

and a professor emeritus of medical physics (1985) at Berkeley.

Toby was a valuable member of the Donner group, which first (in 1945) began to use radioisotope tracers to study various human physiologies. Within that group, Toby led the team that administered a radioactive isotope to humans using carbon-11-labeled carbon monoxide. The ^{11}C tracer was used to investigate, among other phenomena, how pilots developed the “bends” at high altitudes. In 1945, Toby also formulated an analysis of tracer turnover in the human body, which led to methods for quantitating local blood perfusion and to the discovery in 1946 that inert xenon gas, under subatmospheric pressures, can be an effective anesthetic.

As soon as Ernest Lawrence completed the 184-inch synchrocyclotron in 1947, Toby performed the first biology experiments using protons. When the Bevatron was completed in 1954, Toby investigated human therapeutic exposure to accelerated protons, alpha particles, and deuterons. In 1958, he published in *Cancer Research* a rationale for the use of heavy charged particles for radiation therapy of human cancer. Toby's group at LBNL also made the first heavy-ion exposures of unicellular organisms (1957), laminar cerebral lesions by accelerated protons (1958), and corpus callosum cut by accelerated alpha particles in animals (1964). These data led to clinical trials at LBNL for treating arteriovenous malformation (AVM) using accelerated protons and alpha particles, a modality now used to treat AVM at several accelerator facilities.

Soon after the 1947 discovery of high-Z primary cosmic rays in high-altitude balloon flights, Toby wrote an article in 1952 in the *Journal of Aviation Medicine* on the potential hazards of these rays in spaceflight. He predicted that individual heavy ions passing through the retina might produce visual effects and that a very heavy particle could kill or modify a row of cells in its path. In 1969, Edwin Aldrin and the other Apollo-11 astronauts did observe mysterious visual stars and streaks during the first lunar mission. Toby began a series of experiments at the 184-inch synchrocyclotron, and later at the Bevalac, in which he introduced individual accelerated heavy ions to eager scientists' eyes to reproduce the peculiar flashes and streaks of light. Only Toby and a few scientists enjoyed the light show, because a human-use committee stopped the experiment.

When low-energy accelerated heavy ions became available at the SuperHILAC in 1961, Toby and coworkers began a series of heavy-ion radiobiology experiments with yeast cells and bacterial spores. These inquiries showed that the cross section for heavy-ion effects increased proportionally with the square of the linear energy transfer (LET). When dry spores were irradiated, many low-LET effects could be annealed or chemically reversed, whereas high-LET radiation appeared to produce irreversible damages. The radiobiological oxygen effect (that well-oxygenated healthy tissues are more radiosensitive than anoxic tumor cells) was eliminated when argon beams were used. Those findings provided the foundation for heavy-ion radiotherapy to treat human cancer. Toby was honored for his contributions to cellular radiation biology in 1963: He received the Ernest Orlando Lawrence Memorial Award from the US Department of Energy (DOE).

When the Bevatron and SuperHILAC were integrated to form the “Bevalac” in 1975, Toby's group became an active center of basic radiobiological research. Their investigations culminated in an intensive heavy-ion cancer treatment program in collaboration with physicians at UCSF in 1976. Toby retired from LBNL in 1987 as a faculty senior scientist.

In addition to his work at LBNL, Toby was instrumental in the development of hadron treatment facilities in many countries, including Sweden, Russia, Japan, and Germany. Toby also was a member of the radiobiology committee of the National Research Council, president of the Radiation Research Society in 1962, and founding member of the Biophysical Society.

His recent book *People and Particles* (San Francisco Press, San Francisco, 1997), which he wrote with his wife Ida Lanning Tobias, is full of anecdotes and a personal account of the historical development of LBNL and the Donner Lab. An oral history of Toby's human radiation studies can be found at the DOE Web site <http://tis.eh.doe.gov/ohre/roadmap/histories/0480/0480toc.html>.

Toby's life's work applied to many scientific disciplines, from physics to biology to medicine. The results will continue to touch the lives of the many patients who are treated at proton and heavy-ion cancer treatment centers worldwide. We will all miss Toby greatly.

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George Irving Bell

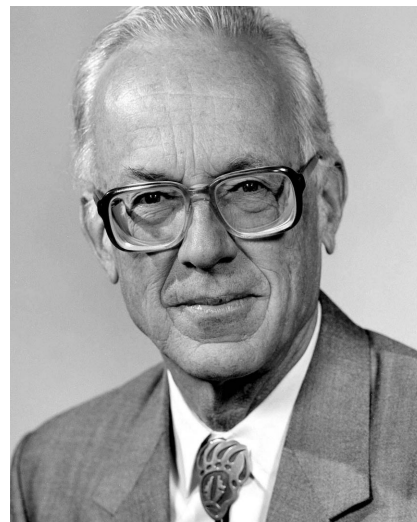
George Irving Bell, a pioneer in the applications of physics and modeling to problems in immunology and cell biology, died on 28 May 2000 in Los Alamos, New Mexico, from complications of leukemia after routine surgery.

Born on 4 August 1926 in Evanston, Illinois, Bell received his BS in physics from Harvard University in 1947 and his PhD in theoretical physics in 1951 from Cornell University. At Cornell, he worked under the supervision of Hans Bethe on the capture and loss of electrons by fission fragments.

In 1951, he joined the theoretical division of Los Alamos National Laboratory (LANL), where he spent the remainder of his scientific career as a staff member (1951–70), associate division leader (1970–76), group leader (1974–90), alternate or acting division director (1976–80), division director (1980–89), and senior fellow until his retirement.

