Seymour Benzer 1921–2007

Mark A Tanouye

Seymour Benzer was 86 years old when he died on November 30 in Pasadena, California of a stroke. He was the James G. Boswell Professor of Neuroscience, Emeritus at the California Institute of Technology. Throughout a distinguished career, Seymour made key original contributions in semiconductor physics, molecular biology and neurogenetics. We are unlikely to encounter again an individual with Seymour's clarity of vision and enormous breadth and depth of scientific accomplishment.

Seymour was born in New York City on October 15, 1921 to an immigrant family from Poland. He received a BA from Brooklyn College and a PhD from Purdue University, with both degrees in physics. He joined the physics faculty at Purdue in 1947. For most of us who knew Seymour as a preeminent biologist, it is difficult to appreciate completely his stature as a semiconductor physicist. Seymour solved one of the outstanding problems of his day: how to fabricate a germanium crystal rectifier capable of withstanding high back-voltages (>100V). This was the major contribution of Karl Lark-Horovitz's semiconductor group at Purdue and was crucial to the subsequent development of the transistor by William Shockley's group at Bell Labs. Seymour held five US patents related to the germanium crystal rectifier, two of these together with Lark-Horovitz.

Seymour was inspired to change directions from physics to biology, amazingly enough, by reading *What is Life?* by Erwin Schrödinger. Seymour learned molecular biology at the Cold Spring Harbor Laboratory Phage Course, then at Caltech with Max Delbrück and at the Pasteur Institute with Andre Lwoff, Francois Jacob and Jacques Monod. Returning to Purdue, he conducted his magnificent study on fine structure mapping of the rII gene in T4 bacteriophage. He identified thousands of rII mutations and mapped them linearly to hundreds of sites within the gene. In this powerful and elegant analysis, Seymour showed unequivocally and for the first time that there are no fundamental or conceptual barriers between classical genetics and the Watson-Crick model of the DNA molecule—there are only differences in scale and resolution.

Seymour discontinued molecular biology experiments and began contemplating the genetics of behavior from watching his two daughters, Barbara and Martha: one was amazingly lively; one was amazingly calm. He took a sabbatical leave to Caltech to learn neurobiology with Roger Sperry; there, he also discovered a love for the fruitfly, *Drosophila melanogaster*, thanks to Ed Lewis. He joined the Caltech faculty in 1967. His first foray into *Drosophila* was a blockbuster, as described in his paper titled "Behavioral mutants isolated by countercurrent distribution" *(Proc. Natl. Acad. Sci. USA* **58**, 1112–1119, 1967). In this one study, Seymour mapped out an entire new field of investigation that was to become known as neurogenetics, and provided a new way of conceptualizing neurobiology and behavior. Rather than studying behavior in individual animals, Seymour introduced the concept that behavior can be studied in populations of flies, treating individual flies as 'molecules' of behavior. According to this idea, small differences in behavioral dysfunction can be discerned because of the multiplicative effect seen within the population. He also showed that single-gene mutations provide a powerful way of dissecting apart the complexities of behavior. Finally, in this study, Seymour introduced an especially simple and elegant method for examining behavioral mutants: he invented a countercurrent apparatus that separated flies on the basis of differences in phototaxis behavior.

Talented fellows and students soon joined Seymour and began extending genetic investigation to many new areas of fly neurobiology and behavior. The Benzer group was studying basic features of nervous system excitation when I joined the lab. Lily Jan and Yuh Nung Jan were examining *Shaker* potassium channel mutants, and Barry Ganetzky and Chun-Fang Wu were studying sodium channel mutants. Alberto Ferrus and I characterized the *Shaker* gene, work that would one day lead directly to molecular analysis of voltage-gated potassium channels. Elsewhere in the laboratory, the basic structure of the nervous system was being dissected using cell-cell interactions in the retina. This was work initiated by Don Ready and extended by Larry Zipursky, Tadmiri Venkatesh and Utpal Banerjee. Some of the most surprising and interesting *Drosophila* mutants affected complex behaviors. The circadian clock was altered by mutants identified by Ron Konopka. In some mutants, the internal clock runs too fast; in other mutants, the clock runs slowly or not at all. Duncan Byers, Chip Quinn, Yadin Dudai and others studied learning in flies. Flies could be taught to associate a particular odor with electric shock in a modified countercurrent apparatus. Mutants were identified that were unable to learn; other mutants were unable to remember. Fruit flies have a complex courtship ritual during mating that precedes copulation. Jeff Hall identified mutants that were unsuccessful in mating because of deficiencies in their courtship capabilities. Seymour and his colleagues identified many other interesting fly behaviors and mutants that affect them.

For many of us who knew Seymour, we would always be together in the lunchroom on the second floor of the Church building. We would gather daily for our family meal, a rather late lunch. It was in the lunchroom that Seymour would prepare his cup of tea, adding his powdered milk. It was in the lunchroom that Seymour taught us how to be scientists. He would say: "If the science is good, you know it first in your gut. Eventually, your brain will agree." He would say: "We must always be on guard, so as not to do pedestrian science." I never quite knew what pedestrian science was, but I have always been on guard. It was in the lunchroom that we first met and were enchanted by Carol Miller, the neuropathologist from the University of Southern California. This was before Seymour and Carol would begin their new life together, along with Renny and Doug and, eventually, Alex. It is the Seymour Benzer of the lunchroom who touched our lives and who will always remain in our hearts. ■

Mark A. Tanouye is in the Department of Environmental Science, Policy, and Management and the Helen Wills Neuroscience Institute, University of California, Berkeley, California 94720, USA.
e-mail: tanouye@berkeley.edu