associates at Berkeley from 1945 to the late 1950's. In 1961 Dr. Calvin received the Nobel Prize in Chemistry for this work.

History Once radioisotopes from reactors became available in quantities sufficient for research in the early 1950's, AEC encouraged the use of these isotopes and sponsored a variety of research relating to problems of fundamental significance. The association with the field of photosynthesis arose because the chemistry of metallic/organic compounds had been applied to the purification of plutonium and uranium during the Manhattan Project. Chlorophyll, the key molecule in photosynthesis, is one such metallic/organic compound and had been an area of research for Dr. Calvin prior to his work on the Manhattan Project. AEC subsequently provided both funding and isotopes to him for extensive fundamental research on tracing the complex physical and chemical processes involved in, or metabolism of, photosynthesis.

Other current directions of research, based upon understanding the physics and chemistry of photosynthesis, include the development of devices to convert solar energy directly into stable chemical forms and, on a longer-term basis, to reduce carbon dioxide in the atmosphere.

Benefits The scientific benefits of this work were twofold. First, understanding of the photosynthetic process was greatly enhanced. This understanding of the detailed biochemistry of the process laid the groundwork for further developments leading to an understanding of metabolic controls in plants. Such an understanding was a prerequisite to any genetically engineered plant modifications and led to commercial applications of chemicals specifically designed to accelerate plant growth and inhibit photorespiration.

The second early benefit was the demonstration of powerful research techniques that have since found extensive use in studies of both plant and animal metabolism. These techniques include the use of radioactive carbon-14 as a tracer to provide detailed autoradiographs (pictures revealing the presence of radioactive material, the film being laid directly on the object to be tested) of the physical movement of carbon atoms through tissues or samples and the use of autoradiography combined with paper chromatography (the separation of mixtures into their constituents by preferential adsorption by a solid, as a strip of filter paper) to identify the intermediate chemical products and enzymes associated with the metabolic path.

Extensive research has continued at Berkeley and throughout the world to further define photosynthesis, not only in terms of carbon dioxide fixation, but also in terms of photochemistry, electron transport, and the metabolic mechanisms that regulate plant chemistry and structure subsequent to the formation of glucose. The development of further metabolic understanding, the codevelopment by other researchers of a spectrum of genetic engineering techniques that permits the insertion of gene fragments into single plant cells, and the ability to grow many types of plants from a single cell have made it possible to modify selectively plant characteristics.

A potential future benefit of research of this type is the transfer of the light-hydrocarbon manufacturing capability of certain tropical species into plants that could be grown in the United States. Another possibility is the genetic improvement of the efficiency of the photosynthetic process itself.

Land Reclamation The program in reclamation of surface-mined land was begun in 1975 and has demonstrated that reclamation of such land is feasible both in the arid West and in the Midwest.

History Two fundamental research efforts in soil science and plant ecology aim at understanding the processes leading to long-term changes in soils and plants. This information is needed to define whether restoration following strip mining of coal is acceptably complete. OHER research focuses on plant competition, plant response to salt and water stress, soil biochemical processes, nutrient availability, and ecological processes of long-term significance affecting plant succession on disturbed landscapes.

The following examples of research efforts show that acceptable reclamation of surface-mined land is feasible.

Demonstration field plots at the Jim Bridger Mine in western Wyoming show that areas with unstored topsoil deposited directly on graded overburden can develop a stand of naturally occurring native plants 400 percent greater than that of a similar area covered with topsoil stored for 2 years prior to reapplication. Vegetation cover on the unstored topsoil plot almost equaled that on unmined areas after 5 years. With this information, the Bridger Coal Company now reapplies fresh topsoil whenever feasible. Because of weather and other factors, however, topsoil cannot always be deposited directly on graded overburden but, instead, must be stockpiled. How long can topsoil be stored before degrading? In 1981 DOE built an experimental topsoil stockpile, planted thousands of native plant seeds of known viability, and installed tubes for sampling gas and measuring soil density. With periodic testing of the viability of the seeds in the pile, the maximum period of storage for acceptable levels of seed germination is being determined. Periodic changes in soil microbial activity are observed in soil and gas samples from the pile. Results suggest that direct reapplication will enable operators to meet the 10-year revegetation period for arid sites mandated by the Office of Surface Mining, but use of stored topsoil may not.

A second, related project is the development of "super plants" adapted to mined-land reclamation in the arid West. The hybrid native shrubs are in the genus Atriplex (saltbush and shadscale) and,