History Before 1973 environmental research into the behavior of the transuranium elements was conducted on an ad hoc basis, usually in response to an accident, such as the loss of nuclear material in military aircraft accidents, or to "hot spots" found in the environment, such as the discovery of plutonium concentrations that exceeded fallout levels (e.g., near the Nevada Test Site). Short studies were usually undertaken to describe the distribution of plutonium and assess the health hazard at the particular site. This information provided some basis for generalized observations about environmental movement, but most of the in-depth studies were only applicable to soils of high pH.

No concerted studies had been made of transuranic element movement through aquatic food chains or the marine environment. Early studies did not address whether biological modification of the transuranium elements might increase their mobilization in the environment, with more movement to humans. To remedy these deficiencies, OHER initiated basic research activities covering all aspects of environmental transport from soil processes to ecosystem cycling.

Benefits The major benefits of the information from OHER's transuranic environmental cycling research are utilized by:

1. *Nuclear Standard-setting Agencies, both National and International.* The results of research on transuranic cycling represent virtually the sole source of such data which is vital to standards writing bodies such as the National Council on Radiation Protection for the United States, the National Radiation Protection Board for the United Kingdom, the International Atomic Energy Authority, and the International Commission on Radiation Protection.
2. *Defendants in Personal Injury Litigation.* The United States and its contractors have been, and are being, sued by plaintiffs who claim damage caused by transuranic elements and other radioactive substances to which the plaintiffs were allegedly exposed. The body of scientific knowledge on transuranic elements developed by OHER-sponsored research is being used in such litigation. The damages sought in these suits can be extremely large. In one such case, the punitive damages sought were $4 billion.
3. *Hazardous Waste Managers.* The mathematical models developed and validated for chemicals containing transuranic elements can be applied to similar materials in the environment. Specifically, the modeling of surface erosion, surface water transport, and sediment transport in the canyons near Los Alamos has helped to determine remedial actions needed to deal with other forms of contamination in Los Alamos County.
4. *Future Plutonium Facility Design and Operation.* The transuranic cycling research at the Savannah River Laboratory and the Savannah River Ecology Laboratory has verified that technology exists for containing plutonium in operating nuclear facilities. The environmental assessment methodology and data can be applied to other nuclear facilities where plutonium is of concern.

Radioisotope Tracers Radioisotope tracers can be used to follow chemical reactions in biological and biomedical research. Radioactive isotopes, such as carbon-14 and hydrogen-3 (tritium), can be used to "tag" organic molecules. Because the tracer's radiation is easily detected, its movement can be followed through the diverse processes and changes occurring in the biological or physical system containing the radioactive tracer.

The following are examples of the successful application of radioisotope tracer techniques in the study of ecosystems and biological systems. The use of radioisotope tracers in medical diagnosis and treatment is discussed in the section on "Nuclear Medicine."

Linkages in Ecological Systems Use of radioisotopes as chemical tracers for food web (lateral food chain linkages) and related studies was developed to help understand and project the fate of radionuclides released to the atmosphere in weapons tests and by nuclear production facilities. These techniques soon played a key role in ecosystem investigations. In radionuclide studies, the tracers enabled researchers to distinguish the specific chains in an ecological food web. With this information they could trace the pathways and identify the processes that concentrated radionuclides as they moved from the environment to humans. More broadly, the successful use of radiotracers in this research area encouraged environmental scientists to use radiotracers for identifying and quantifying linkages in ecological systems that previously were difficult, if not impossible, to trace, thereby opening a whole new range of understanding ecology.

History A prime concern of the AEC and public health agencies was that radioactive materials might move and localize in the environment, thereby becoming concentrated before reaching humans. Recognizing that food webs were the major unknowns in understanding and predicting the fate of radionuclides in the environment and that radiotracers offer unusual possibilities for distinguishing specific pathways (food chains) in an ecological food web, AEC initiated a broad-based research effort on radionuclides and food webs. This research led to an understanding that organisms in ecosystems form feeding relationships and that these chains are usually limited to three or four links. A radioisotope of an element may be transferred up a food chain, concentrated, or discriminated against, at various levels, as it is passed to the next level through feeding and being fed upon.

As investigations yielded quantitative data on these processes, ecologists perceived the potential