

UNDERSTANDING CANCER: TEACHING MODULES FOR HIGH SCHOOL STUDENTS

The first objective is to introduce students to major concepts related to the development and impact of cancer. Today we have a picture of cancer that, while still incomplete, is remarkably coherent and precise. Cancer develops when mutations occur in genes that normally operate to control cell division. These mutations prompt the cell to divide inappropriately. Cancer-causing mutations can be induced by a wide variety of environmental agents and even several known viruses. Such mutations also can be inherited—thus, the observation that some families have a higher risk for developing cancer than others. We still have much to learn about cancer, to be sure, but the clarity and detail of our understanding today speak powerfully of the enormous gains scientists have made in just the last 30 years. One objective of this module is to help students catch a bit of the excitement of these gains.

A second objective is to convey to students the relationship between basic biomedical research and the improvement of personal and public health. Cancer-related research has yielded many benefits for humankind. Most directly, it has guided the development of public health policies and medical interventions that today are helping us prevent, treat, and often even cure cancer. A dramatic illustration of the success that scientists and health care specialists are having in the war against cancer came in the 1998 announcement by the National Cancer Institute, the American Cancer Society, and the Centers for Disease Control and Prevention that cancer incidence and death rates for all cancers combined and for most of the top 10 sites declined between 1990 and 1995, reversing an almost 20-year trend of increasing cancer cases and death rates in the United States.

Research is also pointing the way to new therapies, therapies that scientists hope will combat the disease without as many of the devastating side effects of current treatments. For example, the development of drugs that target the genes, proteins, and pathways unique to cancer cells represents a radical leap forward in cancer treatment. Although most of these drugs are only beginning to be tested, preliminary results offer reason for enthusiasm about the prospects of controlling cancer at its molecular level.

And cancer research has yielded other benefits as well. In particular, it has vastly improved our understanding of many of the body's most critical cellular and molecular processes. The need to understand cancer has spurred research into the normal cell cycle, mutation, DNA repair, growth factors, cell signaling, and cell aging and death. Research also has led to an improved understanding of cell adhesion and anchorage, the "address" system that keeps normal cells from establishing themselves in inappropriate parts of the body, angiogenesis (the formation of blood vessels), and the role of the immune system in protecting the body from harm from within as well as without.

This module addresses our progress in understanding the cellular and molecular basis of cancer and considers the impact of what we have learned for individuals and society. There are many concepts we could have addressed, but we have chosen, with the help of a wide variety of experts in this field, a relatively small number for exploration by your students. Those concepts follow.

- Cancer is a group of more than 100 diseases that develop across time. Cancer can develop in virtually any of the body's tissues, and both hereditary and environmental factors contribute to its development.
- The growth and differentiation of cells in the body normally are precisely regulated; this regulation is fundamental to the orderly process of development that we observe across the life spans of multicellular organisms. Cancer develops due to the loss of growth control in cells. Loss of control occurs as a result of mutations in genes that are involved in cell cycle control.
- No single event is enough to turn a cell into a cancerous cell. Instead, it seems that the accumulation of damage to a number of genes ("multiple hits") across time leads to cancer.
- Scientists use systematic and rigorous criteria to evaluate claims about factors associated with cancer. Consumers can evaluate such claims by applying criteria related to the source, certainty, and reasonableness of the supporting information.
- We can use our understanding of the science of cancer to improve personal and public health. Translating our understanding of science into public policy can raise a variety of issues, such as the degree to which society should govern the health practices of

individuals. Such issues often involve a tension between the values of preserving personal and public health and preserving individual freedom and autonomy.

As an excellent parallel to this module, teaching plans and material also are available through the National Institutes of Health at the following web address:

http://science.education.nih.gov/supplements/nih1/cancer/guide/guide_toc.htm