Agency for Toxic Substances and Disease Registry
Cancer and the Environment - *What You Need to Know. What You Can Do*

Course: **WB1725**
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Cover Page

Key Concepts	• At least two-thirds of all cancers are caused by environmental factors. • One-third of all cancer deaths in the United States could be prevented by eliminating the use of tobacco products. • After tobacco, overweight or obese appears to be one of the most important modifiable causes of cancer. • Excessive alcohol consumption, poor diet, and physical inactivity are also factors that contribute to cancer. • Precautions can be taken in the home and workplace to reduce other harmful, possibly cancer-causing exposures.
Introduction	This training addresses concerns about the connection between ***cancer*** and exposure to toxic substances in the environment. It contains information about which types of substances are known either to cause or likely to cause cancer, and what can be done to reduce exposures to them. It also explains how scientists discover which substances are likely to cause cancer. Although toxic substances may cause other health effects, cancer is the focus of this training. At the end of this training, you will find information about the federal government agencies responsible for reducing exposures to harmful substances and where to go for more information. These agencies develop policies to limit our exposure to agents that can be hazardous to our health such as **lead** in gasoline and paint, ***asbestos*** in building insulation, ***bacteria*** in our water supplies, air pollutants, and ***pesticides***. Some harmful exposures, however, result from personal choices or lifestyles. The good news is that a large number of cancers can be prevented. It is estimated that as many as two-thirds of all cancer cases are linked to environmental causes. This number may even be higher. Many of these are linked to lifestyle factors that can be modified. For example, • We know that one-third of all the cancer deaths in this country could be prevented by eliminating the use of tobacco products. • In addition, about 25 to 30 percent of the cases of several major cancers are associated with obesity and physical inactivity.

Prologue

This training was created by scientists at the **National Cancer Institute** (NCI) and the **National Institute of Environmental Health Sciences** (NIEHS) in response to many public requests for information. The content has been guided by responses from a series of ***focus groups*** that were conducted prior to producing the booklet. People from local communities throughout the country participated in these groups.

NCI and NIEHS are 2 of the 27 institutes/centers that make up the **National Institutes of Health** (NIH), an agency of the Federal Government's **Department of Health and Human Services** supported by your tax dollars. NIH is the major supporter of medical research in universities and academic centers throughout the country. To date, 102 Nobel Prize winners have been supported by funds from NIH, more than any other scientific institution in the world. For details, go to the NIH Web site at **www.nih.gov**.

NCI was established by Congress in 1937 as the Federal Government's principal agency for ***cancer*** research and training. Research projects include a broad range of topics:

- The cellular events in the development of cancer;
- The role of infectious agents or other agents in the environment or workplace;
- The role of genetic and hormonal factors;
- The interactions between environmental agents and genetic factors in the development of cancer;
- Improved imaging techniques and biomarkers in the blood or urine for the early detection of cancer; and
- The role of diet and other chemicals in preventing cancer.

Additional activities include

- Tracking cancer trends,
- Coordinating studies to test new drugs, and
- Supporting new drug and vaccine development.

Since the passage of the National Cancer Act in 1971, which broadened NCI's responsibilities, the institute has built an extensive network that includes

- Regional and community cancer centers,
- Specialized cancer physicians, and
- Cooperative groups of researchers throughout the country and abroad to test new prevention and treatment agents.

NCI's mission also includes

- The collection and dissemination of health information,
- Programs to promote the incorporation of state-of-the-art cancer treatments into care of cancer patients, and

- The continuing care of cancer patients and their families.

For more information, go to NCI's Web site at **www.cancer.gov**.

NIEHS was established by Congress in 1966 to reduce human illness caused by hazardous substances in the environment. The **National Toxicology Program**, which is headquartered at NIEHS,

- Helps coordinate toxicology studies among Federal agencies and
- Identifies substances that might cause cancer.

NIEHS conducts and supports

- Extensive biomedical research,
- Disease prevention, and
- Intervention programs,

as well as

- Training, education, and
- Community outreach efforts.

NIEHS is a leader in understanding the effect of environmental pollution on

- Birth and developmental defects,
- Sterility,
- Alzheimer's and other brain and nerve disorders,
- Pulmonary diseases,
- Poverty and health, and
- Cancer.

For more information, go to the NIEHS Web site at **www.niehs.nih.gov**.

The authors dedicate this publication to Dr. Susan Sieber Fabro (1942-2002), a scientist at NCI, who provided the leadership to make the booklet a reality.

Adaptation for Continuing Education

The Agency for Toxic Substances and Disease Registry (ATSDR) acknowledges the work that the writers, editors, and reviewers have provided to produce this educational resource.

ATSDR

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How to Use This Course

Course: **WB1725**
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Introduction	*Cancer and the Environment What You Need to Know. What You Can Do* addresses the relationship between cancer and exposure to toxic substances in the environment. It contains information about which types of substances are known either to cause or likely to cause cancer, and what can be done to reduce exposures to them. It also explains how scientists discover which substances are likely to cause cancer. The good news is that a large number of cancers can be prevented. It is estimated that as many as two-thirds of all cancer cases are linked to environmental causes.
Available Versions	Two versions of the continuing education course "*Cancer and the Environment What You Need to Know. What You Can Do*" are available. • The HTML version www.atsdr.cdc.gov/risk/cancer/ provides content through the Internet, and offers interactive exercises and prescriptive feedback to the user. • The downloadable PDF version provides content in an electronic, printable format, especially for those who may lack adequate Internet service. You can also download the original NCI and NIEHS version. This document comes with a tutorial in the form of a *PowerPoint* presentation.
Instructions	To make the most effective use of this course: • Take the Initial Check to assess your current knowledge about the role of the environment on cancer. • Read the title, learning objectives, text, and key points in each section. • Complete the progress check exercises at the end of each section and check your answers. • Complete and submit your assessment and posttest response online if you wish to obtain continuing education credit. Continuing education certificates can be printed immediately upon completion.

Instructional Format	This course is designed to help you learn efficiently. Topics are clearly labeled so that you can skip sections or quickly scan familiar content. The format will also allow you to use this training material as a handy reference. To help you identify and absorb important content quickly, each section is structured as follows.

Section Element	Purpose
Title	Serves as a "focus question" that you should be able to answer after completing the section
Learning Objectives	Describes specific content addressed in each section and focuses your attention on important points
Text	Provides the information you need to answer the focus question(s) and achieve the learning objectives
Key Points	Highlights important issues and helps you review
Progress Check	Enables you to test yourself to determine whether you have mastered the learning objectives
Answers	Provide feedback to ensure you understand the content and can locate information in the text.

Learning Objectives	Upon completion of "*Cancer and the Environment: What You Need to Know. What You Can Do*", you will know the content of the Objectives, below.

Content Area	Objectives
What causes cancer?	• Describe factors, both inside and outside the body, that contribute to the development of cancer.
The nature of cancer	• Describe how cancer starts. • Describe types of tumors.
What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?	• Identify substances in the environment known to cause or likely to cause cancer in humans. • Identify where substances known to cause or likely to cause cancer in humans, are found.
What are some ways to reduce the risk of developing cancer?	• Describe some ways to reduce the risk of developing cancer.
What are some ways to detect cancer at an early stage?	• Explain some ways to detect cancer at an early stage.
How do scientists identify cancer-causing substances?	• Explain how scientists identify cancer-causing substances.
How do scientists decide which substances to test in animals, human	• Explain how scientists decide which substances to test in

laboratory cells, or human population studies?	○ Animals, ○ Human laboratory cells, or ○ Human population studies.
What factors do scientists consider in determining the risk associated with different cancer-causing substances?	• Identify the factors scientists consider in determining the risk associated with different cancer-causing substances.
How do public health officials set acceptable exposure levels for environmental chemicals?	1. Explain how public health officials set acceptable exposure levels for environmental chemicals.
How have cancer trends changed over the past few years?	• Describe changes in trends during the past few years of ○ Cancer incidence and ○ Mortality.

Initial Check

Instructions	This Initial Check will help you assess your current knowledge about cancer and the environment. To take the Initial Check, answer the questions that follow.
Initial Check Questions ***Choose the best answer.***	1. Which of the following statements concerning the development of cancer is **INCORRECT**? A. Cancer develops over several years and has many causes. B. Exposure to a wide variety of natural and manufactured substances in the environment accounts for at least two-thirds of all the cases of cancer in the United States. C. Cancer rates DO NOT change when groups of people move from one country to another. D. Different environmental exposures are linked to specific kinds of cancer. *To review relevant content, see "Introduction" and "Environmental Factors" under the "What causes cancer?" section.* 2. Which of the following statements concerning factors inside the body that make some people more likely to develop cancer than others is **INCORRECT**? A. Certain factors inside the body make some people more likely to develop cancer than others. B. One of the ways scientists know that genes play an important role in the development of cancer is from studying certain rare families where family members over several generations develop similar cancers. C. Gene alterations may also contribute to individual differences in susceptibility to environmental carcinogens. D. Exposure to cancer-causing substances ALONE determines who will get cancer. *To review relevant content, see "Factors inside the Body" under the "What causes cancer?" section.* 3. Which of the following statements concerning the interaction of environmental factors and genes in the development of cancer is **INCORRECT**? A. Mechanisms to repair damage to our genes and healthy lifestyle choices help to protect us from harmful exposures. B. The chance that a person will develop cancer in response to a particular environmental agent depends on length of exposure, alone. C. Because of the complex interplay of many factors, it is not possible to predict whether a specific environmental exposure will cause a particular person to develop cancer. D. Particular patterns of gene alterations and environmental exposures make people more susceptible or more resistant

to cancer.

To review relevant content, see "Interaction of Environmental Factors and Genes" under the "What causes cancer?" section.

4. Which of the following statements concerning the development of cancer is **INCORRECT**?
    A. When cancer develops, cells continue to divide even when new cells are not needed, and that growth or extra mass of cells called a tumor.
    B. It takes many years for the development of a tumor and even more years until detection of a tumor and its spread to other parts of the body.
    C. NOT MUCH EVIDENCE is available to suggest that permanent changes in our genes are responsible for tumor development.
    D. One explanation for the fact that cancer occurs more frequently in older people may be that, for a tumor to develop, a cell must acquire several gene alterations that accumulate as we age.

    To review relevant content, see "Introduction" under the "The Nature of Cancer" section.

5. Which of the following statements concerning the different types of tumors **INCORRECT**?
    A. Benign tumors are not cancerous.
    B. Benign tumors spread to other parts of the body.
    C. A malignant tumor can metastasize and spread to nearby parts of the body and eventually to sites far away from the original tumor.
    D. Most cancers are named for the organ or type of cell in which they begin to grow.

    To review relevant content, see "Types of Tumors" under the "The Nature of Cancer" section.

6. Which of the following statements concerning different types of cancers is **INCORRECT**?
    A. Melanoma is a cancer of cells in the skin, eyes, and some other tissues, known as melanocytes.
    B. Leukemias are cancers of the blood cells.
    C. Lymphomas are cancers that develop in the lymphatic system.
    D. Carcinomas are cancers that develop in the connective tissue of certain organs, such as the lung, liver, skin, or breast.

    To review relevant content, see "Types of Tumors" under

the "The Nature of Cancer" section.

7. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?
    A. Exposure to carcinogens in tobacco products accounts for about one-third of all cancer deaths in the United States each year.
    B. Several studies show that heavy consumption of red and preserved meats, salt-preserved foods, and salt probably increase the risk of colorectal and stomach cancers.
    C. Being overweight or obese appears to be one of the most important, modifiable causes of cancer, after tobacco.
    D. Heavy drinkers (more than two drinks/day) have a lesser risk of cancer, particularly among those who also smoke.

    To review relevant content, see "Tobacco", "Diet, Weight, Physical Inactivity" and "Alcoholic Drinks" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

8. Which of the following statements concerning substances that are either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?
    A. Of the nearly 900 active ingredients in registered pesticides in the United States, most have been found to be carcinogenic in animals, although not all have been tested.
    B. Some drugs used to treat cancer have been shown to increase the occurrence of second cancers.
    C. Several solvents used in paint thinners, paint and grease removers, and in the dry cleaning industry are known or suspected in animal studies of causing cancer.
    D. Infectious agents such as viruses and bacteria contribute to the development of several types of cancer.

    To review relevant content, see "Viruses and Bacteria', "Pesticides", "Solvents", and "Medical Drugs" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

9. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?
    A. Radiation from cosmic rays may account for a very small percentage (about 1 percent) of our total cancer risk.
    B. It is estimated that about 20,000 lung cancer deaths every year are caused by radon exposure in homes.
    C. People exposed to radioactive fallout in the form of Iodine-131 may have an increased risk of thyroid disease, including thyroid cancer.

D. Most studies on the long-term effects of exposure to radiation (for example, X-Rays) used to diagnose or screen for cancers or other diseases have shown an elevated cancer risk.

To review relevant content, see "Ionizing Radiation" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

10. Which of the following statements concerning fibers, fine particles, and dust is **INCORRECT**?
    A. Asbestos fibers and all commercial forms of asbestos are human carcinogens.
    B. Asbestos exposures account for the largest percentage of occupational cancer, with the highest risks among workers who smoke.
    C. Increased rates of mesothelioma—a rare cancer of the lining of the lung and abdominal cavity—and cancer of the lung have been consistently observed in a variety of occupations involving asbestos exposure.
    D. Ceramic fibers are now used as insulation materials and are a replacement for asbestos. These fibers are not carcinogenic.

    To review relevant content, see "Fibers, Fine Particles and Dust" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

11. Which of the following statements concerning dioxins is **INCORRECT**?
    A. Dioxins are chemical products synthesized for commercial purposes.
    B. Dioxins are widespread environmental contaminants.
    C. The general population is exposed to low levels of TCDD primarily from eating dairy products, fish, and meat, including poultry.
    D. Modifications of industrial processes such as bleaching and incineration have resulted in reduced dioxin emissions and have lowered dioxin levels in people.

    To review relevant content, see "Dioxins" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

12. Which of the following statements concerning vinyl chloride is **INCORRECT**?
    A. Vinyl chloride, a colorless gas, is a human carcinogen associated with lung cancers and angiosarcomas (blood vessel tumors) of the liver and brain.

B. The major source of releases of vinyl chloride into the environment is believed to be from the plastics industries.
C. People living near a plastics plant are exposed to possible carcinogens by breathing contaminated air.
D. The general population away from the plant also shows levels of exposure.

To review relevant content, see "Vinyl Chloride" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

13. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?
    A. At least two-thirds of the cases of cancer are caused by environmental factors.
    B. One-third of all the cancer deaths in this country could be prevented by eliminating the use of tobacco products.
    C. After tobacco, exposure in the home and workplace appears to be the most important preventable cause of cancer.
    D. Precautions can be taken in the home and workplace to reduce exposure to other harmful exposures.

    To review relevant content, see "Introduction" under the "What are some ways to reduce the risk of developing cancer?" section.

14. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?
    A. The use of tobacco products is linked to many cancers.
    B. Obesity is strongly linked to breast cancer in older women and cancers of the endometrium, kidney, colon, and esophagus.
    C. Inherited traits from parents are the chief causes of obesity.
    D. Large amounts of red and preserved meats, salt, and salt-preserved foods may increase the risk of colorectal and stomach cancers.

    To review relevant content, see "Risk Reduction" under the "What are some ways to reduce the risk of developing cancer?" section.

15. Which of the following statements concerning reducing the risk of developing cancer associated with viral or bacterial infections is **INCORRECT**?
    A. HIV, HPV, hepatitis B, or hepatitis C viral infections increase the risk of developing certain cancers.
    B. The use of recreational injection drugs such as heroin or cocaine may result in HIV, hepatitis B, or hepatitis C infection.

C. Unprotected or otherwise unsafe sexual intercourse may result in HIV, HPV, hepatitis B, or hepatitis C infection.
D. Vaccines can prevent HIV, HPV, hepatitis B, or hepatitis C infections.

To review relevant content, see "Risk Reduction" under the What are some ways to reduce the risk of developing cancer?" section.

