Applications of Nuclear Radiation

Many applications are based on the fact that the physical and chemical properties of stable isotopes are essentially the same as those of radioactive isotopes of the same element. A few uses of radioactive nuclides are discussed below.

Radioactive Dating

Radioactive dating *is the process by which the approximate age of an object is determined based on the amount of certain radioactive nuclides present.* Such an estimate is based on the fact that radioactive substances decay with known half-lives. Age is estimated by measuring either the accumulation of a daughter nuclide or the disappearance of the parent nuclide.

Carbon-14 is radioactive and has a half-life of approximately 5715 years. It can be used to estimate the age of organic material up to about 50 000 years old. Nuclides with longer half-lives are used to estimate the age of older objects; methods using nuclides with long half-lives have been used to date minerals and lunar rocks more than 4 billion years old.

Radioactive Nuclides in Medicine

In medicine, radioactive nuclides, such as the artificial radioactive nuclide cobalt-60, are used to destroy certain types of cancer cells. Many radioactive nuclides are also used as **radioactive tracers,** *which are radioactive atoms that are incorporated into substances so that movement of the substances can be followed by radiation detectors.* Detection of radiation from radioactive tracers can be used to diagnose cancer and other diseases. See **Figure 13.**

Radioactive Nuclides in Agriculture

In agriculture, radioactive tracers in fertilizers are used to determine the effectiveness of the fertilizer. The amount of radioactive tracer absorbed by a plant indicates the amount of fertilizer absorbed. Nuclear radiation is also used to prolong the shelf life of food. For example, gamma rays from cobalt-60 can be used to kill bacteria and insects that spoil and infest food.

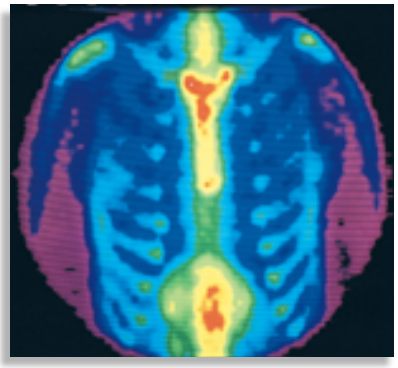

FIGURE 13 Radioactive nuclides, such as technetium-99, can be used to detect bone cancer. In this procedure, technetium-99 accumulates in areas of abnormal bone metabolism. Detection of the nuclear radiation then shows the location of bone cancer.

Nuclear Waste

Nuclear Fission and Nuclear Fusion

In nuclear fission, the nucleus of a very heavy atom, such as uranium, is split into two or more lighter nuclei. The products of the fission include the nuclei as well as the nucleons formed from the fragments' radioactive decay. Fission is the primary process powering nuclear reactors, which include those on nuclear-powered submarines and aircraft carriers. Fusion is the opposite process of fission. In fusion, very high temperatures and pressures are used to combine light atoms, such as hydrogen, to make heavier atoms, such as helium. Fusion is the primary