Initially, as a member of the division's neutronics group, Bell applied neutron transport methods to nuclear reactors and nuclear weapons. He also helped with the planning and analysis of experiments on nuclear explosions; discovered the Bell-Plesset instability that occurs in imploding systems as a result of material granularity; and published, with Samuel Glasstone, the definitive text in nuclear reactor physics and safety, *Nuclear Reactor Theory* (R. E. Krieger, Huntington, N.Y., 1979).

During the 1960s, he was one of a small number of physicists who began to do theoretical work in biology. He first focused on cell biology and developed quantitative models of cell growth and division. This research rapidly led



GEORGE IRVING BELL

to an interest in immunology that would continue for more than a decade. Bell developed the first set of mathematical and computer simulation models of the then-new idea of clonal selection for which Frank Macfarlane Burnet received the Nobel Prize. Bell's work involved generating detailed models of the interaction of ligands with cell surface receptors and introducing a quantitative description of receptor cross-linking, an important process not only in immunology but in all of cell biology. This and subsequent work would create the modern field of theoretical immunology.

Early in his career, Bell recognized that the rapid developments in molecular biology would change the face of biology and medicine, creating unprecedented demands for information storage, handling, and analysis. With Bell's support and encouragement of genetic sequence analysis, Walter Goad at Los Alamos developed the first DNA sequence database. This database evolved into GenBank, the national genetic sequence database now run by the National Library of Medicine.

In the early 1970s, Bell hired Charles DeLisi to work in immunology at LANL. They published a series of papers together. DeLisi later moved to the National Institutes of Health and then to the US Department of Energy to head the Office of Health and Environmental Research; Bell had encouraged DeLisi to apply for that position. It was in that capacity, and inspired by Bell, that DeLisi formally launched the Human Genome Project, for which Bell was an early advocate. Bell served as acting director of the Los Alamos Genome Center when the center was first launched.

In 1974, Bell founded the theoretical biology and biophysics group at LANL, and led it until he retired in 1990. He first focused the group on theoretical immunology. In 1979, he formulated an influential set of physical-chemical models that described the repulsive and attractive forces between cells and how rapidly applied forces would break the chemical bonds holding cells together.

Through his work, leadership, scientific vision, and inspiration of others, Bell profoundly influenced the direction of modern biology. The atmosphere he created both as a colleague and as an administrator was important in bolstering good science in the theoretical division.

Bell was an avid mountaineer and outdoorsman. In the 1950s, he went on four expeditions to the Peruvian

Andes, where he and his team made the first ascents of Yerupajá and Salcantay, two of Peru's most difficult peaks. He joined an ill-fated expedition in 1953 that attempted to scale the then-unclimbed K2, the second highest mountain in the world. During this attempt, Bell slipped and fell, pulling his partner—with whom he was linked by a rope—along with him. Their rope entangled with that of another pair of climbers below them. All four climbers fell down the mountain, entangling the rope of the remaining climbers, one of whom miraculously tied off his rope and held the others in what has perhaps become the most famous belay in mountaineering. Despite his experience on K2, Bell remained an enthusiastic mountaineer.

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Gunter Schwuttke

Gunter Schwuttke, professor emeritus in Arizona State University's College of Engineering and Applied Sciences and founding director of Arizona State's Semiconductor Materials Research Laboratory, died on 4 November 1998 in Scottsdale, Arizona, of complications following surgery.

Gunter was born in Breslau, Germany, on 7 August 1922. He began his studies at the Technical University of Breslau, continuing his education in 1947 at the University of Munich. There, he earned his MS in physics in 1949 and his PhD in physics in 1952. Simultaneously, he held a research associate position at the Max Planck Institute of Physics.

Gunter's first research endeavor in industry was with Siemens in Munich. In 1956, he became a consultant for the US Department of Defense (DOD). A year later, he joined the Sylvania Research Laboratories (later GTE Laboratories) in Bayside, New York, where he studied defects in semiconductor crystals with an emphasis on silicon. At that time, defect densities were generally determined by counting etch pits on specially etched wafer surfaces. He extended this technique to a useful application in a crystal orienter for fast and precise alignment and cutting of crystals into wafers.

In the early 1960s, x-ray topography made it possible to examine defects in the volume of the wafer. Gunter's invention of the scanning oscillator technique and his develop-



GUNTER SCHWUTTKE

ment of precise topographic cameras set the stage for his later work. The stereo x-ray topographs he produced, for example, allowed scientists to view and study the distribution and shape of dislocations tubes throughout the thickness of the wafers.

When Gunter joined IBM in Poughkeepsie, New York, in 1963 as a senior physicist, his colleagues already regarded him among the small cadre of the foremost x-ray topography experts as well as a pre-eminent solid-state physicist. He managed various development groups concerned with semiconductor materials science and processing. This research resulted in the identification of defects generated during semiconductor processing and their elimination to improve the performance of bipolar integrated circuits (ICs) and solar cells. His contributions in this area significantly influenced progress in minimizing defects in large metal-oxide semiconductor memories and complementary metal-oxide semiconductor microprocessors that are used today in computers and other electronic systems. He made other achievements in computer-controlled growth of high-quality silicon crystals and in basic studies of defects generated by radiation damage and by ion implantation.

One of us (Huff) warmly remembers and welcomed the occasional visits of Gunter and his colleagues in the late 1960s, during which we discussed methodologies for the identification, characterization, and control of dislocations introduced during bipolar IC processing. Gunter's work relating his x-ray diagnostic studies with rapid turnaround etchant diagnostic analyses was of critical importance in the