16. Which of the following statements concerning detecting cancers at an early stage is **INCORRECT**?
    A. Men and women (as applicable) should get regular screening tests for breast, cervix, colon and rectum cancers.
    B. Changes in bowel or bladder habits, indigestion or difficulty swallowing and unexplained changes in weight are sure signs of cancer.
    C. You should tell your health care provider about the chemicals you use at work or at home.
    D. You should ask your health care provider if increased cancer risks are associated with your family's or your personal medical history or medical drugs you are taking.

    To review relevant content, see "Detecting Cancers at an Early Stage" under the "What are some ways to detect cancer at an early stage?" section.

17. Which of the following statements concerning detecting cancer at an early stage is **INCORRECT**?
    A. A mammogram is the best method of finding breast cancer before symptoms appear.
    B. The Pap test or Pap smear is the most successful tool to screen for cancer of the cervix.
    C. A fecal occult blood test, a sigmoidoscopy, or a colonoscopy are screening tests used to find colon and rectal cancer.
    D. With a fecal occult blood test, a sigmoidoscopy or a colonoscopy, abnormal tissue can be removed and examined under a microscope.

    To review relevant content, see "Detecting Cancers at an Early Stage" under the "What are some ways to detect cancer at an early stage?" section.

18. Which of the following statements concerning challenges for scientists in identifying substances that cause cancer is **INCORRECT**?
    A. Americans commonly use more than 100,000 different chemicals.
    B. During the synthesis or combustion of other chemicals, cancer-causing substances are sometimes created.
    C. All cancer-causing substances are manufactured as

opposed to natural.

D. Every year, manufacturers introduce another 1,000 or so new chemicals.

To review relevant content, see "Introduction" under the "How do scientists identify cancer-causing substances?" section.

19. Which of the following statements concerning sources of evidence for identifying cancer-causing substances is **INCORRECT**?
    A. Evidence for identifying cancer-causing substances is derived IN PART from human studies.
    B. Evidence for identifying cancer-causing substances is derived IN PART from animal studies.
    C. Evidence for identifying cancer-causing substances is derived IN PART from laboratory experiments with human cells.
    D. Evidence for identifying cancer-causing substances is derived IN PART from theoretical chemical computational calculations.

    To review relevant content, see "Introduction" under the "How do scientists identify cancer-causing substances?" section.

20. Which of the following statements concerning the role animal studies play in identifying causes of cancer in humans is **INCORRECT**?
    A. Nearly all of the approximately 200 agents known to cause cancer in humans have also been shown to cause cancer in rats or mice.
    B. We do not know how many of the several hundred other chemicals that cause cancer in animals are also human carcinogens.
    C. Public health officials do not have to heed the warnings provided by animal tests.
    D. Positive tests in animals are often used as a basis for reducing or eliminating human exposure to probable cancer-causing agents.

    To review relevant content, see "How well do animal tests predict whether a substance can cause cancer in humans?" under the "How do scientists identify cancer-causing substances?" section.

21. Which of the following statements concerning dosage levels given to animals in testing possible cancer-causing substances is **INCORRECT**?
    A. Mice or rats are given dosages much higher than those to which humans normally would be exposed.
    B. Large numbers of people are exposed to low doses of chemicals, but the total effect may not be small at all.

C. Using high dosages, any potential cancer-causing effects are more likely to be detected—even in small groups of rodents.
D. We have greater assurance that the chemical will not cause cancer in people when LOW doses do not cause cancer in animals.

To review relevant content, see "We often read about mice or rats being given dosages much higher than those to which humans normally would be exposed. Are high doses really used and, if so, why?" under the "How do scientists identify cancer-causing substances?" section.

22. Which of the following statements concerning use of human cells grown in the laboratory in testing for cancer is **INCORRECT**?
    A. Experiments with human cells grown in the laboratory are not useful when evaluating whether to perform studies in rats and mice.
    B. For epidemiologists, results from experiments with human cells grown in the laboratory provide clues regarding hypotheses to test in human population studies.
    C. Although in toxicology research experiments with human cells grown in the laboratory might reduce reliance on animal testing, rodent testing of potential carcinogens remains an important part of cancer prevention strategies.
    D. The combination of human studies, animal studies, and laboratory experiments provide scientists with the most complete understanding of the chemical risks of cancer.

    To review relevant content, see "Experiments with Human Cells Grown in the Laboratory" under the "How do scientists identify cancer-causing substances?" section.

23. In deciding which substances should be selected for testing in animals or with human cells, scientists **DO NOT** use
    A. Chemicals that affect a large number of persons or chemicals for which exposure levels have been unusually high.
    B. Chemicals that in laboratory cells cause human DNA alterations.
    C. Reports that people exposed to a particular chemical in the workplace develop certain cancers at rates similar to the general population.
    D. Chemicals that concerned citizens groups first brought to the attention of public health officials.

    To review relevant content, see "Strategies for Testing in Animals or Human Laboratory Cells" under the "How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?" section.

24. Which of the following factors **ARE NOT TAKEN INTO CONSIDERATION** by epidemiologists when beginning large population studies?
    A. Data from animal studies suggesting a cancer-exposure link.
    B. Cancer trends or rates that do not change over time or with location.
    C. Changes in cancer rates within a population after that population has migrated to new area.
    D. Pockets of cancers that cluster in a particular town or place or that are the subjects of unusual case reports.

    To review relevant content, see "Strategies for Carrying out Large Population Studies" under the "How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?" section.

25. Public health agencies classify substances as known or suspected human carcinogens based on evidence of cancer from at least one type of exposure, **EXCEPT FOR**
    A. Either high short- or long-term workplace exposures.
    B. Continuous low-level exposure or occasional exposure to carcinogens in the environment.
    C. Continuous low-level exposure or occasional exposure to carcinogens in the workplace.
    D. Single, acute exposures following industrial accidents or similar incidents.

    To review relevant content, see "Type of Exposure" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

26. Which of the following statements concerning acceptable risk levels by regulatory agencies is **INCORRECT**?
    A. Acceptable risks are generally LOWER for exposure in the workplace than for exposure in the general environment.
    B. Acceptable risks are generally HIGHER for exposure in the workplace than for exposure in the general environment.
    C. The range of the risk level considered acceptable by regulatory agencies for a linear dose response starts at one cancer in every million persons exposed.
    D. The risk level range considered acceptable by regulatory agencies for a linear dose response ends at one cancer in every 1,000 persons exposed.

    To review relevant content, see "Acceptable Risk Levels" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

27. Which of the following statements concerning dose-response

levels and risk of cancer is **INCORRECT**?

A. In a linear dose response, the risk decreases as the exposure decreases—all the way to zero.
B. In a linear dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
C. In a threshold-dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
D. A threshold dose response may include an exposure level below which an increase in risk is not detectable.

To review relevant content, see "Dose Response" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

28. Which of the following statements concerning the setting of acceptable exposure levels for environmental chemicals is **INCORRECT**?

A. One of the first considerations by regulatory agencies is to determine whether a carcinogen exhibits linear or threshold-like dose-response behavior.
B. Absent compelling evidence for a linear response, agencies assume that to protect public health, the dose response is threshold-like.
C. Absent compelling evidence for a threshold-like mechanism, to protect the public health agencies assume that the dose response is linear.
D. Absent compelling evidence to the contrary, agencies assume that any exposure—no matter how small—has some risk.

To review relevant content, see "Linear Dose Response" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

29. Which of the following statements concerning threshold-like dose responses is **INCORRECT**?

A. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are EQUALLY AS SENSITIVE AS are rats or mice to a particular chemical's cancer-causing effects.
B. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are MORE SENSITIVE THAN are rats or mice to a particular chemical's cancer-causing effects.
C. If carcinogens exhibit threshold-like dose responses, the potentially greater health effects on children of pesticide residues in food are taken into consideration when setting

acceptable pesticide exposure levels.

D. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, acceptable levels of exposure are set as much as 1,000 times below the level that causes a substantial increase in cancer in rodents.

To review relevant content, see "Threshold-Like Dose Response" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

30. Which of the following statements about risk versus benefit when regulating environmental chemical exposure is **INCORRECT**?
    A. Many substances that may cause cancer in people also have some benefits.
    B. Tamoxifen, effective in preventing the recurrence of breast cancer in many women, also increases the risk of uterine cancer, blood clots, and strokes.
    C. The serious risks associated with tamoxifen for women who have had breast cancer or for a relatively small number of women who are at high risk of developing breast cancer strongly outweigh the drug's benefits.
    D. Tamoxifen benefits strongly outweigh its serious risks for women who have had breast cancer or for the relatively small number of women who are at high risk of developing breast cancer.

    To review relevant content, see "Risks versus Benefits" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

31. Which of the following statements concerning interpreting incidence rates of cancer is **INCORRECT**?
    A. An increase in new cancer cases may result from exposure to a harmful substance in the environment.
    B. An increase in new cancer cases may reflect certain changes in clinical practice in hospitals or doctors' offices resulting in detection of more cases.
    C. A decrease in cancer incidence may be due to a decreased exposure to harmful substances.
    D. A decrease in cancer incidence may be due to late detection and nonremoval of precancerous growths.

    To review relevant content, see "Introduction" under the "How have cancer trends changed over the past few years?" section.

32. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?
    A. The incidence and mortality rates have been declining for testicular, childhood, cervical, stomach, throat and cancers,

and cancers of the mouth (lip, tongue, gums).

B. The incidence and mortality rates are not improving for breast, lung (in females), bladder, prostate, kidney, liver, esophagus, and brain, non-Hodgkin's lymphoma and melanomas of the skin.
C. The larger percentage increase in lung cancer incidence for women compared with men reflects the fact that women smoke more than do men.
D. Improvements in treatment are thought to account for the reduction in childhood cancer deaths, while increased screening (i.e., Pap smears) accounts for the decrease in cervical cancer rates.

To review relevant content, see "Changing Rates for Specific Cancers" under the "How have cancer trends changed over the past few years?" section.

33. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?
    A. The incidence rates of liver, thyroid, and melanoma cancers had the greatest percentage decrease between the years 1992 and 2000.
    B. The death rates for liver cancer, lung cancer in women, and esophageal cancers showed the largest increase between the years 1992 and 2000.
    C. The yearly rate of new cancer cases increased between 1975 and 1992. Some evidence shows a decline after 1992 followed by stable rates since 1995.
    D. For cancer deaths, the rates increased steadily from 1975 to 1990, stabilized between 1990 and 1994, then declined from 1994 to 1998. Since 1998, the rates again stabilized.

To review relevant content, see "Introduction" and "Changing Rates for Specific Cancers" under the "How have cancer trends changed over the past few years?" section.

Initial Check Answers

The best answer followed by an explanation.

1. Alternative C is the best answer. Cancer rates **DO** change when groups of people move from one country to another.
2. Alternative D is the best answer. Exposure to cancer-causing substances **IS ONLY A PART** of what determines who will get cancer.
3. Alternative B is the best answer. The chance that a person will develop cancer in response to a particular environmental agent depends on several interacting factors, including how long and how often a person is exposed to a particular substance, his/her exposure to other agents, genetic factors, diet, lifestyle, health, age, and sex.
4. Alternative C is the best answer. **MUCH EVIDENCE** suggests that permanent genetic changes are responsible for tumor development.
5. Alternative B is the best answer. Benign tumors **DO NOT** spread to other parts of the body.
6. Alternative D is the best answer. Carcinomas are cancers that

develop in the **EPITHELIAL** tissue of certain organs, such as the lung, liver, skin, or breast.

7. Alternative D is the best answer. Heavy drinkers (more than two drinks per day) have **AN INCREASED** risk of cancer, particularly among those who are also smokers.
8. Alternative A is the best answer. Pesticides registered in the United States include **NEARLY 900** active ingredients. **ABOUT 20** have been found to be carcinogenic in animals, but not all have been tested.
9. Alternative D is the best answer. Most studies on the long-term effects of exposure to radiation (for example, X-Rays) used to diagnose or screen for cancers or other diseases **HAVE NOT SHOWN** an elevated cancer risk.
10. Alternative D is the best answer. Insulation materials now use ceramic fibers as a replacement for asbestos. These fibers cause lung cancer in experimental animals.
11. Alternative A is the best answer. Dioxins are unwanted byproducts of chemical processes that contain chlorine and hydrocarbons.
12. Alternative D is the best answer. The exposure of the general population away from the plant is essentially zero.
13. Alternative C is the best answer. After tobacco, overweight or obesity appears the most important preventable cause of cancer.
14. Alternative C is the best answer. The chief causes of obesity are a lack of physical activity and eating large quantities of high-calorie food.
15. Alternative D is the best answer. HPV vaccines are available for women and hepatitis B for both men and women. No vaccines are available for HIV or hepatitis C infections.
16. Alternative B is the best answer. Cancer does **NOT** always cause changes in bowel or bladder habits, indigestion or difficulty swallowing, or unexplained weight changes. It is important to see a doctor about these or other physical changes that continue for some time.
17. Alternative D is the best answer. Abnormal tissue can be removed and examined under a microscope with a sigmoidoscopy or a colonoscopy. The fecal occult blood test checks for small amounts of blood in the stool. A sigmoidoscopy employs a lighted tube to examine the rectum and lower colon; a colonoscopy examines the entire colon and rectum.
18. Alternative C is the best answer. Besides manufactured chemicals, many natural products can also cause cancer; aflatoxin is one example.
19. Alternative D is the best answer. Evidence for identifying cancer-causing substances comes from human studies, animal studies, and from laboratory experiments with human cells.
20. Alternative C is the best answer. Because it is generally true that materials that cause cancer in one type of animal are found to cause cancer in others, public health officials **MUST** heed the warnings that animal tests provide.
21. Alternative D is the best answer. When **HIGH** doses of the chemical do not cause cancer in **ANIMALS**, the greater is the assurance that high doses of the same chemical will not cause

cancer in **PEOPLE**.

22. Alternative A is the best answer. In addition to lowering animal use, experiments with human cells grown in the laboratory are quicker and more economical than animal use and **CAN BE** helpful in evaluating any purpose for or benefit from rat and mice studies.
23. Alternative C is the best answer. In deciding which substances to test for in animals or in human cells, scientists use reports that people exposed to a particular chemical in the workplace develop certain cancers at **HIGHER THAN EXPECTED RATES**.
24. Alternative B is the best answer. Some of the factors that epidemiologists take into consideration to begin large population studies **INCLUDE** cancer trends—that is, rates that **CHANGE** over time or with location.
25. Alternative C is the best answer. The types of exposure **DO NOT** include continuous low-level exposure or occasional exposure to carcinogensin the workplace.
26. Alternative A is the best answer. For exposure in the workplace, acceptable risks are generally **HIGHER** than for the general environment.
27. Alternative C is the best answer. A threshold dose response may have an exposure level below which no increase in risk is detectable.
28. Alternative B is the best answer. Unless compelling evidence indicates a **THRESHOLD-LIKE** mechanism, to protect the public health agencies assume the dose response is **LINEAR**.
29. Alternative A is the best answer. If the cancer testing is done in rats and mice and if the carcinogens exhibit threshold-like dose responses, scientists consider the possibility that people are **MORE SENSITIVE THAN** are rats or mice to the cancer-causing effects of a particular chemical.
30. Alternative C is the best answer. The Food and Drug Administration, the National Cancer Institute, and the World Health Organization rigorously analyzed the benefits and risks. These organizations concluded that the benefits of tamoxifen for women who have had breast cancer or for a relatively small number of women who are at high risk of developing breast cancer **STRONGLY OUTWEIGH** the serious risks associated with the drug.
31. Alternative D is the best answer. A decrease in cancer incidence may be due to **EARLY** detection and **REMOVAL** of precancerous growths.
32. Alternative C is the best answer. The larger percentage increase in lung cancer incidence rates for women compared with men reflects the fact that women began smoking later in the century than did men.
33. Alternative A is the best answer. Between the years 1992 and 2000, the incidence rates of liver, thyroid, and melanoma cancers had the greatest percentage INCREASE.

What causes cancer?

