NUCLEAR ISOTOPES

From Swords to Plowshares

During World War II, calutrons at the Oak Ridge Y-12 Plant were used to separate electromagnetically two uranium isotopes to produce bomb-grade material for the Manhattan Project. After the war, all but one of the calutron buildings were converted to other uses. The remaining facility was transferred to ORNL for the production of many isotopes for peaceful uses.

ORNL used the calutrons to produce hundreds of stable isotopes for numerous applications; many of these enriched isotopes were the starting materials for the preparation of radioisotopes. Some calutrons also were used to produce highly enriched uranium, plutonium, americium, and curium isotopes.

Radioactive medical isotopes produced from stable calutron-enriched isotopes include palladium-103 for treating prostate cancer; thallium-201 for heart imaging; rhenium-188 for treating cancer and restenosis; gallium-67 for imaging tumors; and strontium-89 for reducing metastatic bone pain. Non-medical products include nickel-63 for electronics and explosives detection and rubidium-87 for atomic clocks for geopositioning and cellular-phone systems. Since 1998 the calutrons have been maintained in a standby mode until needed.

For 56 years ORNL has produced radioisotopes using its reactors. Biochemist Waldo Cohn applied ion-exchange methods to the separation of fission products at the Graphite Reactor and organized the production and national distribution of its radioisotopes, including the first shipment from a reactor to a hospital.

Subsequent ORNL reactors have provided radioisotopes for use in agriculture, industry, and medicine. The High Flux Isotope Reactor is the principal supplier of several radioisotopes used in cancer treatment, nondestructive testing, and explosives detection. An important radioisotope produced at HFIR is californium-252, an excellent neutron source that has been used to find tiny cracks in aircraft parts. Clinical research on more than 5500 patients shows californium-252 has been extremely effective in treating cervical tumors and cancers of the head, neck, and oral cavity.

NUCLEAR MEDICINE

Diagnosing & Treating Disease

Transforming ORNL-produced radioisotopes into agents that can help restore human health has long been the goal of nuclear medicine researchers at ORNL. Led by Russ Knapp since the mid-1970s, they have developed a radioactive imaging agent for medical scanning diagnosis of heart disease. This agent, which has been tested in more than 350,000 patient studies worldwide, is commercially produced in Japan and Russia and used on numerous heart patients. The ORNL agent is a fatty acid labeled with radioactive iodine-123. It can be used to detect how much heart muscle is alive after a heart attack and to predict whether bypass surgery or balloon angioplasty will restore full blood flow.

In 1993 the ORNL group developed the tungsten-188/rhenium-188 isotope generator, tested the radioactive agents at ORNL, and established clinical trials in the United States and abroad. The trials showed that rhenium-188 (formed from the decay of tungsten-188) can reduce cancer-induced bone and liver pain and inflammation in arthritis patients. It also can prevent the buildup of smooth muscle cells in coronary arteries (restenosis) after balloon angioplasty, reducing the need to repeat the procedure.

Because ORNL's radioisotope delivery system offers low-cost therapy, it's being used to treat restenosis and cancer-induced pain in patients in developing countries (thanks to support from the International Atomic Energy Agency) as well as nations such as Germany and the United States.

A radioisotope generator developed by ORNL's Saed Mirzadeh and colleagues is providing a successful treatment for advanced leukemia patients. ORNL has a stockpile of uranium-233. The isotope decays to form actinium-225, which is shipped in ORNL generators to research sites around the world. At Memorial Sloan-Kettering Cancer Center, patients with acute myeloid leukemia are injected with antibodies labeled with bismuth-213, obtained from the decay of actinium-225. The bismuth isotope destroys the blood cells that make these patients dangerously ill.

Russ Knapp (bottom) led the development of the rhenium-188 generator in which tungsten-188 decays to rhenium-188, used to treat restenosis in heart patients and cancer-induced pain.

1947

Mice used to study radiation's genetic effects on mammals

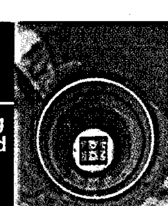
Atomic Energy Commission established

1948

Union Carbide named government contractor in Oak Ridge

Fuel elements designed for use in research reactors

Materials Testing Reactor designed at ORNL and built in Idaho



1949

Purex process developed at ORNL; became worldwide method of recovering uranium and plutonium from spent reactor fuels