and chemistry research and training, which are at the heart of nuclear medicine research and development."

The NAS report spells out how the isotope program is "not now meeting the needs of the research community." Public Law 101-101, the report says, "requires full-cost recovery for DOE-supplied isotopes, whether for clinical use or research [and] [t]he lack of new commercially available radiotracers over the past decade may be due in part to this legislation." In addition, the report notes, the lack of appropriate guidelines of the U.S. Food and Drug Administration for manufacturing radiopharmaceuticals hinders the development and use of new radionuclides.

The NAS report describes the research areas in need of upgrading, stressing the obvious: that there must be long-term financial commitments in order to reap the assured benefits. The report states: "There is an urgent need for the further development of highly specific technology and of targeted radiopharmaceuticals for disease diagnosis and treatment. Improvements in detector technology, image reconstruction algorithms, and advanced data processing techniques, as well as development of lower cost radionuclide production technologies (e.g., a versatile, compact, short-lived radionuclide production source), are among the research areas that should be explored for effective translation into the clinic. Such technology development frequently needs long incubation periods and cannot be carried out in standard 3- to 5-year funding cycles."

In summary, the NAS report aptly states, "We have arrived at a crossroads in nuclear medicine." The question now is whether the nuclear medicine program will take the high road to expansion, or whether it will continue to devolve, costing America both lives and money.

What Are Radioisotopes?

Radioisotopes or radionuclides are artificially produced, unstable atoms of a chemical element, which have a different number of neutrons in the nucleus, but the same number of protons and the same chemical properties. Many live for only minutes. Their existence is measured in "half-lives," how long it takes for half of the isotope to disappear.

To produce radioisotopes, a stable isotope is bombarded with fast neutrons that are produced in a nuclear reactor or a particle accelerator. The stable isotope is transmuted into an unstable isotope of the same element.

Smaller proton linear accelerators (linacs), which can be located near a medical facility are also under development, such as that of the Advanced Medical Isotope Corporation in Washington State. The fusion program of the University of Wisconsin at Madison is investigating a new method of producing isotopes in a small fusion reactor. A 1-watt fusion source has already demonstrated that it could provide very short-lived radioisotope doses for use with a PET (positron emission tomography) scanner.

From the time of the Manhattan Project, scientists had realized that nuclear fission would provide an unlimited amount of "tracer and therapeutic radioisotopes."[1] The first major use of a radioisotope was iodine-131, for diagnosis and treatment of thyroid disease. It was found that the thyroid specifically absorbs iodine.

Now, five decades later, isotope technology has developed to a high degree, defining which unique properties of radioisotopes are best at particular tasks. There are now about 200 radioisotopes in use.

Diagnostics and Treatment

Radioisotopes which emit gamma rays are used today in medical diagnostics, to provide information about how certain organs—the thyroid, bones, heart, liver, and so on—are functioning, without surgery. Radioisotopes can also be used to image the progress of certain treatments, such as shrinking tumors. The radiation does not stay in the body, and there are no side-effects.

The most frequently used radioisotope in medicine today is technetium-99m, which has a half-life of six hours. It is supplied to hospitals in a lead container of its more stable precursor, molybdenum-99, which has a half-life of 66 hours and decays to technetium-99m. The hospital extracts the technetium-99m as needed, and the container is replaced as needed.

Radioisotopes are also used in disease treatment, especially cancer, where gamma-emitting isotopes are attached to some kind of carrier, such as a monoclonal antibody, which targets particular cancer cells. The carrier delivers the radioisotope to the cancer site, where the gamma rays destroy the cancerous cells, with minimal damage to surrounding tissue.

As noted in the accompanying article, research is ongoing into the use of radioisotopes in treating AIDS and other diseases.—*Marjorie Mazel Hecht*

---

1. See "Availability of Radioactive Isotopes: Announcement from Headquarters, Manahattan Project, Washington, D.C." *Science,* June 14, 1946, Vol. 103, No. 2685.