Learning Objective Upon completion of this section, you will be able to

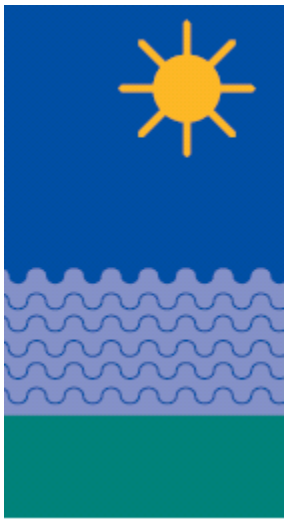
- Describe factors both inside and outside the body that contribute to the development of cancer.

Introduction

Cancer develops over several years and has many causes. Several factors both inside and outside the body contribute to cancer development. In this context, scientists refer to everything outside the body that interacts with humans as the "environment."

Factors outside the Body (Environmental Factors)

In the United States, exposure to a wide variety of natural and manufactured substances in the environment accounts for at least two-thirds all cancer cases. These environmental factors include lifestyle choices such as



- Cigarette smoking,
- Excessive alcohol consumption,
- Poor diet,
- Lack of exercise,
- Excessive sunlight exposure, and
- Sexual behavior that increases exposure to certain ***viruses*** (see **viruses and bacteria**).

Other factors include exposure to certain medical drugs, hormones, radiation, viruses, bacteria, and environmental chemicals possibly present in the air, water, food, and workplace. The cancer risks associated with many environmental chemicals have been identified through studies of occupational groups that have higher exposures to these chemicals than does the general population.

The importance of the environment can be seen in the differences in cancer rates throughout the world and the change in cancer rates when groups of people move from one country to another. For example, when Asians—who have low rates of prostate and breast cancer and high rates of stomach cancer in their native countries—immigrate to the United States, their prostate and breast cancer rates rise over time until they are nearly equal to or greater than the higher levels of these cancers in the United States. Likewise, their rates of stomach cancer fall, becoming nearly equal to the lower U.S. rates. Lifestyle factors such as diet, exercise, and excessive weight are thought to play a major role in the trends for breast and prostate cancers, and infection with the *Helicobacter pylori* bacterium is an important risk factor for stomach cancer. Recently, the rapid rise in the rates of ***colorectal*** cancer in Japan and China suggests an environmental cause such as lifestyle factors.

Different environmental exposures are linked to specific kinds of cancer. For example, exposure to **asbestos** is linked primarily to lung cancer, whereas exposure to benzidine, a chemical found in certain dyes (see **Benzidine**), is associated with bladder cancer. In contrast,

smoking is linked to cancers of

- The lung,
- Bladder,
- Mouth,
- Colon,
- Kidney,
- Throat,
- Voice box,
- Esophagus,
- Lip,
- Stomach,
- Cervix,
- Liver, and
- Pancreas.

Factors inside the Body

Certain factors inside the body make some people more likely to develop cancer than others. For instance, some people either inherit or acquire the following conditions: altered ***genes*** in the body's ***cells***, abnormal hormone levels in the bloodstream, or a weakened immune system. Each of these factors may make a person more ***susceptible*** to cancer.

One of the ways scientists know that genes play an important role in the development of cancer is from studying certain rare families where family members over several generations develop similar cancers. These families are apparently passing on an altered gene that carries a high chance of cancer growth. Several genes that greatly increase a person's chance of developing certain cancers (*e.g.*, colon, breast, and ovary) have been identified. Only a very small percentage of people in the general population have abnormal copies of these genes: known as ***familial cancers***, such genes account for only two to five percent of all cancers.

Gene alterations may also contribute to individual differences in susceptibility to environmental ***carcinogens*** (cancer-causing substances). For instance, people differ in their ability to eliminate from their bodies cancer-causing agents to which they have been exposed or to repair ***DNA*** damage caused by such agents. Subsequent-generation family members may inherit these gene alterations, which may also account for higher rates of cancer in these families. Higher rates of cancer in families may also be related to shared environmental exposures such as diet or workplace exposure to carcinogens.

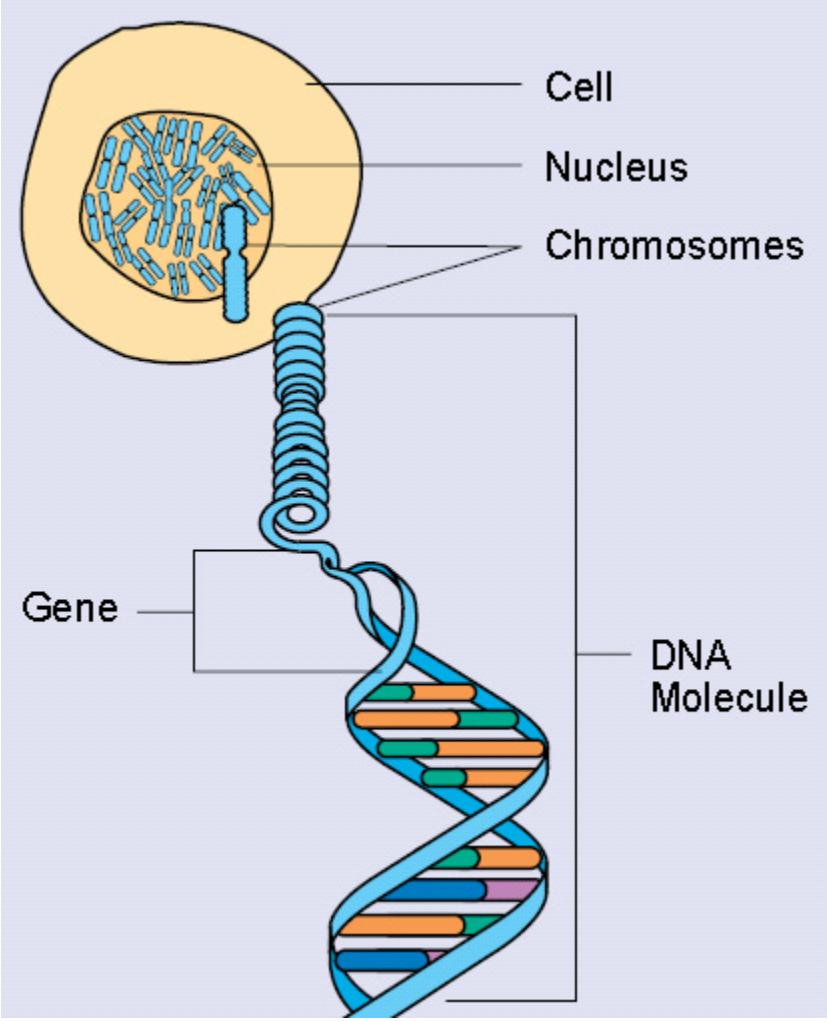


Figure 1. *Tightly coiled strands of DNA, which carry the instructions that allow cells to make **proteins**, are packaged in units called chromosomes. Subunits of DNA are known as genes.*

One of the main objectives of a growing field in cancer research called molecular ***epidemiology*** is to identify gene alterations that increase or decrease a person's chance of developing cancer after an environmental exposure.

Protective Factors

Exposure to cancer-causing substances is only a part of what determines who will get cancer. For example, some people who smoke do not get lung cancer, and not all women who are infected with human papilloma virus (see **Viruses and Bacteria**.) develop cervical cancer. Scientists believe that some protective genes or other factors such as fruits and vegetables in the diet may help prevent disease.

Interaction of Environmental	Throughout our lives, environmental factors such as viruses, sunlight, and chemicals interact with our cells. Mechanisms to repair damage to

Factors and Genes

our genes and healthy lifestyle choices (e.g., wearing protective clothing for sun exposure or not smoking) help to protect us from harmful exposures. But over time, substances in the environment may cause gene alterations that accumulate inside our cells. While many alterations have no effect on a person's health, permanent changes in certain genes can lead to cancer.

The chance that a person will develop cancer in response to a particular environmental agent, however, depends on several interacting factors

- How long and how often a person is exposed to a particular substance,
- His/her exposure to other agents,
- Genetic factors,
- Diet,
- Lifestyle,
- Health,
- Age, and
- Sex.

Diet, alcohol consumption, and certain medications can, for example, affect the levels of chemicals in the body that break down cancer-causing substances.

Because of the complex interplay of many factors, to predict whether a specific environmental exposure will cause a particular person to develop cancer is not possible. We know that certain genetic and environmental factors increase the risk of developing cancer, but we rarely know exactly which combination of factors is responsible for a person's specific cancer. This also means that we usually do not know why one person's body develops malignant tumors and another does not.

Interplay of Factors

Particular patterns of gene alterations and environmental exposures make people more susceptible or more resistant to cancer. One of the challenging areas of research today is identifying the unique combinations of these factors that explain why one person will develop cancer and another will not.

Key Points

- Cancer develops over several years and has many causes.
- Exposure to a wide variety of natural and manufactured substances in the environment accounts for at least two-thirds of all the cases of cancer in the United States.
- The importance of the environment can be seen in the differences in cancer rates throughout the world and the change in cancer rates when groups of people move from one country to another.
- Different environmental exposures are linked to specific cancers.

- Certain factors inside the body make some people more likely to develop cancer than others.
- One of the ways scientists know that genes play an important role in the development of cancer is from studying certain rare families where over several generations family members will develop similar cancers.
- Gene alterations may also contribute to individual differences in susceptibility to environmental carcinogens.
- Exposure to cancer-causing substances is only a part of what determines who will get cancer.
- Mechanisms to repair damage to our genes and healthy lifestyle choices (wearing protective clothing for sun exposure or not smoking) help to protect us from harmful exposures.
- The chance that a person will develop cancer in response to a particular environmental agent depends on several interacting factors: how long and how often a person is exposed to a particular substance, his/her exposure to other agents, genetic factors, diet, lifestyle, health, age, and sex.
- Because of the complex interplay of many factors, to predict whether a specific environmental exposure will cause a particular person to develop cancer is not possible.
- Particular patterns of gene alterations and environmental exposures render people more susceptible or more resistant to cancer.

Progress Check

Choose the best answer.

1. Which of the following statements concerning the development of cancer is **INCORRECT**?

   A. Cancer develops over several years and has many causes.
   B. Exposure to a wide variety of natural and manufactured substances in the environment accounts for at least two-thirds of all the cases of cancer in the United States.
   C. Cancer rates DO NOT change when groups of people move from one country to another.
   D. Different environmental exposures are linked to specific kinds of cancer.

   To review relevant content, see "Introduction" and "Environmental Factors" under the "What causes cancer?" section.

2. Which of the following statements concerning factors inside the body that make some people more likely to develop cancer than others is **INCORRECT**?

   A. Certain factors inside the body make some people more likely to develop cancer than others.
   B. One of the ways scientists know that genes play an important role in the development of cancer is from studying certain rare families where family members over several generations develop similar cancers.

C. Gene alterations may also contribute to individual differences in susceptibility to environmental carcinogens.
D. Exposure to cancer-causing substances ALONE determines who will get cancer.

To review relevant content, see "Factors inside the Body" under the "What causes cancer?" section.

3. Which of the following statements concerning the interaction of environmental factors and genes in the development of cancer is **INCORRECT**?

A. Mechanisms to repair damage to our genes and healthy lifestyle choices help to protect us from harmful exposures.
B. The chance that a person will develop cancer in response to a particular environmental agent depends on length of exposure, alone.
C. Because of the complex interplay of many factors, it is not possible to predict whether a specific environmental exposure will cause a particular person to develop cancer.
D. Particular patterns of gene alterations and environmental exposures make people more susceptible or more resistant to cancer.

To review relevant content, see "Interaction of Environmental Factors and Genes" under the "What causes cancer?" section.

The Nature of Cancer

Learning Objectives

Upon completion of this section, you will be able to

- Describe how cancer starts.
- Describe types of tumors.

Introduction

Cancer types number more than 100. Cancer begins inside a cell—the basic building block of all living things. Normally, when the body needs more cells, older cells die off. Younger cells then divide to form new cells, replacing those that died. When cancer develops, however, the orderly process of producing new cells breaks down. Even when new cells are not needed cells continue to divide, forming a growth or extra mass of cells called a ***tumor***. Over time, changes may take place in tumor cells that cause them to invade and interfere with the function of normal ***tissues***.

Tumor development takes many years, and even more years pass before the tumor is detected. By that time, the tumor has often spread to other parts of the body. People exposed to carcinogens from smoking cigarettes, for example, generally do not develop detectable cancer for 20 to 30 years.

Much evidence suggests that permanent genetic changes are responsible for tumor development. These can be inherited, or acquired throughout a lifetime. Scientists have identified more than 300 altered genes that can play a role in tumor development. An alteration in growth-promoting genes, known as ***oncogenes***, for example, can signal the cell to divide out of control, similar to having a gas pedal stuck to the floorboard. On the other hand, an alteration in ***tumor suppressor genes***, which normally serve as brakes for dividing cells will, rather than repairing the DNA or eliminating the injured cells, allow cells with damaged DNA to continue dividing.

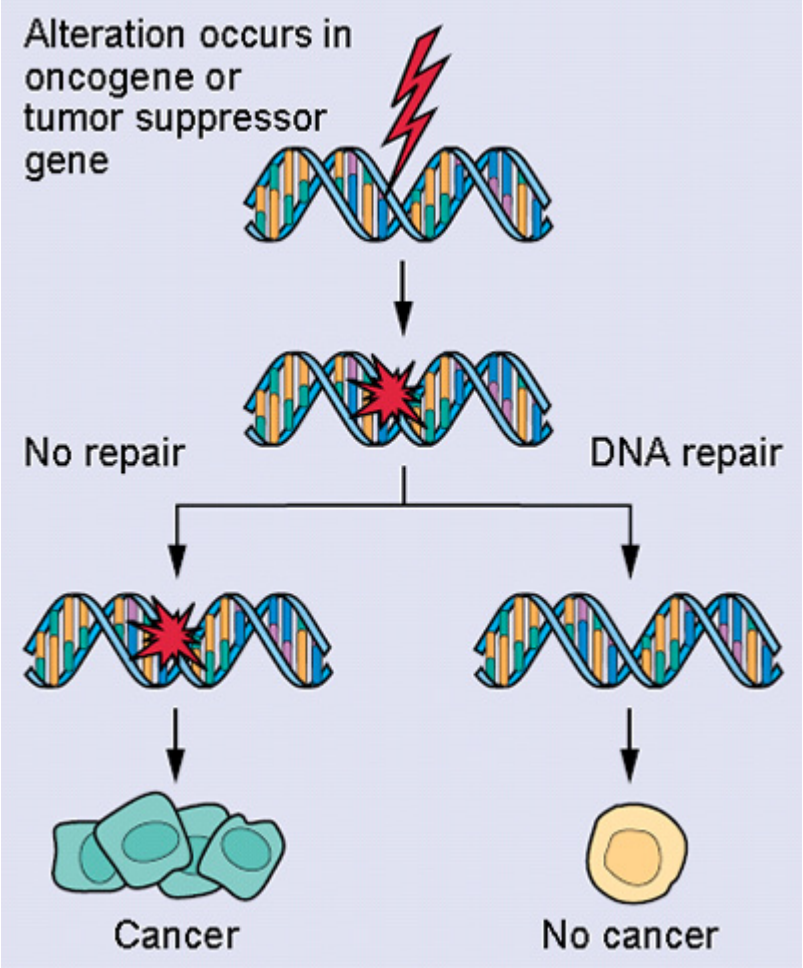


Figure 2. *An alteration in growth-promoting genes, known as oncogenes, can signal the cell to divide out of control. An alteration in tumor suppressor genes will, rather than repair the DNA or eliminate the injured cells, allow cells with damaged DNA to continue their uncontrolled growth.*

One explanation for the fact that cancer occurs more frequently in older people may be that, for a tumor to develop, a cell must acquire several gene alterations that accumulate as we age. As the graph below illustrates, less than 0.1 percent of the total number of cancer cases in the United States occur in people under the age of 15, whereas nearly 80 percent occur in people age 55 or older.

