OBITUARY NOTICE

Stuart Dunsmore Elliott
1907–1986

The half century from the 1930s to the 1980s represents a rich period of growth and productivity for medical microbiology, marked by the rapid accumulation of new knowledge and dramatic changes in the style of research. Stuart Elliott's career spans this period. He was a bacteriologist of the "old school", and the research that led to his many contributions was more in the style of the early part of this period than the later. It is not that he was in any sense behind the times, but he preferred to work alone in developing his own ideas and establishing the validity of his findings. He was not at all averse to collaborating with others, however, and he frequently did so in the course of extending or broadening his findings.

Elliott received his MB at University College Hospital Medical School of the University of London in 1931. Soon thereafter he was active in research and teaching in the Department of

Bacteriology there under Professor C. C. Okell. It was in this setting that he carried out his studies on the occurrence of transient bacteraemia resulting from minor trauma in the oral cavity, including dental manipulations or even mere brushing of the teeth. He recognised the implications of these findings for the aetiology of subacute bacterial endocarditis, and his work was a major advance in the understanding of this problem. Since the organisms encountered in these bacteraemias were all oral streptococci, these studies marked the beginning of his concentration on this genus of bacteria that lasted throughout his life.

As a result of the illness of Okell, Elliott was in charge of the department of bacteriology from 1935 through 1937 and was responsible for all of the teaching during this period. After a year as University Demonstrator in Pathology at Cambridge, he joined the department of bacteriology at

the London Hospital Medical College in 1938. The war soon intervened and he became the director of a public health laboratory of the Emergency Medical Service. Because of his interest in streptococci, he became associated during this period with the noted investigator, Fred Griffith, who had for some time been engaged in an attempt to sort out the numerous varieties of haemolytic streptococci. After Griffith's tragic death in the London blitz in 1941, Elliott succeeded him as director of the Streptococcal Research Laboratory. Here, he soon encountered questions concerning the classification of haemolytic streptococci that shaped the course of his later research.

Elliott noted that there were a number of discrepancies between the schemes for typing haemolytic streptococci that had been worked out by Griffith and that devised independently by Rebecca Lancefield at the Rockefeller Institute in New York. Griffith and Lancefield had for some years been in correspondence with one another and had exchanged strains and sera, but the differences in their experimental methods left unresolved problems. In 1944, Elliott arranged a visit to Lancefield's laboratory with the intent of resolving the discrepancies. This was the beginning of a durable collaboration, fostered at the outset by the great mutual respect of Lancefield and Elliott, but extending in time to many others at Rockefeller. While never relinquishing his primary academic affiliations in England, Elliott managed to spend a period of time, varying from a few weeks to some months, at Rockefeller every succeeding year except one until 1985. Throughout that 40-year period, his studies at home and abroad complemented each other most effectively.

I was on the scene in a nearby laboratory at Rockefeller in 1944 and can attest that Rebecca Lancefield did not anticipate the visit of Elliott with enthusiasm, primarily because of a possible disruptive effect on her own work. This reservation disappeared almost immediately after his arrival, and they quickly became close friends as well as scientific colleagues. Lancefield remained his strongest supporter throughout her life. For example, in the 1950s, when the research at Rockefeller ceased to be supported solely from endowment, she applied for and received her only research grant from the National Institutes of Health for the sole purpose of supporting Elliott's participation in research at Rockefeller.

Early in his first trip to New York, Elliott made an observation that appeared relevant to some of the discrepancies between the Griffith and Lancefield typing methods. This was the finding that

among haemolytic streptococci from human infections (group A), certain strains lose their type-specific M protein (the antigen on which the Lancefield system is based) during the late stages of growth. This led to his discovery of the production of an extracellular proteinase by group A streptococci. In pursuing this finding, he showed that the enzyme is released from the bacteria as an inactive precursor, zymogen, and is activated autocatalytically under reducing conditions. Subsequently, he isolated both the proteinase and its precursor in crystalline form, the only members of the family of streptococcal extracellular products that have been crystallised. The properties of the proteinase and its zymogen proved to be of great interest to biochemists and enzymologists, and Elliott collaborated in several productive studies on the structure and mode of action of these enzymes. In addition, information on the proteinase has contributed to the investigation of a number of streptococcal problems. Thus, his research that began with a practical goal in bacterial classification was pursued in such a way as to yield fundamental new information on streptococcal biology and on enzymology.

