that the optimum gamma-ray energy for detecting brain tumors is below 200 kiloelectron volts, thus calling attention to materials such as technetium-99m. In 1963 Harper introduced a series of important compounds labeled with this nuclide. These compounds are used in medicine to diagnose disease, aid in planning treatment, monitor the response to treatment, and elucidate the cause of the disease. Technetium-99m-labeled compounds amenable to bone scanning were introduced in the early 1970s; labeled methylene disphosphonate and related compounds are now the primary agents used in bone scanning applications.

Benefits Technetium-99m currently has a broad range of diagnostic applications, as shown in Table 3. One important application of technetium-99m is its use in bone scanning to detect the presence of metastases associated with cancer of the prostate. Technetium-99m replaces isotopes of strontium that have high radiation levels, long half-lives, and poor physical properties, as well as isotopes of fluorine-18, which has high energy gamma radiation and must be produced in a cyclotron.

Table 3. Number of In Vivo Nuclear Medicine Examinations Performed by Organ System, 1982

Examination	Number of Millions
Brain	0.81
Bone	1.81
Liver	1.42
Lung	1.20
Thyroid	0.68
Kidney	0.24
Heart	0.95
Other	0.30
Total	7.41

Source: Mettler, F. A., et al., *J. Nuc. Med.* 26(2), 201-05, February 1985.

Cancer of the prostate is the most common cancer in men over the age of 50. The median age for the disease is 70. There are approximately 57,000 new cases and 25,000 deaths each year in the United States. Treatment for the disease varies with the severity and advancement of the cancer and ranges from surgical removal of the prostate (prostatectomy), or radiation therapy in less advanced or localized cases, to hormone treatment for relief from symptomatic pain in the more advanced or metastasized cases.

The use of technetium-99m bone scans enhances the diagnostic ability for early identification. Thus, costly radical prostatectomy surgery or radiation therapy can be avoided in patients with advanced cases where symptomatic relief is the appropriate treatment. Additionally, bone scans allow the physician to respond to various therapies or disease progression safely and noninvasively.

Prostatectomy has been used for decades by pioneering institutions such as the John Hopkins University Hospital as treatment for "curable" prostate cancer. Radiation therapy is an alternative treatment used by such major cancer treatment centers as Sloan Kettering Memorial Institute and is becoming more widespread.

A quantitative benefit of technetium-99m scanning was derived by computing (1) the net prostatectomy costs and (2) the net radiation therapy costs avoided. Averaging the net costs of the two treatments, assuming that one-half of the patients would have had prostatectomies and one-half would have had radiation therapy, yields an estimate of the cost benefit of about $92 million/year.

Gallium-67 for Diagnosis of Hodgkin's Disease Intraveneously administered radiopharmaceuticals containing gallium-67 emit highly penetrating gamma rays (with a half-life of 78 hours) and concentrate in tumors and abscesses. Gallium-67 was discovered at the Berkeley cyclotron in the late 1930s and was demonstrated clinically at Oak Ridge in the late 1960s. A two-dimensional image called a scintigraph is taken after 48 hours, using either a whole-body rectilinear scanner, a large-view gamma-ray camera, or a scanning gamma-ray camera. Gallium-67 scintigraphy is of great value in diagnosing cancer of the lungs and peripheral lung tumors that are not accessible by bronchoscopy. It is a valuable tool for monitoring response to chemotherapy and radiation therapy. The use of gallium-67 for localizing abscesses is increasing and may soon exceed its use for localizing tumors. Early detection of bone inflammation (osteomyelitis) by gallium-67 scintigraphy enables physicians to begin antibiotic therapy before extensive bone destruction occurs. The early use of gallium-67 in investigating "fever of unknown origin" frequently allows the physician to embark on a more fruitful, cost-effective search.

Currently, approximately one-half of all gallium-67 studies are performed for abscess localization and one-half for tumor diagnosis. In 1979 approximately 250,000 gallium-67 scans were performed in the United States at a cost of $5 million.

History The development of gallium-67 for use in detecting tumors and abscesses can be traced to the early 1950s, when H.C. Dudley at the Naval Research Laboratory (NRL) was conducting research on the toxicity of stable gallium-71. In the course of this research, it was noted that gallium-71 has an affinity for osteogenic (bone-related) activity. This led to investigation by ORNL, BNL, and NRL into applications of reactor formed gallium-72 embedded in stable gallium-71 for use in bone scanning. However, the short half-life (14 hours) and high energy of the gamma radiation (4 million electron volts) made this approach unacceptable.

In 1968 gallium-67 in gallium-71 was being evaluated as a new alternative for strontium-85 in bone scans. During this activity R. L. Hayes, C. L. Edwards, and others at the Oak Ridge Associated Universities observed that gallium-67 in its carrier-free form concentrates in tumors and