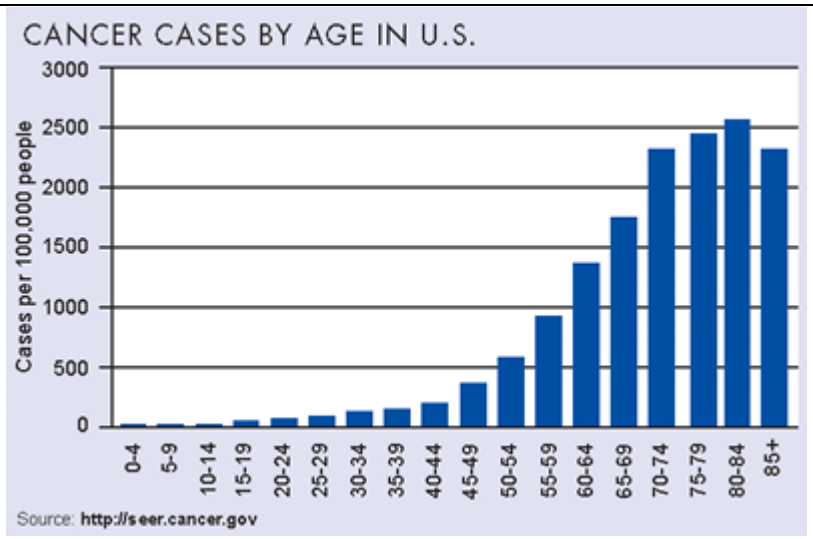


Figure 3. *Cancer cases by age in the United States.*

Types of Tumors

Tumors are classified as either benign or malignant. ***Benign tumors*** are not cancerous and do not spread to other parts of the body.

A ***malignant tumor*** can metastasize—a process during which cancer cells escape from the tumor, enter the bloodstream or ***lymphatic system***, and spread to nearby parts of the body and eventually to sites far away from the original tumor. Some benign tumors may, over time, become malignant tumors. The development of malignant tumors involves many steps taking place over several years. The earlier a tumor is detected, the less likely it will have spread to other parts of the body. In the past 25 years, enormous progress has been made in defining the molecular events that take place as a normal cell becomes malignant and the critical genes thought to be involved. For more information, see resources listed as "**General Cancer Information**" at the end of the booklet.

Most cancers are named for the organ or type of cell in which they begin to grow, such as lung, stomach, breast, or colon cancer. Some of the names for other cancers, however, are less clear. ***Melanoma*** is a cancer of cells in the skin, eyes, and some other tissues, known as melanocytes, that make pigment. ***Leukemias*** are cancers of the blood cells, and ***lymphomas*** are cancers that develop in the lymphatic system. The most common cancers in the U.S are ***carcinomas***. Carcinomas are cancers that develop in the tissue that lines the surfaces of certain organs, such as the lung, liver, skin, or breast. This tissue is called epithelial tissue. Cancers that develop in the epithelial tissue of specific organs are called, for example, carcinoma of the lung, or carcinoma of the breast,. Another group of cancers is ***sarcomas***: these arise from cells in bone, cartilage, fat, connective tissue, and muscle.

Key Points

- When cancer develops, the orderly process of producing new cells breaks down. Cells continue to divide when new cells are not needed, and a growth or extra mass of cells is formed, known as a tumor.

- The development of a tumor takes many years, and even more years until a tumor is detected, and it has spread to other parts of the body.
- Much evidence suggests that permanent changes in our genes are responsible for tumor development.
- One explanation for the fact that cancer occurs more frequently in older people may be that for a tumor to develop, a cell must acquire several gene alterations that accumulate as we age.
- Tumors are classified as either benign or malignant. Benign tumors are not cancer and do not spread to other parts of the body.
- A malignant tumor can metastasize—that is, its cells can escape from the tumor, enter the bloodstream or lymphatic system, and spread to nearby parts of the body and eventually to sites far away from the original tumor.
- Most cancers are named for the organ or type of cell in which they begin to grow, such as lung, stomach, breast, or colon cancer.

Progress Check

Choose the best answer.

4. Which of the following statements concerning the development of cancer is **INCORRECT**?

   A. When cancer develops, cells continue to divide even when new cells are not needed, and that growth or extra mass of cells called a tumor.
   B. It takes many years for the development of a tumor and even more years until detection of a tumor and its spread to other parts of the body.
   C. NOT MUCH EVIDENCE is available to suggest that permanent changes in our genes are responsible for tumor development.
   D. One explanation for the fact that cancer occurs more frequently in older people may be that, for a tumor to develop, a cell must acquire several gene alterations that accumulate as we age.

   To review relevant content, see "Introduction" under the "The Nature of Cancer" section.

5. Which of the following statements concerning the different types of tumors **INCORRECT**?

   A. Benign tumors are not cancerous.
   B. Benign tumors spread to other parts of the body.
   C. A malignant tumor can metastasize and spread to nearby parts of the body and eventually to sites far away from the original tumor.
   D. Most cancers are named for the organ or type of cell in which they begin to grow.

   To review relevant content, see "Types of Tumors" under the "The Nature of Cancer" section.

6. Which of the following statements concerning different types of cancers is **INCORRECT**?

   A. Melanoma is a cancer of cells in the skin, eyes, and some other tissues, known as melanocytes.
   B. Leukemias are cancers of the blood cells.
   C. Lymphomas are cancers that develop in the lymphatic system.
   D. Carcinomas are cancers that develop in the connective tissue of certain organs, such as the lung, liver, skin, or breast.

   To review relevant content, see "Types of Tumors" under the "The Nature of Cancer" section.

What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?

Learning Objectives

Upon completion of this section, you will be able to

- Identify substances in the environment known to cause or likely to cause cancer in humans.
- Identify where substances known to cause or likely to cause cancer in humans, are found.

Introduction

Every 2 years, scientists from a wide range of government agencies and educational institutions collaborate with scientists from the **National Toxicology Program** (NTP) in Research Triangle Park, NC, to publish the ***Report on Carcinogens***. The report identifies substances either known to cause or suspected of causing cancer in humans and to which a significant number of people in the United States are exposed. It is the source for the agents listed in this training.

This training does not include all of the more than 200 agents listed in the ***Report on Carcinogens***. The 50 or so discussed below are those for which there is a great deal of public interest.

10th Report on Carcinogens

The ***10th Report on Carcinogens***, published in December 2002, lists 228 substances either known to cause or suspected of causing cancer. It also describes where they are found and explains the scientific evidence that they cause cancer. The *Report* serves as a useful guide for the federal agencies listed in the back of this booklet. These agencies are responsible for establishing acceptable levels of exposure to chemical substances in the general environment, home, and workplace, and in food, water, and medical drugs. For this and future reports, visit the **National Toxicology Program** (NTP) Web site at **ntp-server.niehs.nih.gov**.

International Agency for Research on Cancer (IARC)

A longstanding international group known as the International Agency for Research on Cancer (IARC) also produces reports on known or suspected carcinogens, as well as occupations associated with cancer risk. Visit the IARC Web site: **www.iarc.fr**.

Tobacco

Exposure to the carcinogens in tobacco products accounts for about one-third of all cancer deaths in the United States each year.

- Cigarette, cigar, and pipe smoking,
- Chewing tobacco,

	• Snuff, and • Exposure to environmental tobacco smoke (ETS or secondhand smoke) are all linked to increased cancer risks. Cigarette, cigar, and pipe smoking have been associated with cancers of the • Lung, • Mouth, • Bladder, • Colon, • Kidney, • Throat, • Nasal cavity, • Voice box, • Esophagus, • Lip, • Stomach, • Cervix, • Liver, pancreas, and • Leukemia. Smokeless tobacco has been linked to cancers of the mouth; and ETS has been implicated in lung cancer. Cigarette smoke contains more than 100 cancer-causing substances. The risk for cancers of the mouth, voice box, and esophagus is further increased among smokers who also drink more than two drinks per day.
Diet, Weight, Physical Inactivity	Because there are few definite relationships between food and cancer, the ***Report on Carcinogens*** does not refer to the cancer-related effects of specific foods. However, several studies show that heavy consumption of red and preserved meats, salt-preserved foods, and salt probably increase the risk of colorectal and stomach cancers. Evidence also suggests that a diet rich in fruits and vegetables may decrease the risks of esophageal, stomach, and colorectal cancers. Being overweight or obese appears after tobacco as one of the most important modifiable causes of cancer. Large population studies show a consistent association between obesity and certain kinds of cancer. The strongest links are with breast cancer in older women, and cancers of the ***endometrium***, kidney, colon, and esophagus. Strong evidence links physical *in*activity with increases in colon and breast cancer risk. The beneficial effect of exercise is greatest among very active people. Together, it is estimated that inactivity and obesity account for 25 to 30 percent of the cases of several major cancers—colon, breast (postmenopausal), endometrial,

kidney, and cancer of the esophagus.

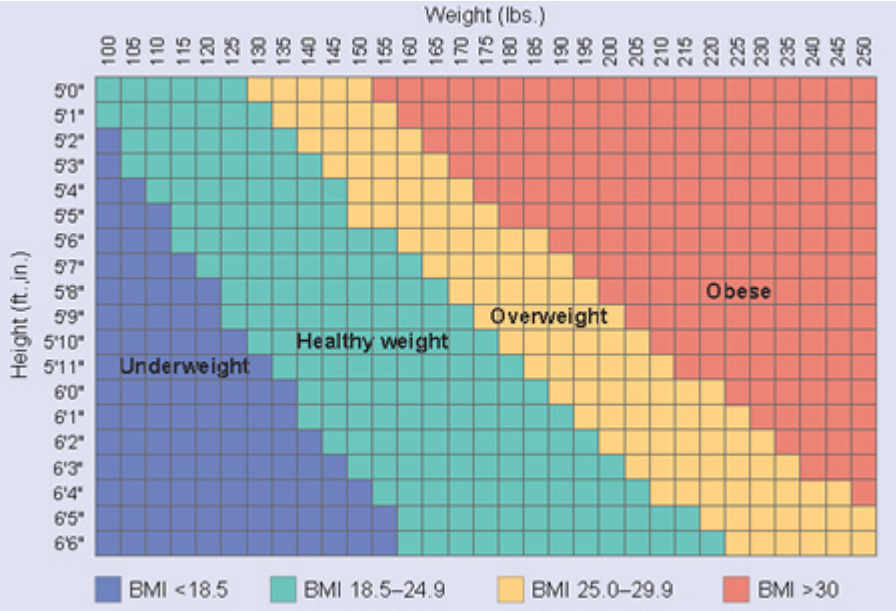
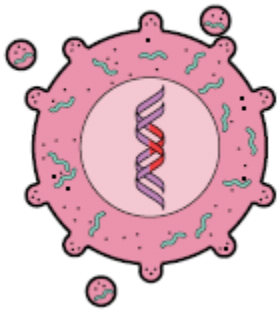


Figure 4. *Body Mass Index (BMI) is a number that shows body weight adjusted for height. Based on their BMIs, adults 20 years and older fall into one of the four categories: underweight; healthy weight; overweight; and obese. Persons in the overweight or obese category have a greater risk for many diseases than do those in the healthy weight category, including certain cancers. To find which category you are in, locate your height and move across the chart to your weight.*

Alcoholic Drinks	Heavy drinkers (more than two drinks per day) have an increased risk of cancer, particularly among those who also smoke. Cancers associated with heavy drinking include cancers of the mouth, throat, voice box, liver, and esophagus. Some evidence also links alcohol and breast cancer.
Ultraviolet Radiation	Ultraviolet (UV) radiation from the sun, sunlamps, or tanning beds causes premature aging of the skin and DNA damage that can lead to melanoma and other forms of skin cancer. The incidence of skin cancers is rapidly increasing.
Viruses and Bacteria	Infectious agents such as viruses and bacteria clearly contribute to the development of several types of cancer. A sexually transmitted virus called **human papillomavirus** (HPV) is the primary cause of cervical and ***anal*** cancer. Women who begin sexual intercourse at age 16 or younger or have many sexual partners have an increased risk of infection. Infection with HPV is increasingly common. Still, although HPV infection is the primary cause of cervical cancer, most infections do not result in cancer. There is a new **vaccine that prevents the types of genital human papillomavirus** (HPV) that cause most cases of cervical cancer and genital warts. The vaccine is routinely recommended

for 11 and 12 year old girls. It is also recommended for girls and women age 13 through 26 who have not yet been vaccinated or completed the vaccine series.



Hepatitis B (HBV) and **hepatitis C** (HCV) viral infections are major causes of liver cancer. In Asia and Africa, HBV is usually acquired in childhood and carries a high risk of liver cancer; HBV infection is, however, less common in the United States. Risk factors for HBV include occupational exposure to blood products, injection drug use, and high-risk sexual behavior (unprotected sex with multiple partners). A vaccine is available to prevent infection with HBV. The rising incidence of liver cancer in the United States is thought to be due to HCV. The strongest risk factor for HCV infection is injection drug use, but sexual transmission is also possible. People who received a blood transfusion before 1989 may also be infected with this virus. Currently, no vaccine is available for HCV.

Almost all adults are infected with **Epstein-Barr virus** (EBV), which is linked to some types of lymphoma. EBV is the virus that causes mononucleosis. Another type of virus, **Kaposi's sarcoma-associated herpesvirus** (KSHV), also known as **human herpesvirus 8** (HHV-8), is linked to a particular type of sarcoma called Kaposi's sarcoma. KSHV infection only occurs through close person-to-person contact. In Mediterranean and African countries, KSHV infection in childhood is common. In the United States, KSHV infection is most common in homosexual men. The risk of cancer for people infected with either KSHV or EBV is low, except for those whose immune systems are weakened, such as people infected with the human immunodeficiency virus (HIV), the virus that causes AIDS.

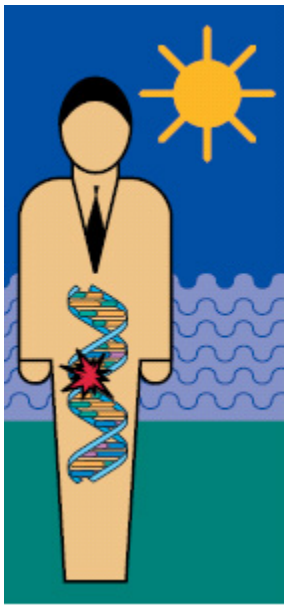
Infection with *Helicobacter pylori*, a bacterium, is widespread and is the primary cause of peptic ulcers and chronic gastritis (inflammation of the stomach). *H. pylori* contributes to the development of stomach cancer. Most *H. pylori* infections, however, result in neither symptoms nor cancer.

Ionizing Radiation

Ionizing radiation is invisible, high-frequency radiation that can damage the DNA or genes inside the body.

Everyone is exposed to very small doses of ionizing radiation from **cosmic rays** (rays that enter the earth's atmosphere from outer space). Radiation from this source may account for a very small percentage (about 1 percent) of our total cancer risk.

Some homes have elevated levels of **radon**, a naturally occurring radioactive gas found at low levels in most soil. Radon is produced by the breakdown of uranium, which naturally releases low levels of ionizing radiation. Higher levels of radon can be found in certain types of rocky soil. The health effects of radon were first seen in the elevated levels of lung cancer found in underground

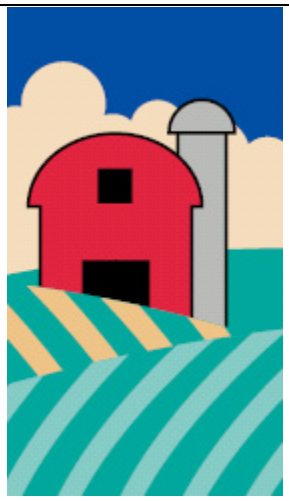


uranium miners in the United States and around the world. Radon gas seeps into homes from the surrounding soil through cracks and other openings in the foundation. About 1 of 20 homes has elevated levels of radon. Although the cancer risks for radon exposure in the home are much lower than for radon-exposed miners, an estimated 20,000 lung cancer deaths every year are caused by radon exposure in homes. Various strategies are available for reducing residential radon exposure.

Another source of ionizing radiation is the radioactive substances released by exploding nuclear weapons known as "**fallout**." The doses of ionizing radiation received by the atomic bomb survivors in Japan resulted in increased risks of leukemia and cancers of the breast, thyroid, lung, stomach, and other organs. Radioactive substances were also released in the aboveground atomic bomb testing conducted by the U.S. government in the late 1950s and early 1960s in Nevada. People exposed, especially as children, to one radioactive iodine **isotope**, Iodine-131 or I-131, which collects in the thyroid gland, may have an increased risk of thyroid disease, including thyroid cancer. For more information visit: **cancer.gov/i131**.

