Today, some of the more publicly visible of these are found in nuclear medicine. After a heart attack, for example, cardiologists need to know the location of coronary artery blockages and the extent to which heart tissues may have been damaged. A standard clinical procedure, called thallium scanning, is used to reveal such information.

The calutrons make thallium scanning possible in the following way. They produce purified quantities of thallium-203, a stable isotope which appears with thallium-205 in natural abundances of 30 and 70 percents, respectively. Thallium is of interest because it behaves chemically in the body much like the element potassium, which is essential for proper heart functioning. Pharmaceutical companies, in turn, bombard the purified thallium-203 with subatomic particles (protons) in specially designed equipment. This sets off a series of nuclear transformations. Thallium-203 is transformed momentarily into an excited and unstable form of lead-204. Through a series of almost instantaneous particle emissions (radioactivity), lead-204 becomes lead-201. Within minutes, lead-201 transforms itself into the radioisotope thallium-201, which has a useful shelf-life of several days. The prepared tracer, thallium-201, is shipped promptly to user hospitals and clinics.

There, thallium-201 is injected into the circulatory system of the patient. As a substitute for potassium, the thallium is drawn naturally to the heart. Cardiologists observe its uptake with special cameras, which detect the slight radioactivity emitted by the thallium-201. Blank or deficient images reveal blocked or damaged tissue areas.

Thallium scanning also enables cardiologists to confirm electrocardiogram tests, evaluate drug therapies aimed at dilating arteries and increasing blood flow to diseased tissues, and gauge the success of coronary bypass operations. Only minute amounts of thallium are required, which soon disappear from the body by natural decay.

Likewise, the Oak Ridge calutrons supply the basic feedstock materials for a broad range of other radiopharmaceuticals. These include zinc-68 (transformed to gallium-67) for soft tumor scanning and Hodgkin's disease, selenium-74 (to selenium-75) for pancreas scanning, strontium-84 (to strontium-85) for bone scanning, and tin-112 (to indium-113) for detection of lung cancer.

More uses include, cadmium-112 (transformed to indium-111) for detection of brain and spinal fluid leakages, tellurium-124 (to iodine-123) for thyroid scanning, mercury-196 (to mercury-197) for brain scanning, and mercury-202 (to mercury-203) for kidney scanning. Altogether, at least 36 enriched stable isotopes are used as precursors for radiopharmaceuticals for medical diagnostics and treatment.

Apart from radiopharmaceuticals, direct use of enriched stable isotopes, which require no nuclear transformations, is growing in importance. These are particularly useful in cases where radioactive isotopes cannot be used safely on certain groups of patients, such as the newborn, young children, and lactating mothers, due to the dangers of absorbed radiation.

Researchers at Washington University and the National Institutes of Health, for example, discovered the utility of calcium-46, a stable isotope, in the monitoring of the effectiveness of vitamin D-fortified milk in nurturing premature infants. Their findings provide quantitative data which can guide nutritional planning for these tiny patients.

In a similar application, millions of older people suffer from a bone-weakening condition, known as osteoporosis, where calcium loss leads to higher risks of hip fractures and broken bones. How or why calcium loss is part of the aging process remains a mystery. Scientists at the National Institutes of Health are learning more about the process, however, by charting calcium flows through the body with the aid of stable calcium isotopes.

Beyond medicine, there are numerous other uses of enriched stable isotopes. Magnesium-26 performs as a biological tracer in agricultural studies. Chlorine-37 serves as an identifier in studies of atmospheric ozone. Rubidium-87 functions as a precise standard for measuring time with atomic clocks. Cadmium-114 is used in the manufacture of commercial lasers. Ytterbium-168, a precursor of ytterbium-169, makes possible a portable source of x-rays for engineers inspecting pressure tank and pipe system welds.

In archaeology and earth sciences, the ages of materials can be determined by calculating the extent of radioactive decay found among the natural constituents of the samples. One method (rubidium-strontium) for dating rocks, for example, involves a technical procedure known as isotopic