanism of infection in *Lolium* is reminiscent of the method found in certain insects in which the eggs are automatically infected before they are laid. The status of the mycorrhizas of forest trees still has to be decided. Circumstantial evidence is, however, strongly in favour of a real dependence of such trees on their mycorrhizal fungi.

In ruminants, symbiotic bacteria, yeasts and protozoans inhabit the paunch. Similar microbiological pictures are shown by the caecum and colon of various mammals, including man. That the bacteria in all these cases benefit their hosts is not easy to prove. That the bacteria of the paunch of ruminants do, however, benefit their hosts has been shown by the following observations: (1) Rumen bacteria digest cellulose whereas the ruminant itself cannot^{31,32}. (2) They generate acetic acid from carbohydrates and thus assist in their digestion. (3) They elaborate protein from ammonium nitrogen, and this protein, together with bacterial polysaccharide, becomes by autolysis and normal digestion available to the host^{33,34}. The elucidation of the chemistry of the water-soluble vitamins of the B-complex has shown that many bacteria inhabiting the bodies of mammals and insects provide their hosts with an endogenous source of these vitamins. There is evidence that even in man B-vitamins are produced by bacteria in the colon. Further investigations will

probably greatly extend the list of animals with such an endogenous symbiotic supply of B-vitamins.

Some of the results of recent investigations of the symbiotic relations of micro-organisms and mammals have been discussed elsewhere^{35,36}.

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OBITUARIES

Dr. D. E. Lea

RADIOBIOLOGY has suffered a serious loss by the death of Douglas Lea as the result of an accident at the early age of thirty-seven. In his short life he had already become one of the leading authorities in the world on the fundamental aspects of the mechanism of the biological actions of ionizing radiations. Fortunately, he had summarized his work and ideas in an excellent book entitled "Actions of Radiations on Living Cells" (Cambridge University Press, 1946). This book is his memorial and is likely to influence radiobiology and radiotherapeutics for many years to come.

Douglas Edward Lea was born in Liverpool on February 8, 1910. From Liverpool Collegiate School he went with scholarships to Trinity College, Cambridge, in 1928. He gained firsts in Part 1 of the Mathematical Tripos in 1929, and in Part 2 (Physics) of the Natural Sciences Tripos in 1931. The whole of his working life was spent in Cambridge. He

started research in physics, working in the Cavendish Laboratory with Lord Rutherford and Dr. (now Sir James) Chadwick. In 1934 he made the discovery of the capture of a neutron by a proton to form a deuterium nucleus with emission of gamma radiation. For this and related work he was elected to a fellowship at Trinity in 1934. He took the degree of Ph.D. (Cambridge) in 1935. Then he turned to biophysics, and went to work at the Strangeways Laboratory, first with a grant from the British Empire Cancer Campaign and then during 1942-46 as Proffit Student of the Royal College of Surgeons. His first work in this field was a study of the mechanism of the bactericidal action of radiations, made in conjunction with his friends Drs. R. B. Haines and C. A. Coulson, and was a promising beginning, with quantitative interpretation of the results in terms of the target theory. Although twenty-one out of his thirty-one biological papers were published in collaboration, it is evident that in many of them Lea made a major contribution both to the experimental technique and the quantitative interpretation. His experimental skill, developed during his period of training at the Cavendish Laboratory, is demonstrated in his papers on a radiation dosimeter and automatic devices for controlling the output of X-ray tubes, and the X-ray equipment he built at the Strangeways Laboratory. He went to great pains to learn the necessary biological techniques, as shown, for example, in his paper on the delayed lethal action of radiations on chick embryos.

Lea's outstanding contributions to radiobiology are to be found in his papers on the target theory of gene mutation, the variation with wave-length of the biological effects of radiations, the inactivation of viruses and enzymes by radiations and the mechanism of induction of chromosome aberrations by radiations. Of great interest and importance was his work in collaboration with Dr. D. G. Catcheside on chromosome aberrations in *Tradescantia*, in which was made the remarkable theoretical prediction, with experimental verification, of the sharp maximum in efficiency of chromatid breakage by soft X-rays at a wave-length between 4 and 5 Å.