People are also exposed to ionizing radiation during certain **medical procedures**. Some patients who receive radiation to treat cancer or other conditions may be at increased cancer risk. For example, persons treated with radiation in childhood to treat acne, ringworm, and other head and neck conditions have been shown to be at increased risk for thyroid cancer and other tumors of the head and neck. **X-rays** used to diagnose or screen for a disease are also forms of ionizing radiation. The dose of radiation from procedures used to diagnose or screen for a disease is much lower than the dose to treat a disease. Most studies on the long-term effects of exposure to radiation used to diagnose or screen for cancers or other diseases have not shown an elevated cancer risk, but a small risk associated with this exposure is possible. That said, children whose mothers received diagnostic X-rays during pregnancy were found to have increased risks of childhood leukemia and other types of cancer. This finding led to the current ban on diagnostic X-rays in pregnant women. Several other studies of women who received small weekly X-ray doses to the chest over extended periods to monitor treatment for tuberculosis showed a radiation-related increased risk of breast cancer.

Pesticides



Of the nearly 900 active ingredients in registered pesticides in the United States, about 20 have been found to be carcinogenic in animals, although not all have been tested. In the United States, a number of pesticides have been banned or their use has been restricted. These include **ethylene oxide**, **amitrole**, some **chlorophenoxy *herbicides*, DDT, dimethylhydrazine, hexachlorobenzene, hexamethylphosphoramide, chlordecone, lead acetate, lindane, mirex, nitrofen,** and **toxaphene**. Studies of people with high exposures to pesticides, such as farmers, pesticide applicators, crop duster pilots, and manufacturers, have found high rates of

- Blood and lymphatic system cancers,
- Cancers of the lip,
- Stomach,
- Lung,
- Brain, and prostate, as well as
- Melanoma and other skin cancers.

So far, human studies have not enabled researchers to sort out exactly which pesticides are linked to which cancers. Therefore, most of these pesticides are still listed in the ***Report on Carcinogens*** as likely to be cancer-causing, rather than as known carcinogens. For more information, visit: **www.aghealth.org**.

Medical Drugs

Some drugs used to treat cancer (*e.g.*, **cyclophosphamide**, **chlorambucil**, **melphalan**) have been shown to increase the occurrence of second cancers, including leukemia. Others used as immunosuppressants, such as **cyclosporin** and **azathioprine** for patients having organ transplants, are also associated with increased cancer risks, especially lymphoma. But the Food and Drug Administration has determined that the life-saving benefits of these drugs outweigh the additional cancer risks that might arise years later. Nevertheless, people should consult a physician or other health care specialist and weigh the risks and benefits concerning the use of a drug.

Some medicines have been linked to reduced risk of cancer. For example, some studies find a reduced risk of colon cancer in persons who regularly take aspirin or other nonsteroidal, anti-inflammatory medicines. Evidence for protection of other cancers such as breast cancer or prostate cancer is inconsistent.

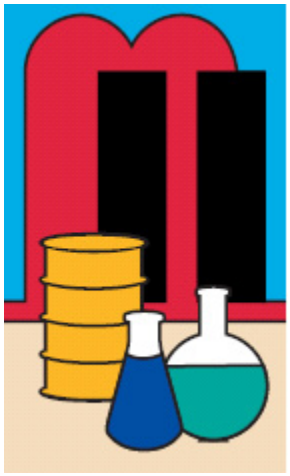
Estrogens used to treat symptoms of menopause and other

gynecological conditions have been shown to increase the incidence of endometrial cancer. In addition, some studies have shown an increased risk of breast cancer with estrogen use, but a reduced risk of colon cancer. **Progesterone** is another hormone now taken in combination with estrogen for hormone replacement therapy in older women. It helps to protect against the increased endometrial cancer risk with estrogen alone. Nevertheless, increased risks of breast cancer, heart disease, stroke, and blood clots have recently been shown to be associated with the use of estrogen plus progestin, a synthetic form of progesterone. Long-term users of combination oral contraceptives have substantially reduced risks of endometrial and ovarian cancers, but may experience increases in early-onset breast cancers and liver cancer. The amount of estrogen and progesterone in oral contraceptives is substantially less than in previous years, which means that the risk of the current formulations is likely to be less than those used in the past.

Tamoxifen use is associated with increased risks of endometrial cancer as well as increased risks of stroke and blood clots. Tamoxifen is a synthetic hormone used to prevent the recurrence of breast cancer after breast cancer surgery. It is also used to prevent breast cancer in women who, because of family history or other factors, are at high risk for the disease. Again, people should consult a physician or other health care specialist and weigh the risks and benefits concerning the use of a drug.

Diethylstilbestrol (DES) is a synthetic form of estrogen prescribed to pregnant women from the early 1940s to 1971. Their daughters who were exposed to DES before birth were determined to have an increased chance of developing a rare type of cervical and vaginal cancer. In addition, women who took DES during pregnancy may have a slightly higher risk for developing breast cancer. Because of these findings, DES is no longer prescribed, and it has been banned as a cattle feed additive.

Solvents



Several solvents used in paint thinners, in paint and grease removers, and in the dry cleaning industry are, based on in animal studies, known or suspected of causing cancer. These include **benzene**, **carbon tetrachloride**, **chloroform**, **dichloromethane (methylene chloride)**, **tetrachloroethylene**, and **trichloroethylene**. Except for benzene (a known carcinogen), human studies are suggestive, but not conclusive. Therefore, with the exception of benzene, these substances are listed as likely to cause cancer in humans.

Benzene, however, is known to cause leukemia in humans. Its use is widespread as a solvent in the chemical and drug industries and as a gasoline component. After 1997, it was banned as an ingredient in pesticides. Workers employed in the petrochemical industry, pharmaceutical industry, leather industry, rubber industry, gas stations, and in the transportation industry are exposed to benzene. Inhaling contaminated air is the primary

	method of exposure. Because benzene is present in gasoline, air contamination occurs from vapors around gas stations and from automobile exhaust in congested areas. It is also present in cigarette smoke. Half of the estimated exposure to benzene in the United States is from cigarette smoking. About half of the U.S. population is exposed to benzene from industrial sources, and virtually everyone in the country is exposed to benzene in gasoline.
Key Points	• Exposure to the carcinogens in tobacco products accounts for about one-third of all cancer deaths in the United States each year. • Several studies show that heavy consumption of red and preserved meats, salt-preserved foods, and salt probably increases the risk of colorectal and stomach cancers. Some evidence also shows that a diet rich in fruits and vegetables may decrease the risks of esophageal, stomach, and colorectal cancers. • After tobacco, being overweight or obese appears to be one of the most important modifiable causes of cancer. Strong evidence indicates that physical inactivity increases the risk for colon and breast cancer. • Heavy drinkers (more than two drinks per day) have an increased risk of cancer—particularly heavy drinkers who also smoke. • Ultraviolet (UV) radiation from the sun, sunlamps, or tanning beds causes premature aging of the skin and DNA damage that can lead to melanoma and other forms of skin cancer. • Infectious agents such as viruses and bacteria clearly contribute to the development of several types of cancer. • Ionizing radiation is invisible, high-frequency radiation that can damage the DNA or genes inside the body. Common sources of ionizing radiation are radon gas, cosmic rays, nuclear fallout, and certain medical procedures, *e.g.*, X-rays. • Of the nearly 900 active ingredients in registered pesticides in the United States, about 20 have been found to be carcinogenic in animals, although not all have been tested. • Some drugs used to treat cancer have been shown to increase the occurrence of second cancers. Others used as immunosuppressants for patients having organ transplants are also associated with increased cancer risks. • Animal studies have shown that several solvents used in paint thinners, in paint and grease removers, and in the dry cleaning industry are known or suspected carcinogens (i.e., cancer-causing substances or agents).
Progress Check	7. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?

Choose the best answer.

A. Exposure to carcinogens in tobacco products accounts for about one-third of all cancer deaths in the United States each year.
B. Several studies show that heavy consumption of red and preserved meats, salt-preserved foods, and salt probably increase the risk of colorectal and stomach cancers.
C. Being overweight or obese appears to be one of the most important, modifiable causes of cancer, after tobacco.
D. Heavy drinkers (more than two drinks/day) have a lesser risk of cancer, particularly among those who also smoke.

To review relevant content, see "Tobacco", "Diet, Weight, Physical Inactivity" and "Alcoholic Drinks" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

8. Which of the following statements concerning substances that are either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?

A. Of the nearly 900 active ingredients in registered pesticides in the United States, most have been found to be carcinogenic in animals, although not all have been tested.
B. Some drugs used to treat cancer have been shown to increase the occurrence of second cancers.
C. Several solvents used in paint thinners, paint and grease removers, and in the dry cleaning industry are known or suspected in animal studies of causing cancer.
D. Infectious agents such as viruses and bacteria contribute to the development of several types of cancer.

To review relevant content, see "Viruses and Bacteria', "Pesticides", "Solvents", and "Medical Drugs" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

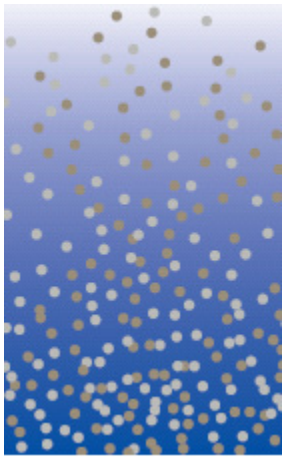
9. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?

A. Radiation from cosmic rays may account for a very small percentage (about 1 percent) of our total cancer risk.
B. It is estimated that about 20,000 lung cancer deaths every year are caused by radon exposure in homes.
C. People exposed to radioactive fallout in the form of Iodine-131 may have an increased risk of thyroid disease, including thyroid cancer.

D. Most studies on the long-term effects of exposure to radiation (for example, X-Rays) used to diagnose or screen for cancers or other diseases have shown an elevated cancer risk.

To review relevant content, see "Ionizing Radiation" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found? *(continued)*

Fibers, Fine Particles and Dust 	Exposures to various **fibers, fine particles**, and **dust** occur in several industrial settings and are associated with increased cancer risks. Exposure can also occur in nonindustrial settings. **Asbestos** fibers and all commercial forms of asbestos are human carcinogens. In a variety of occupations involving asbestos exposure, increased rates have been consistently observed of mesothelioma—a rare cancer of the lining of the lung and abdominal cavity—and cancer of the lung. Asbestos exposures account for the largest percent of occupational cancer, with the greatest risks among workers who smoke. Asbestos fibers are released into the environment from the use and deterioration of more than 5,000 asbestos products, including • Roofing, • Thermal and electrical insulation; • Cement pipe and sheet; • Flooring; • Gaskets; • Plastics; and • Textile and paper products. Workers in asbestos insulation, brake maintenance and repair, and building demolition jobs are exposed to high levels of asbestos. And because asbestos has been so widely used, the entire population may have been exposed to some degree. Since the restriction of asbestos in the United States, exposure to the general population has decreased. Nonetheless, through renovations, repairs, and demolitions, workers employed in construction trades and electricians and carpenters can still experience high levels of asbestos exposures. **Ceramic fibers** are now used as insulation materials and are a replacement for asbestos. Because ceramic fibers can withstand high temperatures, they are used to line furnaces and kilns. Ceramic fibers have, however, caused lung cancer in experimental animals. **Silica dusts** are associated with an excess risk of lung cancer in humans and are found in industrial and occupational settings such as coal mines, mills, granite quarrying and processing, crushed stone and related industries, and sandblasting operations. **Wood dust**, associated with cancers of the nasal cavities and sinuses, is a known carcinogen for unprotected workers exposed regularly from sanding operations and furniture manufacturing.
Dioxins	**Dioxins** are unwanted byproducts of chemical processes. Dioxins comprise chlorine and hydrocarbons (i.e., substances that contain both hydrogen and carbon). At least 100 different

kinds of dioxins are known. Industry does not intentionally manufactured them; they are produced by

- Paper and pulp bleaching;
- Incineration of municipal, toxic, and hospital wastes;
- Certain electrical fires; and
- ***Smelters*** (i.e., plants in which metals are extracted from ores).

Dioxins are also found as a contaminant in some insecticides, herbicides, and wood preservatives. Dioxins are widespread environmental contaminants; they accumulate in fats and break down slowly. A particular dioxin likely to be carcinogenic to humans is **TCDD** (2,3,7,8-**t**etra**c**hloro**d**ibenzo-*p*-**d**ioxin). TCDD is highly carcinogenic in animals, and, in highly exposed workers, increased overall cancer death rates have been reported. Fortunately, modifications of industrial processes such as bleaching and incineration have reduced dioxin emissions and have lowered dioxin levels in people. The general population remains exposed to low levels of TCDD primarily from eating dairy products, fish, and meat, including poultry.

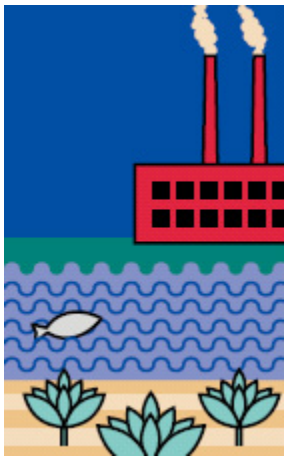
Polycyclic Aromatic Hydrocarbons (PAHs)

A number of studies show increased incidence of cancer (lung, skin, and urinary cancers) in humans exposed to mixtures of polycyclic aromatic hydrocarbons (PAHs). The primary source of PAHs is the burning of carbon-containing compounds. Burning wood and other fuels in homes produces PAHs in air. They are also contained in gasoline and diesel exhaust, soot, ***coke***, cigar and cigarette smoke, and charcoal-broiled foods. In addition, they are the byproducts of open fires, waste incinerators, coal gasification, and coke oven emissions. Foods that contain small amounts of PAHs include smoked, barbecued, or charcoal-broiled foods, roasted coffees, and sausages.

Metals

Arsenic compounds are associated with many forms of skin, lung, bladder, kidney, and liver cancers, particularly when high levels are consumed in drinking water. Occupational exposure to inhaled arsenic, especially in mining and copper smelting, has been consistently associated with an increased lung cancer risk. Arsenic is also used in wood preservatives, glass, herbicides, ***insecticides*** (ant killers), and pesticides and is a general environmental contaminant of air, food, and water.

Beryllium compounds are known to cause lung cancer, as worker studies in beryllium production facilities have shown. Beryllium compounds are used as



- Metals for aerospace and defense industries;
- For electrical components,
- X-ray tubes
- Nuclear weapons
- Aircraft brakes
- Rocket fuel additives
- Light aircraft construction, and the manufacture of ceramics;
- And as an additive to glass and plastics,
- Dental applications, and
- Golf clubs.

Industry is also increasingly turning to beryllium for fiber optics and cellular network communication systems. Workers can be exposed through jobs related to the above-listed activities, as well as through recycling of computers, cell phones, and other high-tech products. Outside of these industries, beryllium exposure occurs primarily through the burning of coal and fuel oil. The general population can be exposed to trace amounts of beryllium by inhaling air and consuming food contaminated with beryllium residues. Small beryllium concentrations have been reported in drinking water, food, and tobacco.

Studies of worker groups show that **cadmium metal** and **cadmium compounds** are associated with an increased risk of lung cancer. Workers with the highest exposures are those involved in removing zinc and lead from minerals, producing cadmium powders, welding cadmium-coated steel, and working with solders that contain cadmium. Cadmium metal's primary use is as a metal coating to prevent corrosion. Other uses are in plastic and synthetic products, in batteries, stabilizers for polyvinyl chloride, and in ***fungicides***. The industrial processes involved in making these products release cadmium into the air, surface water, groundwater, and topsoil where cadmium can be taken up by both land and water plants and, in turn, transferred to animals. Contaminated topsoil that allows uptake into tobacco plants may be indirectly responsible for the greatest nonoccupational human exposure to cadmium—smoking. For nonsmokers, food is the main source of human exposure to cadmium.

