1903 Alexander Graham Bell proposed using radium to treat tumors.

1923 Hungarian chemist George de Hevesy used a natural radioisotope of lead to investigate the metabolism of lead in plants. His realization that radioactivity had no effect on the biochemical properties of the lead laid the groundwork for all subsequent biological uses of radiotracers. Hevesy would receive the Nobel Prize for Chemistry in 1943.

1929 Ernest O. Lawrence invented the cyclotron, which would become a major tool for the production of radionuclides. Lawrence would win the Nobel Prize for Physics in 1939.

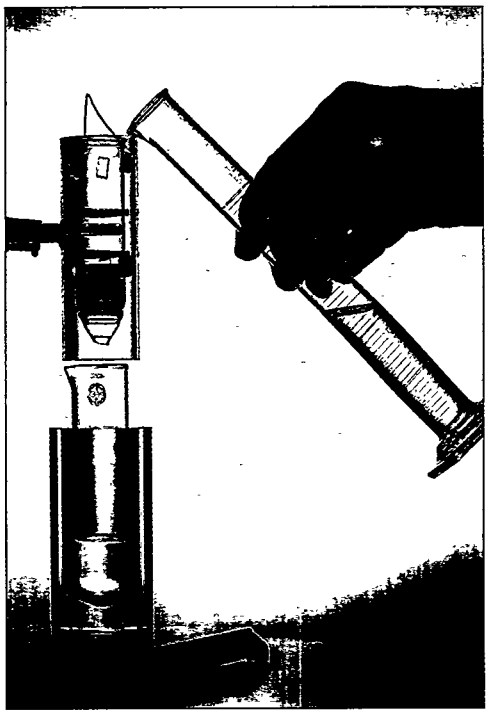
1936 At Berkeley's Radiation Laboratory, John H. Lawrence made the first clinical use of an "artificial" radionuclide, treating a leukemia patient with phosphorus-32.

KEYS TO THE PLANT KINGDOM Melvin Calvin's early use of carbon-14 tracers uncovered many of the mysteries of photosynthesis and led to the 1961 Nobel Prize for Chemistry. The central metabolic cycle by which plants transform carbon dioxide and water to sugar is now known as the Calvin cycle.

the body, but rather the details of function and dysfunction.

Even more widespread than thallium heart scans is the use of technetium-99m for diagnosing diseases of the thyroid, kidney, liver, heart, brain, and bones. About thirteen million patients per year, roughly one-quarter of all U.S. inpatients, receive technetium-99m scans as one of their diagnostic tests. As a radiotracer, its properties are nearly ideal: It exposes the patient to minimal radiation, while sending out a clear beacon to the camera. And its activity then diminishes in a matter of hours. On the other hand, owing to its short, six-hour half-life (the period during which half of the material undergoes radioactive decay), technetium-99m was long overlooked as a practical tool for widespread use; in effect, it had no "shelf life." But in the late fifties, Walter Tucker, Powell Richards, and others at Brookhaven discovered a way by which hospitals and research institutes could "milk" technetium-99m as needed from its longer-lived parent isotope. And in the years following, the next necessary step was also taken—the incorporation of the radioisotope into biologically active molecules, much of the work being done at the Argonne Cancer Research Hospital and at Brookhaven.

In medical diagnostics, radioisotopes serve as tiny sources of invisible but detectable light, revealing their presence as they accumulate in organs or tumors, or course through veins and arteries. Moreover, as long as a tracer's activity persists, its movements can be traced even as it



MILKING MOLYBDENUM Technetium-99m, a short-lived decay product of molybdenum-99 and the most widely used tracer in modern nuclear medicine, is a practical tool only because of a Brookhaven discovery in the late fifties. A chemical means, embodied in the early "generator" shown here, was found for separating the technetium from the molybdenum, thus providing hospitals a way to obtain the tracer on demand.