During the last few years Lea was becoming increasingly interested in the mechanism of radiochemical reactions in relation to biological effects. In October 1946 he was appointed reader in radiobiology in the Department of Radiotherapeutics of the University of Cambridge, though on account of the shortage of laboratory space he continued to work at the Strangeways Laboratory. Only two days before his death he was informed that he had been successful in his application for the degree of Sc.D. of the University of Cambridge. He had many plans, and had arranged to take leave of absence during the next academic year to work at the Memorial Hospital in New York.

Lea had come to occupy an exceptional position as collaborator, adviser and friend to a great many workers in a wide range of subjects requiring the application of biophysical, statistical and mathematical techniques. We all liked him for his unending kindness, his integrity, his modesty and his patient helpfulness. He always produced the information required, without considering time or trouble. It is very difficult to estimate the extent of his influence. Although it could be said that his work was his main interest, he was also essentially a family man, and greatly devoted to his wife and two young children.

J. S. MITCHELL

K. H. Stephensen

AFTER a short illness from pneumonia Knud Henshø Stephensen, inspector of the University Zoological Museum of Copenhagen, died on March 13.

Stephensen was born on November 29, 1882, and took his degree as *candidatus magisterii* at the University of Copenhagen in 1907. Besides teaching at a grammar school, he at once embarked upon the study of crustaceans, which held his interest for the rest of his life. From 1914 he was curator of the crustacean collections of the University Zoological Museum and was thus the successor of H. J. Hansen and, before him, Henrik Krøyer; under his care, the collections were kept in excellent order and grew considerably. At the same time he was a very productive investigator, the total number of his papers being about 130; practically all of them deal with crustaceans and pycnogonids.

Stephensen's work was primarily systematic and faunistic, and he seldom attempted to draw general conclusions of a higher order; but all his papers bear witness to his deep penetration into his subject; he was a capable draughtsman, and had a thorough knowledge of the literature of the Crustacea. He dealt with almost all groups of the Malacostraca, and was one of the few systematicists left who really mastered this big group. But even he had to realize the necessity of specialization; and he chose one of the most difficult and largest groups, the amphipods. A long series of papers appeared on the North Atlantic species, benthonic as well as planktonic; big reports on the collections of the *Ingolf* and the *Thor* Expeditions were followed by papers on collections from almost every part of the world. At his death he was undoubtedly the leading authority on the systematics of amphipods. Yet one of his last papers—and an excellent one—was on the crabs of the Persian Gulf.

Stephensen led a happy life; he was enthusiastic about his work, whether sitting quietly at the microscope in the museum or collecting in the field. In 1912 he spent the summer in West Greenland studying the fauna of the fjords; during 1921-22 he took part in the *Dana* Expedition to the Sargasso Sea, West Indies and the Gulf of Panama, and in 1925 he collected in the Faroe Islands.

While his publications show him mainly as a carcinologist, Stephensen's general interests were wide; he was a keen all-round naturalist and also much interested in architecture and archaeology. Many colleagues all over the world will miss his long and personal letters, written in his beautiful handwriting—colleagues who became his friends for life, if they happened to visit Copenhagen and once experienced the friendliness and hospitality of Stephensen and his wife.

Stephensen considered a sound taxonomy of fundamental importance to all branches of biology, ecology, physiology, etc., a view which has not been sufficiently appreciated by many working in these fields; so much the greater was his pleasure when, in 1946, he was made a corresponding member of the Linnean Society of London, for he took it as a token that his work on the lines of Linnæus, whom he admired very much, had not been in vain.

Every empty chair in the field of zoological systematics is difficult to fill nowadays, and Stephensen's death means a great loss to Danish zoology; but his authority will be missed beyond the borders of his own country.

ANTON FR. BRUNN