Some **chromium compounds** are known to cause lung cancer. The steel industry is the major consumer. Chromium, is used for protection against corrosion of metal accessories, including automotive parts, as well as for electroplating, (i.e., layering one metal over another). Electroplating converts chromium(VI)—the carcinogenic form—into a noncarcinogenic form. This means that workers who handle chromium VI are at greater risk than is the general population. Other chromium uses include nuclear and high-temperature research, the textile and leather-tanning industry, pigments for floor covering products, paper, cement, and asphalt roofing, and creating

emerald-colored glass. Chromium is widely distributed in the air, water, soil, and food. Through some of these media, the entire population is probably exposed. The highest chromium exposure occurs in occupations related to stainless steel production, welding, chrome plating, and leather tanning. Typical levels are low in most fresh foods.

Lead acetate and **lead phosphate** are, given the evidence of kidney and brain tumors in animal studies, likely human carcinogens. Lead acetate is used in cotton dyes; as a coating for metals; as a drier in paints, varnishes, and pigment inks; as a colorant in certain permanent hair dyes (progressive dyes); in explosives; and in washes to treat poison ivy. Lead phosphate is a stabilizer in certain plastics and specialty glass. Primary exposures are through skin contact, eating, and inhaling.

Nickel and **nickel compounds** are associated with several kinds of cancers in rats and mice. Human-population studies link nickel exposure to cancers of the nasal cavity, lung, and possibly the larynx (voice box). Nickel is used in steel, dental fillings, copper and brass, permanent magnets, storage batteries, and glazes. Because in the United States nickel is present in the air, water, soil, food, and consumer products, we are exposed through eating, breathing, and skin contact.

Metal	Cancers	Present In	Human Carcinogen?	Workers Exposed
Arsenic	Skin, lung, bladder, kidney, liver	Wood preservatives, glass, pesticides	Yes	Smelting of ores containing arsenic, pesticide application, and wood preservation
Beryllium	Lung	Nuclear weapons, rocket fuel, ceramics, glass, plastic, fiber optic products	Yes	Beryllium ore miners and alloy makers, phosphor manufacturers, ceramic workers, missile technicians, nuclear reactor workers, electric and electronic equipment workers, and jewelers
Cadmium	Lung	Metal coatings, plastic products, batteries, fungicides	Yes	Smelting of zinc and lead ores, producing, processing and handling cadmium powders, welding or remelting of cadmium-coated steel, and working with solders that contain cadmium
Chromium	Lung	Automotive parts, floor covering, paper, cement, asphalt roofing; anticorrosive metal plating	Yes	Stainless steel production and welding, chromate production, chrome plating, ferrochrome alloys, chrome pigment, and tanning industries
Lead	Kidney,	Cotton dyes, metal	Probable	Construction work that involves

	brain	coating, drier in paints, varnishes, and pigment inks, certain plastics, specialty glass	carcinogen	welding, cutting, brazing, or blasting on lead paint surfaces; most smelter workers, including lead smelters where lead is recovered from batteries; radiator repair shops
Nickel	Nasal cavity, lung	Steel, dental fillings, copper and brass, permanent magnets, storage batteries, glazes	Nickel metal: Probable carcinogen Nickel compounds: Yes	Battery makers, ceramic makers, electroplaters, enamellers, glass workers, jewelers, metal workers, nickel mine workers, refiners and smelters, paint-related workers and welders

Diesel Exhaust Particles	The particles in diesel exhaust are suspected carcinogens because of the elevated lung cancer rates found in occupational groups exposed to diesel exhaust, such as railroad workers, mine workers, bus garage workers, trucking company workers, car mechanics, and people who work around diesel generators. Cancer risks are unknown from lower exposures in day-to-day living.
Toxins from Fungi	**Aflatoxins** are cancer-causing substances produced by certain types of fungi growing on food. Grains and peanuts are the most common foods on which these fungi grow. Meat, eggs, and milk from animals that eat aflatoxin-contaminated feed are other exposure sources. Agricultural workers are potentially at risk if they inhale contaminated airborne grain dust. Exposure to high levels of aflatoxins increases the risk of liver cancer. In most countries, including the United States, peanuts are screened for aflatoxin, before processing. The risk of aflatoxin exposure is higher in developing countries where screening for the fungus does not occur.
Vinyl chloride	Vinyl chloride, a colorless gas, is a human carcinogen associated with lung cancers and angiosarcomas (blood vessel tumors) of the liver and brain. In the United States it is used almost exclusively by the plastics industry in manufacturing many consumer products, including containers, wrapping film, electrical insulation, water and drain pipes, hosing, flooring, windows, and credit cards. Human exposure occurs primarily in workers in the plastic industry—not in using the end products such as vinyl siding or hosing. The plastics industries are believed to be the major source of vinyl chloride releases into the environment. Although people living near a plastics plant are exposed by breathing contaminated air, exposure of the general population away from a plastics plant is essentially zero.

Benzidine

Benzidine was one of the first chemicals recognized as associated with increased cancer risk in humans. As early as 1921, increased cases of bladder cancer were reportedly associated with benzidine, a compound used in the production of more than 250 benzidine-based dyes for textiles, paper, and leather products. Human exposure to either benzidine or **benzidine-based dyes** is now known as carcinogenic. Once inside the body, the dyes break down into benzidine. In most cases, dyes that metabolize to benzidine are hazards only near dye and pigment plants where wastes may escape or may be discharged.

Key Points

- Exposures to various fibers, fine particles, and dust occur in several industrial settings and are associated with increased cancer risks.
- Dioxins are unwanted chlorine- and hydrocarbon-containing byproducts of chemical processes. A particular dioxin likely to be carcinogenic to humans is **TCDD** (2,3,7,8-**t**etra**c**hloro**d**ibenzo-*p*-**d**ioxin). TCDD is highly carcinogenic in animals, and increased overall cancer death rates have been reported in highly exposed workers.
- A number of studies show an increased incidence of cancer in humans exposed to mixtures of polycyclic aromatic hydrocarbons (PAHs).
- Arsenic compounds are associated with many forms of cancers, particularly when high levels are consumed in drinking water.
- Beryllium compounds are known to cause lung cancer, based primarily on worker studies in beryllium production facilities.
- Studies of groups of workers show that cadmium metal and cadmium compounds are associated with an increased lung cancer risk.
- Some chromium compounds are known to cause lung cancer. Chromium is widely distributed in the air, water, soil, and food. The entire population is probably exposed to some of these compounds.
- Lead acetate and lead phosphate are likely human carcinogens, based on animal-study evidence of kidney and brain tumors.
- Nickel and nickel compounds are associated with several kinds of cancers in rats and mice. Because in the United States nickel is present in the air, water, soil, food, and consumer products, we

are exposed through eating, breathing, and skin contact.

- The particles in diesel exhaust are suspected carcinogens because of the elevated lung cancer rates found in occupational groups exposed to diesel exhaust.
- Aflatoxins are cancer-causing substances produced by certain types of fungi growing on food.
- Vinyl chloride is a human carcinogen used almost exclusively in the United States by the plastics industry in manufacturing many consumer products
- Benzidine was one of the first chemicals recognized as associated with increased cancer risk in humans. It is used in the production of dyes.

Progress Check

Choose the best answer.

10. Which of the following statements concerning fibers, fine particles, and dust is **INCORRECT**?

    A. Asbestos fibers and all commercial forms of asbestos are human carcinogens.
    B. Asbestos exposures account for the largest percentage of occupational cancer, with the highest risks among workers who smoke.
    C. Increased rates of mesothelioma—a rare cancer of the lining of the lung and abdominal cavity—and cancer of the lung have been consistently observed in a variety of occupations involving asbestos exposure.
    D. Ceramic fibers are now used as insulation materials and are a replacement for asbestos. These fibers are not carcinogenic.

    To review relevant content, see "Fibers, Fine Particles and Dust" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

11. Which of the following statements concerning dioxins is **INCORRECT**?

    A. Dioxins are chemical products synthesized for commercial purposes.
    B. Dioxins are widespread environmental contaminants.
    C. The general population is exposed to low levels of TCDD primarily from eating dairy products, fish, and meat, including poultry.
    D. Modifications of industrial processes such as bleaching and incineration have resulted in reduced dioxin emissions and have lowered dioxin levels in people.

    To review relevant content, see "Dioxins" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

12. Which of the following statements concerning vinyl chloride is **INCORRECT**?

A. Vinyl chloride, a colorless gas, is a human carcinogen associated with lung cancers and angiosarcomas (blood vessel tumors) of the liver and brain.
B. The major source of releases of vinyl chloride into the environment is believed to be from the plastics industries.
C. People living near a plastics plant are exposed to possible carcinogens by breathing contaminated air.
D. The general population away from the plant also shows levels of exposure.

To review relevant content, see "Vinyl Chloride" under the "What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?" section.

What are some ways to reduce the risk of developing cancer?

Learning Objective

Upon completion of this section, you will be able to

- Describe some ways to reduce the risk of developing cancer.

Introduction

At least two-thirds of cancer cases of are caused by environmental factors. Many of these cancers are linked to lifestyle factors that can be modified, such as cigarette smoking, excessive alcohol consumption, poor diet, physical inactivity, and being overweight or obese. For example, one-third of all the cancer deaths in this country could be prevented by eliminating the use of tobacco products. After tobacco, being overweight or obese appears the most important preventable cause of cancer.

In addition to lifestyle choices, precautions can be taken in the home and workplace to reduce exposure to other harmful substances.

Risk Reduction

Here are some rules you can follow to reduce your risk of developing cancer.

- Do not smoke cigarettes, pipes, or cigars. Do not chew tobacco or dip snuff. Avoid smoke-filled rooms. The use of tobacco products is linked to many cancers.
- Lose weight if you are overweight. Obesity is strongly linked to breast cancer in older women and cancers of the endometrium, kidney, colon, and esophagus.
- Exercise regularly, at least 30 minutes per day for most days of the week. Evidence strongly suggests that exercise by itself reduces the risk of colon and breast cancer. Among very active people, that risk is decreased the most.
- Avoid high-calorie, high-fat food. The chief causes of obesity are a lack of physical activity and eating too much high-calorie food.
- Avoid consuming large amounts of red and preserved meats, salt, and salt-preserved foods. These may increase the risk of colorectal and stomach cancers.
- Eat a daily diet that includes a variety of foods from plant sources, such as fresh fruits, vegetables, whole grains, and whole grain breads and cereals. Fruits and vegetables contain substances (*e.g.*, antioxidants) that help defend against toxic agents and disease.
- Drink alcohol in moderation, if at all, especially if you smoke. (One or two alcoholic drinks a day is considered moderate.) Heavy drinking is linked to cancers of the mouth, throat, esophagus, voice box, liver, and breast.
- Avoid too much sunlight, particularly if you are fair skinned, by avoiding sun exposure at midday (10 a.m.–4 p.m., when sun exposure is strongest), wearing protective

clothing, and using sunscreen. Many of the more than one million skin cancers diagnosed every year can be prevented by protection from the sun's rays. Avoid tanning beds and other artificial sun or UV exposure.

- Avoid viral or bacterial infections:
    - Do not engage in unprotected or otherwise unsafe sexual intercourse that may result in HIV, HPV, hepatitis B, or hepatitis C infection.
    - Do not use recreational injection drugs, such as heroin or cocaine, which may result in HIV, hepatitis B, or hepatitis C infection.
    - Get vaccinated against hepatitis B infection, an easy and safe procedure if you are 18 years of age or younger. Also, get vaccinated if you are over 18 and at risk of infection. At-risk people include health care workers, IV drug users, and homosexual men. Currently, no vaccine is available for hepatitis C.

      For vaccination information, visit **www.cdc.gov/vaccines/**.)

    - Get vaccinated against genital human papillomavirus (HPV) that cause most cases of cervical cancer and genital warts.

      For vaccination information, visit **www.cdc.gov/std/hpv/STDFact-HPV-vaccine-young-women.htm**

    - Seek medical attention for chronic stomach problems—they might be caused by *H. pylori* infection, which can be treated.
- If you have HIV or hepatitis C infection, seek medical attention and adhere to recommended treatments. These infections increase your risk of developing certain cancers.
- Because repeated exposure to diagnostic X-rays could be harmful, talk to your doctor about the need for each X-ray and the use of shields to protect other parts of the body.
- Check your home for high levels of radon. Radon levels in a home can be greatly reduced by a professionally installed ventilation system in the basement.

  For more information, visit the Environmental Protection Agency Web site: **www.epa.gov/radon/**.)

- Avoid contact with pesticides. Exposure to pesticides comes largely through the skin. If contact occurs, wash up quickly.
- When working with solvents, make sure the room is well ventilated. If possible, work outside or open the windows.
- If you work in an environment with high exposures to fine particles, fibers, or dusts, wear the appropriate protective mask over your nose and mouth. Make sure it fits properly and does not obstruct your view.
- When handling chemicals in the home or workplace, use good work practices. Wear proper personal protective equipment, keep protective equipment well maintained, clean spills immediately, keep work surfaces as free of dust and chemicals as possible, and use wet cleaning methods to avoid generating dust.
- Be aware that certain occupations are known to be associated with high cancer risks. Some of these include painters, furniture makers, workers in the iron, steel, coal, and rubber industries, and workers involved in boot and shoe manufacture or repair.

  For more information, call the National Institute for Occupational Safety and Health toll-free number, 1-800-356-4674.) or visit **ehp.niehs.nih.gov/roc/tenth/append/appa.pdf**

- Inquire at your workplace about Material Safety Data Sheets (MSDSs). A MSDS is a document that manufacturers of chemical products are required to develop for any product that contains hazardous substances. The MSDS contains information on the toxicity of a substance, whether it is considered carcinogenic, the recommended exposure levels of the ingredients in the product, and appropriate precautions to take or appropriate recommended personal protective equipment to wear. Employers are required to make the MSDSs accessible to employees and to inform/train employees about the information.

  For information about possible workplace issues, call the toll-free number, 1-800-356-4674 or visit the National Institute for Occupational Safety and Health Web site at **www.cdc.gov/niosh/topics/chemical-safety**

- Make sure your employer has put in place appropriate engineering controls such as local exhaust ventilation.

Key Points

- Do not smoke cigarettes, pipes, or cigars. Do not chew tobacco or dip snuff. Avoid smoke-filled rooms.
- If you are overweight, lose weight.
- Exercise regularly, at least 30 minutes per day for most days of the week.

- Avoid high-calorie, high-fat food.
- Avoid consuming large amounts of red and preserved meats, salt, and salt-preserved foods.
- Eat a daily diet that includes a variety of foods from plant sources.
- Drink alcohol in moderation, if at all, especially if you smoke.
- Avoid too much sunlight, particularly if you are fair-skinned.
- Avoid viral or bacterial infections.
- If you have HIV or hepatitis C infection, seek medical attention and adhere to recommended treatments.
- Talk to your doctor about the need for each X-ray and the use of shields to protect other parts of the body.
- Check your home for high radon levels.
- Avoid contact with pesticides.
- When working with solvents, make sure the room is well ventilated.
- When you work in an environment with high exposures to fine particles, fibers, or dusts, wear the appropriate protective mask over your nose and mouth.

Progress Check

Choose the best answer.

13. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?

    A. At least two-thirds of the cases of cancer are caused by environmental factors.
    B. One-third of all the cancer deaths in this country could be prevented by eliminating the use of tobacco products.
    C. After tobacco, exposure in the home and workplace appears to be the most important preventable cause of cancer.
    D. Precautions can be taken in the home and workplace to reduce exposure to other harmful exposures.

    To review relevant content, see "Introduction" under the "What are some ways to reduce the risk of developing cancer?" section.

14. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?

    A. The use of tobacco products is linked to many cancers.
    B. Obesity is strongly linked to breast cancer in older women and cancers of the endometrium, kidney, colon, and esophagus.
    C. Inherited traits from parents are the chief causes of obesity.
    D. Large amounts of red and preserved meats, salt, and salt-preserved foods may increase the risk of colorectal and

stomach cancers.

To review relevant content, see "Risk Reduction" under the "What are some ways to reduce the risk of developing cancer?" section.

15. Which of the following statements concerning reducing the risk of developing cancer associated with viral or bacterial infections is **INCORRECT**?

