National Institutes of Health

Fact Sheet — *Gene Toxicity and Cancer*

Thirty Years Ago

- In 1953, the double-helix structure of DNA was discovered by Watson and Crick. Mapping the human genome was decades away, and mutation was primarily seen as an engine of evolutionary change and the possible cause of unusual diseases.
- As the field of genetics burgeoned in the 1970s and 1980s, the workings of chromosomes, their constituent genes, and DNA became a driving force in the biological sciences at large. Gradually genetics became central to biomedical research. Specific genes, called oncogenes, were associated with the occurrence of cancer.
- By the early 1970s, the connection between mutations, and the chemical and environmental agents that cause mutations, and a number of cancers emerged.

Today

- Research by NIH over the years on genetic toxicity of various classes of environmental agents established this biological effect as a major route of cancer causation. This knowledge led to some of the most effective early screening techniques for cancer causing agents, and reduction of many genotoxic chemicals in the environment, such as butadiene, benzene, and urethane.
- This research also allowed physicians and researchers to understand the importance of gene toxicity in human health and disease and led to new treatments for cancer. NIH research identified how cells protect themselves from cell death and harmful mutations after environmental exposure to genotoxic stress. For example, polluted air, wood smoke, tobacco smoke, and even barbequed food frequently expose humans to polycyclic aromatic hydrocarbons (PAHs) that form as a result of combustion of organic materials. PAHs are metabolized in the liver into molecules that react with and damage the genetic material, and lead to mutations, cell death, or other forms of toxicity.
- Extensive research on PAHs facilitated development and use of environmental protection policies and public education programs, and led to new forms of chemotherapy for cancer. Many therapeutic agents used in cancer treatment work by attacking cancer cells the same way that PAHs induce disease, by damaging the cancer cell's genetic material. Hence, the understanding of how PAHs create cancer cells aided the development of fundamental approaches in cancer chemotherapy.
- Through the NIH National Toxicology Program, genotoxicity tests are part of a standard array of studies of potentially hazardous chemicals. These tests are used widely in other governmental research and regulatory agencies and in the pharmaceutical and chemical industries to establish the risk and safety of chemicals.

Tomorrow

- Researchers are now poised to identify individual personal susceptibility and risk from exposure to PAHs and other forms of genotoxic stress based on inherited factors and co-exposures to other stressors.
- Researchers hope to harness strategic gene damage to enhance chemotherapy and discover even more precise targets for intervention.
- Researchers plan to use these discoveries in genotoxicity to identify markers of genotoxic stress that place individuals at greater risk of developing cancer, so that individuals can avoid specific exposures or take other remedial steps to prevent the development of the disease.