BIOLOGICAL SYSTEMS

Glimpses of Life's Fabric

ORNL's biological research program was established to determine the nature and effects of radiation on living cells. These studies were motivated by concerns about health effects of radiation from reactors, atomic weapons testing, and radioactive elements that enter the body.

Alexander Hollaender, a world authority in radiation biology, came to Oak Ridge in 1946 to lead studies on the effects of radiation on microorganisms, fruit flies, plants, and later mice. He built a broad program that once gave ORNL the largest biological laboratory in the world. Twenty researchers who have worked in the biological sciences at ORNL have been elected to the National Academy of Sciences.

Under Hollaender, Bill and Liane Russell started a large-scale mouse-genetics project in 1947. They began to build up special mouse strains for study of the effects on offspring born to parents exposed to radiation. The mouse-genetics program eventually would accommodate a steady-state census of 250,000 mice.

The Russells also initiated a project to study radiation effects on development. In 1950, Liane Russell reported that specific types of birth defects resulted from radiation exposure during "critical periods" in embryonic development. In 1952, the Russells jointly informed the medical community that the stage of prenatal development at which radiation is introduced strongly influences the amount and type of damage to the human embryo and fetus. They made specific recommendations on avoiding risks to unsuspected human pregnancies from diagnostic X rays that were adopted worldwide.

Gene Oakberg's studies of mouse development have helped biologists worldwide interpret the genetic effects of mutagens. ORNL's radiation-mutagenesis studies had generated so many findings by 1956 that a National Academy of Sciences committee used these mouse data to formulate projections for the genetic effects of radiation in humans. National and international bodies continued to rely on ORNL data on the effects of biological and physical variables on mutation rates in recommending limits for human radiation exposures.

Also in 1956, Takashi Makinodan used high radiation doses to suppress mouse immune systems by destroying certain blood cells and then performed the world's first successful transplants of bone marrow (from rats into mice). That same year Elliott Volkin and Larry Astrachan discovered messenger RNA, which "reads" DNA's genetic code and becomes a template for mass-producing proteins. Nine years earlier, Volkin and Waldo Cohn observed that RNA (ribonucleic acid) has the same general structure as DNA (deoxyribonucleic acid), a discovery that had a fundamental impact on molecular biology, virology, and genetics.

In 1958 Bill Russell and colleagues demonstrated that spreading a given radiation dose over days or weeks produced fewer mutations in mice than administering the same amount of radiation within minutes. This provided the first evidence that DNA damage that would result in mutations can be repaired. The finding also had implications for permissible exposure levels.

In 1959 Liane Russell and colleagues found that maleness in the mouse depends on the presence of the Y chromosome and is unrelated to the number of X chromosomes. A year later she showed that only one of the two X chromosomes of a mammalian female is active.

In the mid-1960s, ORNL biologists began measuring the genetic effects of chemicals, using several methods that had been developed for research on radiation effects. The National Cancer Institute supported ORNL investigations of the complex biochemical events leading to cancer growth in mice exposed to radiation or chemicals. Arthur Upton (who later became NCI director), John Storer, and others conducted experiments to determine whether lung cancer tumors in mice form as a result of exposure to pesticides, sulfur dioxide, city smog, or cigarette smoke, both singly and together.

In 1967, Oscar Miller and Barbara Beatty placed frog eggs under a high-resolution experimental microscope built at ORNL and photographed genes in the act of making RNA. The journal *Cell Biology* named the resulting paper a landmark publication.

In 1972 ORNL's Peter Mazur and Stanley Leibo (with England's David Whittingham) froze, thawed, and implanted mouse embryos in surrogate mothers that gave birth to healthy mouse pups. The technique, featured on the cover of *Science* magazine, was adopted by the cattle industry for multiplying

1974

Herman Postma appointed ORNL director, a position he held for 14 years

Chrome-moly steel developed; used in electric utility boilers and oil refinery furnaces worldwide

1975

AEC abolished; replaced with Energy Research and Development Administration (ERDA) and Nuclear Regulatory Commission (NRC)

Computer models of ecosystems developed, making ORNL leader in systems ecology

Tough iridium alloy developed to encapsulate nuclear fuel in space probes