During this period in which the proteinase work was carried out, others in the Rockefeller laboratory were studying the nature of the group-specific antigen that Lancefield had used as the basis for her serological grouping of the large family of streptococci. In the several groups examined (A, B, C, F, and G), this antigen proved to be a polysaccharide that is a major constituent of the insoluble, protective cell wall. The common structural feature of these polysaccharides is a core consisting of a rhamnose polymer, with variable hexose side chains accounting for the individual immunologic specificity. Elliott's initial studies in this area dealt with group-D streptococci, a large and diverse group of organisms widely distributed in man and animals. He showed that the cell-wall rhamnose polysaccharide was not the antigen that defined this group, but rather a new type of antigen that later came to be designated as teichoic acids. In streptococci, these are polymers of glycerophosphate, with side chains of sugars and D-alanine, that are not an integral part of the cell wall. Elliott worked with Baddiley, one of the discoverers of the teichoic acids, in further defining the group-D antigen and the sugars responsible for its specificity. He also found that in those few cases where specific types had been assigned to group-D streptococci, the antigen involved was the cell-wall rhamnose polysaccharide. Later, he extended his work on the nature of group antigens by demonstrating that

group N is also dependent on a teichoic acid antigen.

Elliott was for some time Assistant Director of Research in the Department of Animal Pathology at Cambridge. This brought him again to a consideration of bacterial infections of animals, with which he had had some earlier experience. A notable example of his efforts in this area is the series of studies on pig meningitis. This disease is encountered in epidemic form and has a serious economic impact as well as implications for human disease through the transfer of the infection to animal and meat handlers. Elliott found that the causative organisms were members of streptococcus group D. They had been designated as groups R, S, and T by another worker, but all strains produced the group D teichoic acid, and Elliott showed that the antigens responsible for the R, S, and T subdivision were capsular polysaccharides. He studied the chemistry, immunology, and biological significance of these polysaccharides, demonstrating that as in the case of pneumococci and many other pathogens, they were important determinants of virulence. This led to his development of an effective polysaccharide vaccine for the prevention of the pig disease.

In the years following his election as a Fellow of Corpus Christi College, Cambridge, in 1964, Elliott became a tutor for advanced students in the college and at the same time continued his research in the Department of Pathology. He found more time for undivided attention to his research interests during his intervals at Rockefeller. He enjoyed the opportunities for discussion and interaction with the members of the group there that shared his interests in streptococci, although his research at the bench was carried out in his own inimitable style and on his own time schedule. He developed a number of special skills. As an example, no one seems to have been able to match his ability to produce streptococcal proteinase in the high yields required for the chemical studies, and for many years his colleagues who were engaged in work on the enzyme depended on him for the grams of pure protein required. As a matter of fact, his letter to me in August 1985, explaining why he would be unable to make the planned trip to New York, included an apology for "letting down" his colleague who was depending on him for a fresh supply of the enzyme.

Probably only a bachelor could have had Stuart Elliott's freedom to shuttle back and forth between England and the USA with such frequency. He was not a dry, ivory-tower type of scientist, however, and he gave considerable time to his other consuming interest, music, on both sides of the Atlantic. Somehow he had found time to attend and graduate from the Royal Academy of Music during the early part of his career in medical science, and thereafter he remained a devoted amateur, both as a pianist and as a concertgoer. One can cite many examples of the depth of his commitment to music: his founding of an annual scholarship at the Royal Academy of Music; his gift to Rockefeller University in 1984 of the new edition of the *Grove Encyclopedia of Music*; and his volunteer task of cataloguing the music collection of the Cambridge library during his last years after his laboratory was closed.

Stuart Elliott was modest and self-effacing, both in his science and in his music. There was no element of self-promotion in his character, and he lived frugally while supporting generously the institutions and activities that he respected. Even his good friends were not aware of all of his benevolence. Not surprisingly, he did not receive the recognition he deserved in either field during his lifetime.

My own friendship with Stuart began during his first trip in 1944, and from 1946 on we were also co-workers in streptococcal research in the laboratory, collaborating frequently on common problems and on at least one occasion publishing together. In addition, I visited him a number of times in England, both in Cambridge and in the setting of his family, where I became acquainted also with his sister, Margaret, and his brother, Sir Norman Elliott, both of whom survive him. When I saw him last in London in July 1986 he was eager for news of the research at the Rockefeller laboratory and clearly regretted that he was no longer participating in it.

Although he was beginning to be plagued by some annoying ailments, Stuart remained active until the end and died suddenly while at dinner with a friend, on September 17, 1986. He would have hated a lingering and debilitating illness.

MACLYN McCARTY