NATIONAL ACADEMY OF SCIENCES

GEORGE STREISINGER

1927—1984

A Biographical Memoir by

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GEORGE STREISINGER WAS a leading contributor to the genetics of the T-even bacterial viruses, culminating in his demonstration and rationalization of the circular linkage map. During the infancy of molecular biology, he provided crucial links between genetics and biochemistry with his demonstration of the consequences of frameshift mutations. He identified and developed zebra fish as a system for the genetic analysis of vertebrate development.

PERSONAL HISTORY

George Streisinger was born in Budapest, Hungary, on December 27, 1927. To escape Nazi persecution, he and his parents left Budapest for New York when he was ten years old. He attended public schools, graduating from the Bronx High School of Science in 1944. During his high school days, George filled his home with salamanders, spiders, and snakes and collaborated with Theodosius Dhobzansky on studies of courtship in *Drosophila*. George's first three scientific papers (1944, 1946, 1948), two of them sole authored, resulted from that precocious enterprise.

George obtained a B.S. degree in genetics from Cornell University in 1950 and a Ph.D. in genetics from the Univer-

sity of Illinois in 1953. His postdoctoral studies were at the California Institute of Technology from 1953 to 1956.

In 1949 George married Lotte Sielman. They had two children, Lisa and Cory, born in 1955 and 1956, respectively.

George's career was influenced by Salvadore E. Luria, with whom he took his Ph.D., and, more so, by Max Delbrück and Jean Weigle, with whom he studied as a postdoctoral fellow. George influenced a number of other collaborators and friends, and it is plausible that they influenced him, too. They include Sidney Brenner, Seymour Benzer, Matt Meselson, Robert Edgar, Jan Drake, and myself.

PROFESSIONAL HISTORY

George was one of many who used the low-cost School of Agriculture at Ithaca to gain access to a high-quality Cornell University undergraduate education. As always, he put his efforts where his interests were, For instance, while at Cornell, he met and married Lotte Sielman, a refugee from Munich. Furthermore, he spent an academic year on a farm working off a provisional status earned by his neglect of required ROTC and/or physical education courses. (This requirement could have been worked off in the summer, but George spent all his summers at Cold Spring Harbor.)

Following his graduation from Cornell, George undertook graduate studies in the genetics of T-even coliphage with S. E. Luria in the Bacteriology Department of the University of Illinois. The phages T2 and T4, while distinguishable, are obviously related and had been shown by Delbrück to recombine with each other to give hybrid phages of varying degrees of viability. George identified single genes responsible for the differences between T2 and T4 in UV sensitivity (1956,1), host range, and serological specificity (1956,2), respectively. These studies revealed phenotypic

mixing, in which a phage with the host-range genotype of one phage type was found in a particle whose phenotype was that of the other (1956,2). George based his Ph.D. thesis on these experiments. When they were published in 1956, they had a profound impact on viral biology.

Upon obtaining his degree, George went off to CalTech to pioneer the study of plant somatic cell genetics. He couldn't make those studies fly, however, and while still at CalTech he returned to the genetics of phage. With Jean Weigle, he undertook further studies on T2 × T4 hybrids, which led to the discovery of DNA modification (by glucosylation).

With Naomi Franklin, George undertook a fine-structure recombination study of the host-range *(h)* locus of T2, after the fashion of Benzer's studies on the *r*II locus of T4. However, whereas, the *r*II protein escaped detection, it was probable that the protein product of the *h* gene, T2's tail fibers, would be tractable. Although the connection between gene and protein was not made, these studies foreshadowed George's later work (described below) on the T4 lysozyme gene.

With Victor Bruce (1960), George showed that the known genetic markers of T4 could be arrayed on a single linkage group. This simplification of the previously held view of three linkage groups was an essential step in the coalescence of genetics with emerging physical data on T4 DNA.

After his postdoc at CalTech, George took a position at Cold Spring Harbor. (His science knew no boundaries and his publications no timetable. Add to that the free flow of personnel and ideas among phage labs in those days, and the chronology of my recitation occasionally becomes a bit vague.)

George took leave from Cold Spring Harbor to spend a year at the MRC in Cambridge, England, with Sidney Brenner.

In collaboration with other visiting Americans, they initiated studies on T4 proteins with an eye to decoding the relationship between DNA and protein (1959). One product of that work was the identification of T4's endolysin (lysozyme) as a promising object for such studies.

