an alternate host on which the rust gathers its strength for its attack on the wheat; it is also a common ground on which the various physiological races of the rust can meet and hybridize with the production of new races.

In 1938 Hansen[10] described the 'dual phenomenon' in Fungi Imperfecti and explained this by the hypothesis of heterokaryosis. In *Botrytis cinerea*, for example, the conidium has several nuclei and it is suggested that they are not necessarily genetically alike. When such a spore gives rise to a colony a sector may develop differing from the rest. This sector may have arisen from a branch which, instead of having a mixture of nuclei of two or more different genotypes, has received nuclei of only one. It is well known that, in Nature, such a fungus as *Botrytis* occurs as a number of strains. When two strains meet, anastomoses (vegetative fusions) occur freely, and through these the nuclei can pass from one strain into the other, thus producing the heterokaryotic condition. The freedom with which nuclei can move through a mycelium of septate cells has been emphasized by Buller[11], who directed attention to the fact that the central pore existing in the cross-wall of higher fungi allows free streaming of protoplasm and transport of nuclei from cell to cell.

This peculiar heterokaryotic condition which may arise in the higher fungi offers interesting possibilities to the geneticist, in spite of the fact that no karyogamy is involved. The question has been discussed by Pontecorvo and Gemmel[12,13] in recent contributions to *Nature*.

Recent work by Beadle and Coonradt[14] on heterokaryosis in physiological mutants of *Neurospora* is especially interesting and suggestive. For the growth of fungi certain vitamins are necessary. Some fungi are capable of synthesizing some or all of these, others can grow only if the necessary ones are provided. Both vitamin B_1 (thiamin) and B_6 (pyridoxin) are necessary for the vegetative growth of *Neurospora*. Beadle and Coonradt obtained a strain which could synthesize B_1 but not B_6 and another which could make B_6 but not B_1. Neither would grow by itself on a standard basal medium. When, however, macroconidia belonging to the two strains were sown together, vegetative fusions occurred and the heterokaryotic mycelium, capable of synthesizing both B_1 and B_6, grew freely.

Something is now known of the genetical causes of the instability of pure cultures originating from single cells or single spores. In yeasts genetical segregation may occur, in cultures started from a single cell, at ascus formation. In conidial fungi with multinucleate spores heterokaryosis may be the cause of variation. Finally, in any cell and at any time gene-mutation may occur.

The genetics of fungi is an exciting and rapidly expanding subject, but one must bear in mind the warning words of Albrech von Haller more than two hundred years ago when he described fungi as "a mutable and treacherous tribe".

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OBITUARIES

Prof. J. Stanley Gardiner, F.R.S.

JOHN STANLEY GARDINER, emeritus professor of zoology in the University of Cambridge and one of the outstanding figures in British zoology, died suddenly on February 28 at the age of seventy-four. His research career began in 1896 when he took part in the Royal Society's well-known expedition of Funafuti; from then onwards he was recognized as an authority on the distribution of marine animals in general and on the madreporarian corals in particular. Between 1897 and 1909 he organised and led three major expeditions to the Indian and Pacific Oceans, each of which threw considerable light on the broad relationships between the physical and biological aspects of oceanography. Perhaps the most interesting of these expeditions was that to the Maldive Archipelago, for it led to the theory that a large land mass could be eroded to a depth of about 150 fathoms, thus giving rise to a submerged plateau which would later provide a foundation for coral reefs. From 1909 onwards, university duties prohibited further expeditions, but at least three other major projects owe much to Gardiner's inspiration and active support: the Suez Canal expedition under Munro Fox (1924), the Indian Ocean expedition (1933) under Seymour Sewell and the Lake Titicaca expedition under H. C. Gilson (1937). Gardiner's work was recognized by his election to the Royal Society at the relatively early age of thirty-six, and in later years he received the Agassiz Medal of the U.S. National Academy of Science, the Gold Medal of the Linnean Society, and the Darwin Medal of the Royal Society. He delivered the Lowell Lectures at Harvard in 1930.

After each of his expeditions, Gardiner returned to Cambridge to play an active part in college and university life. He became a fellow of Caius in 1898, dean in 1903 and senior proctor in 1907. In 1909 he succeeded Adam Sedgwick as professor of zoology and for the next twenty-eight years remained in residence in the University. He was, above all else, a man of wide scientific vision, and his influence was felt far beyond the limits of his own research interests. He was in no sense a physiologist, but he saw clearly that the study of animal form could acquire new significance when considered in relation to function. As head of his Department at Cambridge, he did all in his power to weld morphology and physiology into one indivisible science. Between 1909 and 1914 his own lectures on "The Principles of Zoology" gave to students this new point of view, but perhaps of even greater significance was Gardiner's ability to gather round him men of inspiring personality. In 1910 Leonard Doncaster and Cresswell Shearer joined his staff, and these with Gardiner formed a nucleus around which advanced students rapidly gathered.

On the outbreak of war in 1914, Gardiner shouldered an extremely heavy burden of teaching, but nevertheless devoted a great deal of energy to the organisation of fishery research, of which he acted in the official capacity of director of scientific investigations until 1920. At the end of the War of 1914–18, Gardiner, with characteristic foresight and generosity, gave to each returning member of his staff a full year's freedom from teaching, and he encouraged them by every means in his power to develop their research interests. During the next fifteen years he continued to foster the functional outlook, but, at the same time, developed other aspects of zoology, notably ento-

mology and hydrobiology. Much new material was introduced into the teaching and inevitably some of the older topics were omitted. For this Gardiner was, at times, sharply criticized by some of his colleagues in other universities, but by 1930 he had the satisfaction of knowing that his Department was the recognized centre of functional morphology in Great Britain. It received large endowments and its present laboratories are the fruit of Gardiner's endeavour.

