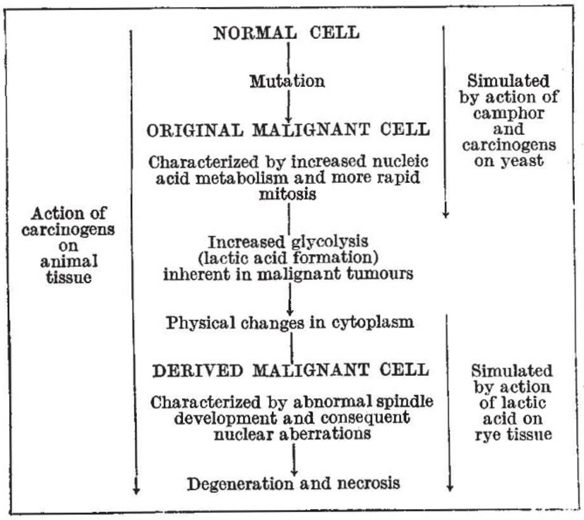
proteins. We may therefore suppose from these different kinds of evidence that lactic acid is the immediate cause of spindle defects in tumours. The question as to whether the formation of lactic acid in the tumours is itself secondary and a consequence of excessive growth activity, or whether it is bound up with the primary change in nucleic acid metabolism, does not now need to concern us.

To summarize, we may arrange, as in the accompanying table, the probable sequence of events in tumour development.



The change from a normal to a malignant cell is of the nature of a mutation, but until recently we had few ideas as to how it might be brought about. We have seen that a change in the amount of heterochromatin may be one way and we also know that mutation in a single nuclear gene may induce polymitosis[21]. We now have the further possibility of an effect through mutation in cytoplasmic elements. In this there is a remarkable similarity of views between two workers engaged in entirely different fields of research. Darlington[22], basing his arguments primarily on cytogenetic grounds, considers that there are genetically important elements in the cytoplasm which are self-perpetuating. These he calls plasmagenes. They differ from viruses in their adaptation to the 'host' and in their interaction with the cell nucleus. Both plasmagenes and viruses depend on chemical equilibrium for their continuance, so that a mutation in them can alter not only their equilibrium but also their interaction with the cell nucleus. Potter[23], as an enzymologist, considers that cancer is caused by the introduction of "an abnormal protein" which he calls a "cancer virus" and which he assumes "to arise spontaneously in certain cases, to be formed by the action of carcinogenic agents in other cases and to be introduced into the cell in the case of tumours known to be of virus origin". This 'cancer virus' is assumed to be almost identical with an enzyme X which he believes is a complex of respiratory enzymes of the nature of a ribonucleoprotein. A change in equilibrium is brought about by competition between these two for the same 'building blocks', and when the ratio $\frac{\text{cancer virus}}{\text{enzyme } X}$ reaches a certain value the cell becomes malignant. The change is thought to be irreversible because the 'cancer virus' competes more successfully than enzyme X for the 'building blocks'. The reaction is analogous to what Darlington calls 'suppressiveness' as between plasmagenes.

These experiments and theories seem to show that a common basis has been reached for the study of the cancer problem. They seem to shew also that the elements of the problem can be pulled apart, robbed of their complexity and subjected to profitable experimental tests that will now have a meaning.

I am much indebted to Mr. S. H. Revell for technical assistance with some of the experiments discussed in this article.

Note added in proof. Since the above article was written, Potter has also directed attention to this remarkable coincidence of views in *Science*, **101**, 609 (1945).

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OBITUARIES

Prof. C. E. Spearman, F.R.S.

CHARLES E. SPEARMAN was born in London on September 10, 1863. He came of a Northumberland family, the more prominent members of which had been either Army officers or mining engineers. With one or other of these possible professions in view, he gave himself assiduously in his early youth to the study of applied mathematics. Eventually he entered the Army, and served in the Burmese War. During the Boer War he was deputy assistant adjutant-general in Guernsey; and in this way became interested in problems of personnel. He resigned his commission in order to study experimental psychology at Leipzig, at Göttingen, and at Würzburg.

Spearman's interests first centred on the problem of determining sensory thresholds. Here his mathematical knowledge enabled him to suggest several improvements in the psycho-physical methods of Wundt and Muller. But, coming as he did with a mature experience of practical affairs, he quickly decided that the experimental psychology of those days was engrossed too exclusively with questions far removed from those of ordinary human life. His early aim, therefore, was, in his own phrase, "to connect the psychics of the laboratory with those of real life".