    A. HIV, HPV, hepatitis B, or hepatitis C viral infections increase the risk of developing certain cancers.
    B. The use of recreational injection drugs such as heroin or cocaine may result in HIV, hepatitis B, or hepatitis C infection.
    C. Unprotected or otherwise unsafe sexual intercourse may result in HIV, HPV, hepatitis B, or hepatitis C infection.
    D. Vaccines can prevent HIV, HPV, hepatitis B, or hepatitis C infections.

    To review relevant content, see "Risk Reduction" under the What are some ways to reduce the risk of developing cancer?" section.

What are some ways to detect cancer at an early stage?

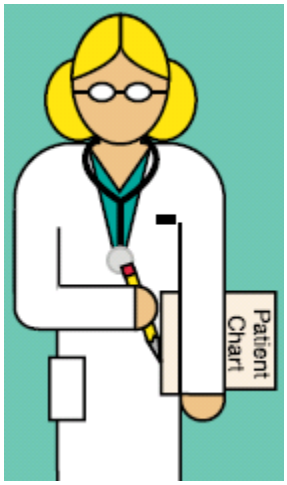
Learning Objective Upon completion of this section, you will be able to

- Explain some ways to detect cancer at an early stage.

Introduction

Sometimes exposures to toxic substances cannot be avoided. Certain diagnostic procedures will not reduce the exposure to substances in the environment but may detect cancers at an early stage before they spread to other parts of the body.

Detecting Cancers at an Early Stage



- Tell your health care provider about the chemicals you use at work or at home. With this information, your health care provider can perform appropriate medical screening tests for early detection of cancer.
- Ask your physician if increased cancer risks are associated with your family or personal medical history or medical drugs you are taking. He or she may advise appropriate screening procedures.
- Get a screening test regularly for these cancers:
  - *Breast:* A mammogram, an X-ray of the breast, is the best method of finding breast cancer before symptoms appear. Several organizations recommend mammography screening every 1 to 2 years after age 40. Women at higher than average risk of breast cancer should seek expert advice about screening before age 40 and about the frequency of screening.
  - *Cervix:* The Pap test or Pap smear is the most successful screening tool used to screen for cancer of the cervix. Cells are collected from the cervix and examined under a microscope to detect cancer or changes that may lead to cancer. Many doctors recommend yearly Pap tests. Less frequent screening is recommended by some organizations for women with at least three consecutive negative exams.
  - *Colon and Rectum:* A number of screening tests are used to find colon and rectal cancer. If a person has a family medical history of colorectal cancer or is over the age of 50, a doctor may suggest one or more of these tests:
    - The fecal occult blood test checks for small amounts of blood in the stool;
    - A sigmoidoscopy is the use of a lighted tube to examine the rectum and lower colon;
    - A colonoscopy is performed to see the entire colon and rectum.

      With either a sigmoidoscopy or a colonoscopy, abnormal tissue can be removed and examined under a microscope.

  - As new information becomes available, guidelines are

constantly revised for the age and frequency of screening tests. To find out more, see the Web site: **cancer.gov/cancer_information/testing**.

- Be alert for changes in your body. Cancer may cause a variety of symptoms. Here are some:
  - Thickening or lump in any part of body,
  - Obvious change in a wart or mole,
  - A sore that does not heal,
  - Nagging cough or hoarseness,
  - Changes in bowel or bladder habits,
  - Indigestion or difficulty swallowing,
  - Unexplained changes in weight, and
  - Unusual bleeding or discharge

  Cancer DOES NOT always cause these symptoms. It is important to see a doctor about these or other physical changes that continue for some time. Because certain cancers have no obvious symptoms, routine physical exams are recommended.

- Stay informed and be proactive.
  - Ask your doctor questions.
  - If you suspect that you are exposed to a carcinogen in your work or home environment, try to find out more. Use the resources at the end of the training to contact the agencies responsible for protecting the environment.
  - Get involved in activities aimed at reducing our exposure to cancer-causing substances. Government agencies, industries, health professionals, and individuals can all contribute to reducing the risks in the environment. For example, to control the obesity epidemic, efforts to increase physical activity and promote healthy eating are needed in many parts of society, including families, schools, day care centers, food companies, restaurants, work sites, health care systems, and departments of transportation and city-planning.

Good Places to Look

For local environmental issues:
www.cdc.gov/mmwr/international/relres.html
For workplace issues:
www.cdc.gov/niosh/topics/chemical-safety
For health effects of ingredients in common household products:
householdproducts.nlm.nih.gov

Key Points

- Tell your health care provider about the chemicals you use at work or at home.
- Ask your physician if increased cancer risks are associated with your family or personal medical history or with medical drugs you are taking.
- Get a screening test regularly for breast, cervix, colon, and rectum cancers.
- Be alert for changes in your body. Cancer may cause a variety of symptoms.

- Stay informed and be proactive.

Progress Check

Choose the best answer.

16. Which of the following statements concerning detecting cancers at an early stage is **INCORRECT**?

    A. Men and women (as applicable) should get regular screening tests for breast, cervix, colon and rectum cancers.
    B. Changes in bowel or bladder habits, indigestion or difficulty swallowing and unexplained changes in weight are sure signs of cancer.
    C. You should tell your health care provider about the chemicals you use at work or at home.
    D. You should ask your health care provider if increased cancer risks are associated with your family's or your personal medical history or medical drugs you are taking.

    To review relevant content, see "Detecting Cancers at an Early Stage" under the "What are some ways to detect cancer at an early stage?" section.

17. Which of the following statements concerning detecting cancer at an early stage is **INCORRECT**?

    A. A mammogram is the best method of finding breast cancer before symptoms appear.
    B. The Pap test or Pap smear is the most successful tool to screen for cancer of the cervix.
    C. A fecal occult blood test, a sigmoidoscopy, or a colonoscopy are screening tests used to find colon and rectal cancer.
    D. With a fecal occult blood test, a sigmoidoscopy or a colonoscopy, abnormal tissue can be removed and examined under a microscope.

    To review relevant content, see "Detecting Cancers at an Early Stage" under the "What are some ways to detect cancer at an early stage?" section.

How do scientists identify cancer-causing substances?

Learning Objective Upon completion of this section, you will be able to

- Explain how scientists identify cancer-causing substances.

Introduction

Over the last 30 years, scientists have worked hard to identify substances in the home, workplace, and general environment that cause cancer. This is a challenging task: in the United Sates more than 100,000 chemicals are commonly used in household cleaners, solvents, pesticides, food additives, lawn care, and other products. Every year another 1,000 or so chemicals are introduced. These are single substances that do not take into account the mixtures and various combinations of commercial and consumer products to which people in the United States are exposed every day. And many chemicals may be changed to different substances by the atmosphere, water, plants, and by incineration or combustion.

Identification of cancer-causing substances is further compounded by the fact that cancer-causing substances are sometimes created during the synthesis or combustion of other chemicals. Dioxin is an example of this kind of unwanted contaminant (see **Dioxins**). And besides manufactured chemicals, many natural products can also cause cancer. One example is aflatoxin (see **Toxins from Fungi**).

Evidence for identifying cancer-causing substances comes from three sources:

- **Human studies**,
- **Animal studies**, and
- **Laboratory experiments with human cells**.

Evidence from each of these sources is important in helping public health officials decide whether exposure to certain substances needs to be reduced or eliminated. The more information available, the more likely it is that they will be able to identify carcinogenic substances.

Human Studies

The most certain method of identifying such substances is to observe whether they have caused cancer in people. Epidemiologists design studies that follow certain populations over time to observe whether a specific agent (*e.g.*, arsenic or benzene) or exposure (*e.g.*, sunlight or smoking) is likely to cause cancer. Environmental causes of cancer have frequently been first noticed in the workplace. This is because workers in certain occupations have higher exposures to particular chemicals and for longer periods of time than do the general population.

The International Agency for Research on Cancer (**http://www.iarc.fr**), an agency of the **World Health Organization**, classified certain occupations as associated with cancer-causing exposures because of the increased incidence of

cancers in these settings. Some of these include

- Painters,
- Furniture makers,
- Workers in the iron, steel, coal, and rubber industries, and
- Workers involved in boot and shoe manufacture or repair.

This knowledge has helped these industries and public health specialists develop processes and safety procedures designed to minimize worker exposure to cancer-causing substances. The risk is less now than in previous years.

Yet health agencies would fail in their responsibility to prevent cancer if they merely documented workplace-related cancers. They would find out about cancer risks only after many people developed symptoms of the disease, sometimes 20 to 30 years after exposure. Other epidemiology studies compare the exposure histories of people who have developed cancer with comparison groups who have not developed cancer at a particular point in time. Such studies allow researchers to look at a wide range of past exposures that may have occurred in a variety of settings, not just at those in a particular occupational setting. But these studies may miss some important links between exposures and cancer. To determine what chemicals people were exposed to many years earlier, to what degree they were exposed, and which specific ones are harmful is often difficult. But we cannot test potential cancer-causing agents with people. Observational epidemiological studies, then, are the best source of data on real world exposures and often do provide important clues.

Other testing methods involving animals and laboratory experiments are also important. They allow scientists to anticipate potential cancer-causing exposures before those exposures result in large numbers of human cancers.

Animal Studies

Mice or rats are most commonly used to test for cancer-causing substances. Rats and mice are not only smaller, easier to handle, and more economical than larger animals; in their response to carcinogens, they are generally similar to humans. Most major forms of human cancer have been reproduced in such animals through exposure to chemical carcinogens. Because the lifetime of rodents is only 2 to 3 years, they generally provide information about the cancer-causing potential of test materials relatively quickly. Special strains of mice

and rats have been developed to be particularly suitable for cancer testing. However, differences in animal and human digestive physiology complicate the relevance of diet studies in animals.

How well do animal tests predict whether a substance can cause cancer in humans?

Of the approximately 200 agents known to cause cancer in humans, nearly all have also been shown also to cause cancer in rats or mice. But how many of the several hundred other chemicals that cause cancer in animals are also human carcinogens is as yet unknown. In some instances, positive tests with mice or rats were later confirmed by the occurrence of cancer in exposed humans. In other instances, studies in human populations have failed to confirm the positive tests in mice. Most importantly, however, for many chemicals suspected of causing cancer in humans, no human studies have yet been done. Thus we do not know for sure whether these chemicals do or do not cause cancer in humans.

Yet materials that cause cancer in one type of animal have been found to cause cancer in other animals. Public health officials must therefore heed the warnings animal tests provide. Positive tests in animals are often serve as a basis for reducing or eliminating human exposure to probable cancer-causing agents., One example is when drinking water disinfectant byproducts and several solvents were shown to be carcinogenic in rats and mice. Regulatory controls to reduce human exposures were immediately established.

We often read about mice or rats being given dosages much higher than those to which humans normally would be exposed. Are such high doses really used, and if so, why?

Yes, high doses are often used to increase the ability of the tests to detect cancer-causing potential.

Large numbers of people are exposed to low doses of chemicals, but the total impact may not be small at all—a carcinogen might cause one tumor in every 10,000 people exposed to it. But exposure of 230 million Americans would result in 23,000 cancers—a public health disaster. To detect such a low cancer rate, we would need tens of thousands of mice. This would cost approximately $50 million for every chemical tested: not only expensive and time-consuming, but requiring far too many animals.

With high dosages, any potential cancerous effects are more likely detected—even in small groups of rodents. This is because the cancer rate among the test animals is increased correspondingly. If 20 or 30 of a test group of 50 mice develop cancers at much higher doses while the group not receiving the chemical has only a few cancers, the subject chemical is capable of causing cancer. When high doses do not cause cancer in animals, the greater is the assurance that the chemical

	will not cause cancer in people.
Experiments with Human Cells Grown in the Laboratory	As part of an ongoing effort to reduce the use of animals in cancer testing, researchers are using human cells grown in the laboratory. Cells exposed to potential carcinogens are monitored to see whether molecular changes characteristic of cancer cells develop. Besides reducing the use of animals, these kinds of studies can be done more quickly and economically and can be useful in evaluating whether to perform the studies in rats and mice. Results from laboratory experiments also provide clues to epidemiologists about which hypotheses to test in human population studies. Human observational studies evaluating the effect of exposure to formaldehyde and methylene chloride were initiated because of data from laboratory and animal studies. In a few cases, evidence from laboratory experiments—and knowledge of the behavior of related compounds known to be carcinogenic—is strong enough to classify a chemical as a known or probable human carcinogen. Experiments using human cells helped to classify more than 200 benzidine-based dyes as human carcinogens. Benzidine had already been classified as a known human carcinogen and scientists suspected that any dye that released benzidine inside the human body would also be a human carcinogen. When human cells grown in the laboratory were exposed to a particular dye, they were able to test whether benzidine was released. Those that did were classified as human carcinogens. In another example, one piece of data from laboratory experiments showing that it caused DNA damage in blood cells from exposed workers led to the classification of **ethylene oxide** (used as a starting material in the production of other chemicals and as a disinfectant and sterilant) as a known human carcinogen. Although such studies might reduce reliance on animals in toxicology research, testing of potential carcinogens in rodents remains an important part of cancer prevention strategies. But all scientific data available for a potential carcinogen are important, and the combination of human studies, animal studies, and laboratory experiments with human cells provides scientists with the most complete understanding of chemical risks of cancer.
Key Points	• In the United States more than 100,000 chemicals are commonly used in household cleaners, solvents, pesticides, food additives, lawn care, and other products. Every year, another 1,000 or so chemicals are introduced. • Besides manufactured chemicals, many natural products can also cause cancer. • The combination of human studies, animal studies, and laboratory experiments provides scientists with the most complete understanding of chemical risks of cancer. • Human studies ○ The most certain method of identifying cancer-causing substances is to observe whether those substances have caused cancer in people.

- Environmental causes of cancer have frequently been first identified in the workplace.
- Health agencies would fail in their responsibility to prevent cancer if they merely documented workplace-related cancers; they would find out about cancer risks only after many people developed symptoms of the disease, sometimes as long as 20 to 30 years after the exposure.
- Other epidemiology studies compare the exposure histories at a particular point in time of people who 1) have developed cancer, with 2) comparison groups of people who have not developed cancer. Such studies allow researchers to look at a wide range of exposures that may have occurred in a variety of settings in the past—not just at those that occurred in a particular occupational setting.
- To determine what chemicals people were exposed to many years earlier, to what degree they were exposed, and which specific chemicals were harmful is often difficult.

- Animal studies
  - Mice or rats are most commonly used to test for cancer-causing substances because they are smaller, easier to handle, and more economical than larger animals. Also, they are generally similar to humans in their response to carcinogens.
  - Of the approximately 200 agents known to cause cancer in humans, nearly all have also been shown to cause cancer in rats or mice. But we do not know how many of the several hundred other chemicals that cause cancer in animals are also human carcinogens.
  - High doses are often used to increase the ability of tests to detect cancer-causing potential. With high dosages, any potential cancer-causing effects are more likely detected, even in small groups of rodents. This is because the cancer rate among the test animals increases correspondingly.
- Laboratory experiments with human cells
  - Researchers use human cells grown in the laboratory as part of an ongoing effort to reduce the use of animals in cancer testing.
  - Such studies can be done more quickly and economically and can be useful in evaluating whether to perform additional or follow-up studies in rats and mice.

Progress Check

18. Which of the following statements concerning challenges for scientists in identifying substances that cause cancer is **INCORRECT**?

Choose the best answer.

A. Americans commonly use more than 100,000 different chemicals.
B. During the synthesis or combustion of other chemicals, cancer-

causing substances are sometimes created.
C. All cancer-causing substances are manufactured as opposed to natural.
D. Every year, manufacturers introduce another 1,000 or so new chemicals.

To review relevant content, see "Introduction" under the "How do scientists identify cancer-causing substances?" section.

19. Which of the following statements concerning sources of evidence for identifying cancer-causing substances is **INCORRECT**?

A. Evidence for identifying cancer-causing substances is derived IN PART from human studies.
B. Evidence for identifying cancer-causing substances is derived IN PART from animal studies.
C. Evidence for identifying cancer-causing substances is derived IN PART from laboratory experiments with human cells.
D. Evidence for identifying cancer-causing substances is derived IN PART from theoretical chemical computational calculations.