It would be wrong to regard Gardiner's great services to zoology as the result of careful and precise planning. It was not so. It was due to the width of his scientific vision and his ability to focus his attention on essential points. He never became immersed in detail, but would follow up an idea with vigour and enthusiasm. These were the qualities he looked for in others, and if Gardiner were satisfied on these two points, no young man ever approached him in vain, however strange his project might be at first sight. He never forgot that one of the primary objects of a university is to train young men to think for themselves and not to burden their memories with factual knowledge. If an exposition of somewhat arid facts were unavoidable, Gardiner would inject a leaven of speculation which, at times, might be somewhat disconcerting—as also was his famous examination question: "Discuss any zoological problem which is of particular interest to yourself".

Not the least of Gardiner's contributions to Cambridge zoology was the development of the Balfour Library. Starting with the books bequeathed by Francis Maitland Balfour, Gardiner built it up into one of the finest zoological libraries in Britain, and it is fitting that his portrait should hang over its doorway.

Gardiner was elected a trustee of the British Museum in 1931 and a member of the Standing Commission on Museums and Galleries in 1942. For these appointments he was peculiarly well fitted, for in addition to his scientific knowledge, he had a deep sense of appreciation of water-colour painting, his own collection being of considerable interest. Gardiner's hours of leisure were spent in his garden, in yachting or in fishing. During his later years he took relatively little part in the administrative affairs of his College or of the University. He belonged to a generation of scientists who regarded administration as the servant of learning. The work of a committee warranted respect in so far as it facilitated work in the laboratory and no further; if it failed in this respect it was essentially something to be laughed at or ignored. In administrative circles Gardiner's particular genius was not always readily appreciated; but any conception of Gardiner as an indifferent administrator would be false. When he was sufficiently interested in a problem, his facts were accurate and his exposition concise.

Gardiner was elected to his professorship under statutes which did not involve retirement at a specific age, but he placed himself voluntarily under an obligation to retire in 1937. After a brief holiday in Cyprus, he returned to Cambridge full of vigour and devoted himself to picking up the threads of the *Sealark* expedition and to re-organising sections of the Balfour Library. His health failed suddenly about two years ago.

Gardiner was a leader in the sense that he broadened the field of biological research. Above all, however, he was an outstanding personality capable of inspiring in others the enthusiasm and confidence necessary for them to tackle difficult problems however remote these might be from Gardiner's own immediate interests. Perhaps the secrets of his success were that he never grew old in mind or spirit, and never took himself or others too seriously. He derived not a little amusement by disguising the real point of a conversation to the very last moment; to earnest-minded students or colleagues this was often disconcerting, but he did not do this at moments of crisis. When a situation demanded action, Gardiner was quick and effective; when help was needed Gardiner never failed to respond. He endeared himself not only to colleagues and assistants in the laboratory, but also to each generation of students in turn. The crayon drawing by Ronaldson which hangs in the Balfour Library reflects faithfully the spirit of a distinguished scientist and a most unselfish man.

J. GRAY.

Prof. F. A. Cavenagh

BY the death of Prof. F. A. Cavenagh on April 21 the academic study of education in Great Britain has lost one of its outstanding exponents. Many generations of teachers whom he trained will also regret the passing of an inspiring leader, a wise counsellor and a firm friend.

Francis Alexander Cavenagh was born in 1884 and was educated at University College, London, of which he afterwards became a fellow. He was also a student, under Sir Percy Nunn, at what was formerly known as the London Day Training College (now the Institute of Education). In 1909 he obtained the M.A. degree with distinction in classics. He then served as a schoolmaster, first at Cheltenham Grammar School and afterwards at the recently founded King Edward VII School, Lytham. In 1912 the Lytham headmaster, Mr. Bompas Smith, went on to the University of Manchester as professor of education and two years later Cavenagh was appointed as a lecturer on his staff. Cavenagh's work at Manchester was interrupted by a period of service in the Artists' Rifles and the R.G.A., and in 1919 he acted as Area Education Officer, H.Q. London District, and as lecturer at the War Office School of Education, Oxford. In 1921 he became professor of education at University College, Swansea. He worked up the Department there, almost single-handed at times in the early days, and rapidly made his mark as one of the most distinguished professors of education in Great Britain. In 1933 Prof. Dover Wilson temporarily relinquished the chair of education at King's College, London, in order to undertake a year's full-time research, and Cavenagh took charge of the Department there; but at the end of the year he was appointed the first professor of education at Reading, where he remained until 1937. He then returned to King's College as University professor of education.

Cavenagh's tenure of the King's College professorship coincided with a time of great national difficulty. Soon after the outbreak of war his Department was evacuated to Bristol; but the conditions there were no less trying than in London. Cavenagh had not only to cope with the administrative problems arising from evacuation, but he also threw himself wholeheartedly into A.R.P. work; and there is little doubt that his exertions and devotion in this service undermined his health. When King's College returned to London there was still a period of flying bombs and rockets to be endured, and Cavenagh continued to give himself unsparingly until his health finally broke down.