The idea of using sensory thresholds to measure general ability or intelligence he took from Galton. In the United States, one of Galton's own pupils, J. McKeen Cattell, had applied laboratory tests to students, and, on assessing the results by Galton's method of correlation, had been surprised to find that the agreement of the various modes of assessment was extremely low. Cattell, Thorndike and others were consequently led to the conclusion that there was no general faculty of intelligence, as Galton had assumed, and that the mind was a "host of particular abilities". This negative result Spearman believed to be erroneous. Adapting a more elaborate statistical procedure from Karl Pearson and Yule, he endeavoured to eliminate the irrelevant factors which appeared to be obscuring the underlying correlations, and then found an almost perfect agreement between the various tests and assessments. These results he published in one of his earliest and most important articles in 1904—"On General Intelligence Objectively Determined and Measured". In this research he believed he had demonstrated "the profoundly important conclusion that there exists something which we may provisionally term general sensory discrimination"; and this he identified with "general ability" in Galton's sense. Few papers in psychology have given rise to such productive controversies and to so long a list of suggestive investigations.

In 1907 Spearman returned to England. At that time McDougall was interested in Galton's scheme for an anthropometric survey which should include intelligence tests. In France, Binet had produced his scale of tests; and at University College, London, Karl Pearson had already been working with correlational methods applied to teachers' assessments of their pupils' mental characteristics. On McDougall's recommendation, Spearman was appointed reader in experimental psychology at the same College, and four years later became Grote professor of mind and logic. During the next twenty years, he and his research students were systematically engaged on demonstrating the supreme importance of a general intellectual factor, which he himself preferred to call, not intelligence, but *g*.

At first Spearman relied mainly on sensory tests of a laboratory type—the æsthesiometer, Galton's cartridge weights, and a dichord of his own invention for testing discrimination of pitch. Other workers in Great Britain, however, showed that better results might be secured by using tests of more complex abilities, particularly those involving the perception or use of logical relations, such as could be given without apparatus to large groups of children in school. These suggestions Spearman readily incorporated. His main interest, however, lay rather in the theoretical study of the mind in general than in educational or other practical applications.

His later work with tests of this new type led him to formulate his "fundamental noegenetic principles". According to this doctrine all intellectual processes were to be conceived as depending essentially upon the "education of relations and correlates". His first book, on "The Nature of Intelligence and the Principles of Cognition", gave a systematic picture of the workings of the human mind based on this hypothesis. It was quickly followed by a second volume on "The Abilities of Man", which gave the final statement of his 'two-factor theory'—the theory that all mental processes are pervaded by a single central function, combined with a second highly specific factor peculiar to each test or trait.

Later, in a smaller work on "The Creative Mind", Spearman endeavoured to show how his fundamental noegenetic laws could be applied to other intellectual fields. His last work, "Psychology Down the Ages", was a historical study in two volumes of the evolution of the chief doctrines of psychology, with the intention of showing how nearly all the more acceptable formulations were dim foreshadowings of his noegenetic laws.

In 1931, on his retirement, Spearman was made emeritus professor in the University of London. He had already been elected a fellow of the Royal Society, and been honoured by numerous scientific bodies in Germany, France, the United States and Czechoslovakia. All who worked with him, or discussed with him their common problems, will testify to his remarkable gift for inspiring enthusiasm both in his own colleagues and pupils and in those who were drawn to criticize his views. Few have possessed his power of co-ordinating and concentrating the interests of numerous research workers on a single fertile scheme.

C. BURT.

Dr. Frank Chapman

THE death has been announced of Dr. Frank Chapman, who for many years was head of the bird departments of the American Museum of Natural History, until his retirement in 1942.

Dr. Chapman was born at Englewood, New Jersey, on June 12, 1864, and on leaving school entered a New York bank. So keen on birds was young Chapman that he used to get up at daybreak, hunt birds on the way to the station, where he would arrive at 7.30, change into his city clothes and catch the 7.39 to town. All his spare time was devoted to collecting and studying birds, and after six years in the bank he decided that was not the life he could live. In 1886 he left the bank and two years later was appointed assistant to Dr. J. A. Allen, curator of mammals and birds in the American Museum of Natural History. This was the beginning of his long connexion with the Museum and the great bird collection which was so wonderfully developed under his charge. When Chapman joined the Museum the study collection consisted of only 300 skins! Under the joint care of Allen and Chapman the collection grew apace, and the latter made many expeditions to different parts of the States and the West Indies to secure further material.

Early in his career Chapman became interested in the life zones of the Andes, and thereafter most of his work was devoted to studying the birds of the Andes in Venezuela, Colombia, Chile and Peru. He published several monographs dealing with the subject and was the recognized authority on the birds of these regions. As Chapman himself wrote, he was more interested in watching live birds in the field than in collecting or studying skins, and after the First World War he settled on an ideal spot for the purpose. This was Barro Colorado Island in the Panama Canal zone, and there he built a house, called Fuertes House, after his friend the American bird artist. Here he could study and photograph wild life to his heart's content. Among the trees toucans, guans, parrots and woodhewers abounded, and down below were ocelots, peccaries and other interesting