(CO_2), carbon monoxide (CO), the cyanide radical (CN), and others. These intermediates are then attached to the larger organic molecules, thus forming radiopharmaceuticals used as biological carriers or probes. No human biochemical system can be studied with PET without an appropriately labeled probe for that system in its normal or diseased state.

The compact cyclotron and hot atom chemistry provided the means for locally producing the positron-emitting radiopharmaceuticals. Today, these two advances are fully incorporated into modern and commercially available medical cyclotrons. More than 35 such machines are in use throughout the United States, usually associated with hospitals. They are not only reliable but simple to operate. Several private companies manufacture PET units. Although each unit costs more than a million dollars, five to ten units are sold annually, and sales are expected to increase as new uses for PET are developed.

Highly specific biological probes are needed for each situation. Building on the base of knowledge created by Basic Energy Sciences research, these are proliferating. The early success of measuring regional brain glucose metabolism, for example, was achieved with a special probe named ^{18}F-FDG (^{18}F-fluorodeoxyglucose).

Likewise, the ability to measure brain oxygen utilization and blood flow was made possible with two other probes, ^{15}0-O (oxygen) and $H_2{}^{15}O$ (water). More recent and notable innovations include the use of ^{11}C-labeled amino acids for evaluating protein synthesis or tumor metabolism, and ^{11}CDG (^{11}C-deoxyglucose) and ^{18}FDG for evaluating patients with Alzheimer's disease.

Encouraged by these successes, medical researchers worldwide are discussing applications of other new compounds. Amino acids for pancreatic and liver tumors and ^{18}F-labeled steroids for breast tumors are just two of the many new areas under study and development. At Brookhaven National Laboratory, a new method for quantifying enzymes in the brain using ^{11}C-labeled compounds is under development in order to relate the enzyme levels to diseases such as Parkinsonism.

In summary, Basic Energy Sciences research played a key role in creating the knowledge underlying these advances and facilitating their application. Less directly, but importantly, Basic Energy Sciences research also contributed by providing the seminal education, training, and experience for many of the scientists who are now actively engaged in PET-related work today.

In 1986, the National Institutes of Health recognized these contributions by conferring upon Basic Energy Sciences principal investigator, Dr. Alfred Wolf, a mechanistic organic chemist, and his colleagues at Brookhaven National Laboratory, the Javits Neuroscience Investigator Award. Also in 1986, Dr. Wolf received the prestigious George von Hevesy Memorial Medal from the Fourth World Congress of Nuclear Medicine, in acknowledgment of his "pioneering work—recognized worldwide—in the field of radiochemistry and radiopharmacy for the nuclear medicine community."

Although cures for the most serious neurological and organ disorders still remain beyond the grasp of modern medicine, positron emission tomography has opened the door to new frontiers of medical research.

RARE EARTHS

As a result of splitting large atoms into smaller ones during the process of nuclear fission, an unusual family of metals began to appear inside America's first nuclear reactors. Reactor designers needed to know what effects, if any, these metals, called rare earth elements, had on reactor performance. Their designs depended on it.

Research aimed at obtaining this knowledge required significant quantities of rare earth elements in highly purified form. Unfortunately, this was a problem. Chemically, the 15 naturally occurring rare earth elements are virtually indistinguishable from one another. As a result, they are found co-mingled in rare earth-bearing ores and are difficult to separate. In pure form they are truly rare, as their name implies.

Ultimately, Basic Energy Sciences researchers provided the key to solving this problem. They developed sophisticated rare earth separation technologies, described below, which produced the quantities required. Reactor designs proceeded and nuclear technology was advanced.

More profoundly, however, these technologies provided for the first time easy access to rare