At Cold Spring Harbor and the University of Oregon's Institute of Molecular Biology, where George took a position in 1960, he developed the methods for selecting mutants, revertants, and recombinants in the T4*e* gene, which encodes the phage endolysin. His first applications of this know-how was in a demonstration that phage containing 5-bromouracil have a high mutation rate when they are allowed to grow in medium that is free of 5-bromouracil. The second application was the demonstration, at the level of amino acid sequence, that frameshift mutations in the *e* gene really do shift the translation reading frame, as predicted by Francis Crick's hypothesis of a commaless triplet code (1966,1,2). The first in vivo codon assignments resulted from this work. The third application of George's mastery of the *e* gene was an analysis of the roles played by amino acid sequence in determining protein stability. In 1992, impelled by the methods of modern genetics, this work remains a major activity of several chemists and physicists at Eugene who study protein folding as well as stability.

The physical studies on phage T4 seemed to indicate that each T4 particle contained one Watson-Crick duplex DNA molecule. Contemporaneous genetic studies, however, argued that regions of heterozygosity in T4 were 4-stranded and that these regions were variable in position. This paradox was resolved by Meselson and Streisinger's suggestion that the chromosomes of T4 are circularly permuted and terminally redundant. After George moved to Eugene, he tested predictions of that notion, most notably the prediction that the unitary linkage map of T4 be circular. Since *E.*

coli was the only creature previously known to have a circular map, George's demonstration with Bob Edgar (1964) was important in establishing the concept of widespread circularity among microbes. Subsequent papers support George's notions of terminal redundancy of a permuted chromosome whose length is determined by the amount of DNA that can be fit into a phage head (1965, 1967).

Frameshift mutations are proflavin inducible, and George's interests extended to the mechanism of that mutation induction. He offered a proposal that has played a central role in our understanding of the origin of duplications and deletions (1972).

Like many phage workers, George eventually set his sights on more complex systems. Working initially without students (because it would not be fair to risk their careers), George developed the methods for the mutation and genetic analysis of zebra fish (1981;1983,1,2). It was his aim to make the fish as tractable as phage so that it could be used for a genetic analysis of the vertebrate nervous system. The degree to which he succeeded can be judged by his masterpiece on the development of the pigmented retina (1989) and by the many laboratories that are now exploiting this little Indian import to unravel other mysteries of vertebrate development. This work, better even than his work on the code, illustrates his imagination and courage. His career was reaching its zenith when he died of a heart attack during his final exam in a scuba diving class.

George's research contributions ensured his position in world science. His position in Oregon was ensured equally by his extraordinary contributions as a teacher, a politically involved citizen, a chef, and a warmly sociable friend and colleague.

As a teacher, George was unbelievably dedicated to the students. His dedication was backed by energy (he was al-

ways available), imagination (he conscripted a dance class to illustrate protein synthesis), and, of course, deep understanding. The University of Oregon recognized his teaching with a prestigious award.

George was politically active both on and off campus. He spent a major part of his first two years in Eugene organizing grass-roots resistance to the Vietnam War and legislative opposition to John Kennedy's civil defense program. He played a central role in the successful effort to restrict the use of potentially mutagenic herbicides in Douglas fir reforestation. This extracurricular activity informed his published work (1983,3). He led and won a battle to exclude secret war department research from the University of Oregon campus.

An invitation to dinner at the Streisinger home was never refused, because in the 1960s there were no restaurants in Eugene that could come close to the cuisine offered there. A barbecue was sometimes a suckling pig, at other times a giant Chinook salmon. Memorable winter meals were traditional Hungarian. Breakfast was for children. It featured crepes poured to resemble animals and served with chocolate syrup. Magic tricks sometimes followed.

When George was chairman of our Biology Department, he combatted the paperwork blues by unsuccessfully breeding pheasants (the foxes got them) and by successfully training to be a goat judge (he was in great demand at county fairs throughout the West).

George's family continues to have its impact on Eugene and Oregon. Eugene's well-known Saturday Market was founded in the early 1960s by George's wife, Lotte, a potter, who currently serves the community as an art administrator. His daughter, Lisa, founded a company in Portland that administers health care systems. Cory, his younger daugh-

ter, served as lawyer for Governor Neil Goldschmidt and is currently lawyer for the Port of Portland.

George's impact on the University of Oregon has been symbolized by the naming of a beautiful research building for cell and molecular biology. George's impact on his colleagues in the Institute of Molecular Biology has been marked by an annual lecture, quickly recognized as both a scientific and a social highlight of our community.

LOTTE STREISINGER AND AARON NOVICK made important contributions to this memorial.

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