concern and on the pathways and mechanisms by which the pollutants might produce such effects.

Thus the benefits deriving from the health research will be realized in terms of reducing uncertainties regarding the nature and magnitude of adverse health effects among the public and the synfuels-industry work force. The value of this reduced uncertainty, though difficult to quantify in economic terms, can nevertheless be appreciated when one merely considers the consequences of occupational exposures to cancer-causing organic chemicals in industries that were in operation before risks were clearly understood and before hazards could be adequately mitigated. For example, workers exposed to airborne emissions in coke-oven plants have shown a greater potential to develop lung cancer than the general population.

Risk analysis is developing as one possible approach to the systematic use of information to estimate potential health and environmental consequences of man's activities. Thus risk analysis, also, has become an integral part of the program of the Office of Health and Environmental Research, and this activity has also made its contribution to knowledge of synfuels effects. As an example, it has long been recognized that a portion of the particles in the air we breathe comes from coal combustion, the use of petroleum fuels in diesel and gasoline engines, and, potentially, from synfuels processing. The risk-analysis activity made use of data on the characteristics of these particles and their dispersion and transport in air to estimate the health consequences of their uptake and retention in people. Such estimates have proved particularly useful where particles pose the principal concern, as in the exhausts of automotive diesels. A related activity studied the possible consequences of substituting coal for oil as utility fuel, and here other pollutants such as sulfates (which themselves can be particles) become dominant concerns. Eventually, what began as more limited contributions (i.e., developing methods for estimating the health effects of particles and sulfates) found application in a wide range of analyses of the risks of other pollutants, including many encountered in synfuels.

Responding to Hazardous Events Events in recent years, such as the reentry and distribution of nuclear space debris within the Earth's atmosphere and the atmospheric testing of nuclear weapons by some foreign powers, have given rise to questions regarding our ability to evaluate and to react to such possible emergencies and their consequences. Two complementary systems that provide such a capability were developed under the OHER research program and are operational today. One, the Atmospheric Release Advisory Capability (ARAC), can predict the travel and dispersion of hazardous substances released into the atmosphere, is easily activated, and can provide results to users via direct communications. Initiated in the 1960's because of concern about fallout from atmospheric nuclear-weapons testing, the system has been expanded to provide 24-hour coverage for federal and state emergency-response support in a range of such possible situations as nuclear-weapons tests and accidents, spills of hazardous chemicals, and nuclear-power-plant releases.

The second system is designed specifically for forecasting fallout from nuclear-weapons tests and to alert federal agencies having responsibilities for monitoring, for contaminant collection and analysis, and for informing the public. Forecasting the consequences of the test is accomplished by providing relevant input to ARAC (described previously).

Detection and Measurement of Human Health Effects

Program responsibilities have required support for developing instruments and techniques to detect energy-related human health effects. These developments have found specialized use in hospitals and clinical laboratories, in research laboratories, and in government and industrial applications.

Cell Sorting Two instruments of this kind in use today in hospitals and clinics are the *flow cytometer* and the *centrifugal fast analyzer*. The flow cytometer was developed in 1965 to distinguish cells damaged by radiation from normal cells. Since then, the methods used for cell sorting and their applications have continued to increase. Today the flow cytometer is used routinely for complete blood counts (its greatest single application), for detecting cancer and monitoring its treatment, and for detecting genetic abnormalities. The centrifugal fast analyzer also had its beginnings in the search for tools to measure radiation effects in humans. The analyzer, which exploits advances made in centrifuge technology in the 1960's, can handle simultaneously a large number of blood samples for automated analysis. It is used principally to run blood-chemistry tests for diagnostic purposes and accounts for about 10 percent of all such tests conducted in hospitals and commercial laboratories in the United States each year. About 10,000 units are in worldwide use.

A Fast Test for Cancer-Causing Chemicals *Short-term cell bioassays* were developed largely for research purposes. These tests are intended as quicker and cheaper screens prior to more costly animal tests in screening for cancer-producing or cell-altering characteristics. A number of tests are included within the meaning of short-term cell bioassays. One of the most widely used of these is the Ames Test developed in this program. In this test, chemicals