To review relevant content, see "Introduction" under the "How do scientists identify cancer-causing substances?" section.

20. Which of the following statements concerning the role animal studies play in identifying causes of cancer in humans is **INCORRECT**?

A. Nearly all of the approximately 200 agents known to cause cancer in humans have also been shown to cause cancer in rats or mice.
B. We do not know how many of the several hundred other chemicals that cause cancer in animals are also human carcinogens.
C. Public health officials do not have to heed the warnings provided by animal tests.
D. Positive tests in animals are often used as a basis for reducing or eliminating human exposure to probable cancer-causing agents.

To review relevant content, see "How well do animal tests predict whether a substance can cause cancer in humans?" under the "How do scientists identify cancer-causing substances?" section.

21. Which of the following statements concerning dosage levels given to animals in testing possible cancer-causing substances is **INCORRECT**?

A. Mice or rats are given dosages much higher than those to which humans normally would be exposed.

B. Large numbers of people are exposed to low doses of chemicals, but the total effect may not be small at all.
C. Using high dosages, any potential cancer-causing effects are more likely to be detected—even in small groups of rodents.
D. We have greater assurance that the chemical will not cause cancer in people when LOW doses do not cause cancer in animals.

To review relevant content, see "We often read about mice or rats being given dosages much higher than those to which humans normally would be exposed. Are high doses really used and, if so, why?" under the "How do scientists identify cancer-causing substances?" section.

22. Which of the following statements concerning use of human cells grown in the laboratory in testing for cancer is **INCORRECT**?

A. Experiments with human cells grown in the laboratory are not useful when evaluating whether to perform studies in rats and mice.
B. For epidemiologists, results from experiments with human cells grown in the laboratory provide clues regarding hypotheses to test in human population studies.
C. Although in toxicology research experiments with human cells grown in the laboratory might reduce reliance on animal testing, rodent testing of potential carcinogens remains an important part of cancer prevention strategies.
D. The combination of human studies, animal studies, and laboratory experiments provide scientists with the most complete understanding of the chemical risks of cancer.

To review relevant content, see "Experiments with Human Cells Grown in the Laboratory" under the "How do scientists identify cancer-causing substances?" section.

How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?

Learning Objective	Upon completion of this section, you will be able to • Explain how scientists decide which substances to test in animals, human laboratory cells, or human population studies.
Strategies for Testing in Animals or Human Laboratory Cells	Because resources are limited, scientists must decide out of thousands of candidates which substances to select for testing in animals or in human cells. The tests are costly and time-consuming: determining whether a chemical causes cancer in rats or mice can cost several million dollars and take several years to complete. Three factors generally guide the decision to test a substance.  **The Number of People Exposed** We want to test those chemicals that affect a large number of people or those for which the exposure levels have been unusually high. Pesticides, for example, fit both categories. They potentially affect a large number of people because of trace amounts on foods and their use in or around the home, and in farming-related occupations, exposure levels are high. **Previous Data** This could be a report that in laboratory cells, a chemical causes alterations in human DNA. Or it could be a report that people exposed to a particular chemical in the workplace or at a specific geographical location have developed specific cancers at higher rates than expected. This kind of information provides important clues for decisions about animal testing. Even before any animal testing was done, studies on human and animal cells indicated dioxins and polycyclic aromatic hydrocarbons were suspected carcinogens. **Public Concern** Chromium and some pesticides are examples of a group of concerned citizens first bringing to the attention of public health officials concerns about chemicals. The **National Toxicology Program** has a Web site available to the public to suggest agents suspected of causing cancer: **ntp-server.niehs.nih.gov**; click on "**Nominations to the Testing Program**."
Strategies for Carrying out Large Population Studies	Similar considerations guide epidemiologists as to whether to begin large population studies. Some of these factors include • Animal study data suggesting a cancer-exposure link

	(*e.g.*, vinyl chloride) or a related agent that raises suspicion (*e.g.*, acrylonitrile was studied because of its structural similarity to vinyl chloride). • Results from other epidemiologic studies (large population studies) that suggest the need for additional studies • An exposure's biological mechanisms that suggest a possible link to cancer. • Pockets of specific cancers that cluster in a particular town or place or unusual case reports. • Cancer trends—that is, rates that change over time or with location. • Changes in cancer rates within a population after migration to a new area. • Introduction of a new exposure or technology for which epidemiologic data are needed, or an unusual exposure pattern needing evaluation.

Key Points	• Resources are limited. Scientists must decide out of thousands of candidates which substances should be selected for animals or human cell testing. Tests are costly and time-consuming.
	  ○ Accordingly, we want to test
	  ▪ Those chemicals that affect a large number of people, or
	  ▪ Those for which the exposure levels have been unusually high, or
	  ▪ We might want to test both.
	  ○ Previous data provide important clues for decisions about animal testing. For example
	  ▪ A chemical causes alterations in human DNA in laboratory cells, or
	  ▪ A report that people exposed to a particular chemical in the workplace, or
	  ▪ A report that people at a specific geographical location are getting cancer at higher rates than expected, or
	  ▪ A combination of all three.
	  ○ On occasion, a group of citizens first bring their concerns about chemicals to the attention of public health officials.
	• Similar considerations guide epidemiologists as to whether to begin large population studies.

Progress Check ***Choose the best answer.***	23. In deciding which substances should be selected for testing in animals or with human cells, scientists **DO NOT** use A. Chemicals that affect a large number of persons or chemicals for which exposure levels have been unusually high. B. Chemicals that in laboratory cells cause human DNA alterations. C. Reports that people exposed to a particular chemical in

the workplace develop certain cancers at rates similar to the general population.

D. Chemicals that concerned citizens groups first brought to the attention of public health officials.

To review relevant content, see "Strategies for Testing in Animals or Human Laboratory Cells" under the "How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?" section.

24. Which of the following factors **ARE NOT TAKEN INTO CONSIDERATION** by epidemiologists when beginning large population studies?

A. Data from animal studies suggesting a cancer-exposure link.
B. Cancer trends or rates that do not change over time or with location.
C. Changes in cancer rates within a population after that population has migrated to new area.
D. Pockets of cancers that cluster in a particular town or place or that are the subjects of unusual case reports.

To review relevant content, see "Strategies for Carrying out Large Population Studies" under the "How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?" section.

25. Public health agencies classify substances as known or suspected human carcinogens based on evidence of cancer from at least one type of exposure, **EXCEPT FOR**

    A. Either high short- or long-term workplace exposures.
    B. Continuous low-level exposure or occasional exposure to carcinogens in the environment.
    C. Continuous low-level exposure or occasional exposure to carcinogens in the workplace.
    D. Single, acute exposures following industrial accidents or similar incidents.

    To review relevant content, see "Type of Exposure" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

26. Which of the following statements concerning acceptable risk levels by regulatory agencies is **INCORRECT**?

Choose the best answer.

    A. Acceptable risks are generally LOWER for exposure in the workplace than for exposure in the general environment.
    B. Acceptable risks are generally HIGHER for exposure in the workplace than for exposure in the general environment.
    C. The range of the risk level considered acceptable by regulatory agencies for a linear dose response starts at one cancer in every million persons exposed.
    D. The risk level range considered acceptable by regulatory agencies for a linear dose response ends at one cancer in every 1,000 persons exposed.

    To review relevant content, see "Acceptable Risk Levels" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

27. Which of the following statements concerning dose-response levels and risk of cancer is **INCORRECT**?

    A. In a linear dose response, the risk decreases as the exposure decreases—all the way to zero.
    B. In a linear dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
    C. In a threshold-dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
    D. A threshold dose response may include an exposure level below which an increase in risk is not detectable.

    To review relevant content, see "Dose Response" under the "What factors do scientists consider in determining the risk associated with different cancer-causing substances?" section.

How do public health officials set acceptable exposure levels for environmental chemicals?

Learning Objective Upon completion of this section, you will be able to

- Explain how public health officials set acceptable exposure levels for environmental chemicals.

Linear Dose Response

Regulatory agencies such as the Environmental Protection Agency, Food and Drug Administration, and Occupational Safety and Health Administration usually first determine whether a carcinogen exhibits linear or threshold-like dose-response behavior. Although government scientists conduct rigorous scientific reviews to evaluate everything known about a cancer-causing substance, frequently not enough information is available to distinguish between these two kinds of dose responses. In the absence of compelling evidence for a threshold-like mechanism, to protect the public health agencies assume a linear dose response. This means that any exposure, no matter how small, would carry some risk.

Threshold-Like Dose Response

For carcinogens that exhibit threshold-like dose responses, other factors such as age, sex, genetic makeup, and diet are taken into consideration. When setting acceptable exposure levels of pesticides for example, the potentially greater health effects on children of pesticide residues on food are taken into consideration. Moreover, if the cancer testing is done in rats and mice, scientists consider the possibility that people are more sensitive than are rats or mice to the cancer-causing effects of a particular chemical. These factors can result in setting acceptable levels of exposure as much as 1,000 times below the level that causes a substantial increase in cancer in rodents. This approach provides a safety margin such that the acceptable level of exposure set by a regulatory agency will indeed protect the public health.

Risks *versus* Benefits

Another factor adds to the difficulty of regulating exposure to environmental chemicals: many substances that might cause cancer in people might also provide benefits to people.

Pharmaceuticals are the best example of routine benefit/risk analyses. With cancer chemotherapy drugs, we know they may be effective in treating or preventing cancer, but they also might increase the risk of second cancers developing years after the treatment. Yet cancer is often immediately life-threatening; thus the benefits usually outweigh the risks. Tamoxifen is effective in preventing the recurrence of breast cancer in many women, but also increases the risk of uterine cancer, blood clots, and strokes. The U.S. Food and Drug Administration, the National Cancer Institute, and the World Health Organization rigorously analyze the benefits and risks. They all concluded that the benefits of tamoxifen for women who have had breast cancer or for a relatively small number of women at high risk of developing breast cancer strongly outweigh the serious risks associated with the drug.

Pesticides are another example. Pesticides use has increased crop

	yields and has significantly benefited agricultural production. Yet concern remains over potential health effects of pesticide residues on foods consumed by humans. These potential risks are reduced by setting maximum residue levels on fruits, vegetables, and other produce and by using noncarcinogenic pesticides.
Uncertainty and Public Debate	Public health officials are in the best position to identify accurately carcinogens when evidence is available from all levels—human, animal, and laboratory—but this is seldom the case. Officials often have to exercise scientific judgment and make decisions in the face of uncertainty. In these circumstances, public health agencies operate under the principle that public health protection is paramount. Decisions are debated in open public forums involving scientists from diverse disciplines and interested members of industry, environmental groups, and the public. Public health agencies communicate this uncertainty by placing the substances in categories depending on the strength of the evidence. The categories used by the U.S. Department of Health and Human Services' (DHHS) ***Report on Carcinogens*** are "known to be" and "reasonably anticipated to be" human carcinogens.
Protection of Public Health	In the face of uncertainty, public health agencies operate under the principle that protection of public health is paramount. This means that acceptable levels of exposure are set as much as 1,000 times below the level that causes a substantial increase of cancer in laboratory animals.

Key Points	• One of the first considerations by regulatory agencies is to determine whether a carcinogen exhibits linear or threshold-like dose-response behavior.
	• In the case of carcinogens exhibiting threshold-like dose responses, other factors such as age, sex, genetic makeup, and diet are taken into consideration.
	• Another factor adding to the difficulty of regulating exposure to environmental chemicals is that many substances that might cause cancer in people might also have some benefits for people.
	  ○ With cancer chemotherapy drugs, we know that while they might be effective in treating or preventing cancer, they also might increase the risk of second cancers developing years after the treatment.
	  ○ Pesticides use has increased crop yields and has significantly benefited agricultural production. Yet concern remains over potential health effects of pesticide residues on foods consumed by humans.
	• Public health officials are in the best position to identify carcinogens accurately when evidence is available from all levels—human, animal, and laboratory—but this is seldom the case. Officials often have to exercise scientific judgment and make decisions in the face of uncertainty.
	• Given such uncertainty, public health agencies operate on the principle that protection of public health is paramount.
	  ○ This means that acceptable levels of exposure are set as much as 1,000 times below the level that causes a

substantial increase of cancer in laboratory animals.

Progress Check

Choose the best answer.

28. Which of the following statements concerning the setting of acceptable exposure levels for environmental chemicals is **INCORRECT**?

    A. One of the first considerations by regulatory agencies is to determine whether a carcinogen exhibits linear or threshold-like dose-response behavior.
    B. Absent compelling evidence for a linear response, agencies assume that to protect public health, the dose response is threshold-like.
    C. Absent compelling evidence for a threshold-like mechanism, to protect the public health agencies assume that the dose response is linear.
    D. Absent compelling evidence to the contrary, agencies assume that any exposure—no matter how small—has some risk.

    To review relevant content, see "Linear Dose Response" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

29. Which of the following statements concerning threshold-like dose responses is **INCORRECT**?

    A. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are EQUALLY AS SENSITIVE AS are rats or mice to a particular chemical's cancer-causing effects.
    B. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are MORE SENSITIVE THAN are rats or mice to a particular chemical's cancer-causing effects.
    C. If carcinogens exhibit threshold-like dose responses, the potentially greater health effects on children of pesticide residues in food are taken into consideration when setting acceptable pesticide exposure levels.
    D. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, acceptable levels of exposure are set as much as 1,000 times below the level that causes a substantial increase in cancer in rodents.

    To review relevant content, see "Threshold-Like Dose Response" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

30. Which of the following statements about risk versus benefit when regulating environmental chemical exposure is **INCORRECT**?

    A. Many substances that may cause cancer in people also have

some benefits.

B. Tamoxifen, effective in preventing the recurrence of breast cancer in many women, also increases the risk of uterine cancer, blood clots, and strokes.
C. The serious risks associated with tamoxifen for women who have had breast cancer or for a relatively small number of women who are at high risk of developing breast cancer strongly outweigh the drug's benefits.
D. Tamoxifen benefits strongly outweigh its serious risks for women who have had breast cancer or for the relatively small number of women who are at high risk of developing breast cancer.

To review relevant content, see "Risks versus Benefits" under the "How do public health officials set acceptable exposure levels for environmental chemicals?" section.

How have cancer trends changed over the past few years?

Learning Objective

On completion of this section, you will be able to

- Describe changes in trends of cancer incidence and mortality during the past few years.

Introduction

The yearly rate of new cancer cases increased between 1975 and 1992, as the graph below shows. Note some evidence of a decline after 1992 followed by stable rates since 1995. In this graph, scientists use the term ***incidence*** to describe the number of persons who develop cancer out of 100,000 persons within a certain period of time.

Increases in incidence rates are sometimes difficult to interpret. An increase in the number of new cases of cancer may result from exposure to a harmful substance in the environment. But increasing incidence may also reflect changes in clinical practice in hospitals or doctors' offices. These changes result in more cases being found—perhaps even some cases that would never produce symptoms of the disease. Decreases in incidence, on the other hand, are probably due to a decreased exposure to harmful substances or to early detection and removal of precancerous growths.

For cancer deaths, the graph bellow shows that the rates increased steadily from 1975 to 1990, stabilized between 1990 and 1994, then declined on average 1.4 percent per year from 1994 to 1998. Since 1998, the rates again stabilized. In this graph, ***mortality*** is the number of cancer deaths that occur out of 100,000 cases within a certain period.

This is very good news: decreases in mortality are the best measure of progress against cancer. Mortality rates would be expected to decrease with a reduction in risk factors (stopping smoking and less exposure to certain pesticides, organic solvents, and **asbestos fibers**), successful early screening efforts (mammography, Pap test, and fecal occult blood test), or better treatments.

Changing Rates for Specific Cancers

In recent decades the incidence and mortality rates for some cancers have been declining. These include testicular, childhood, cervical, stomach, throat, and cancers of the mouth (lip, tongue, gums). For example, in the last 25 years, mortality rates for childhood cancer (ages 1–14) and cervical cancer have nearly halved. Improvements in treatment are thought to account for the reduction in childhood cancer deaths, while increased screening (i.e., Pap smears) accounts for the decrease in cervical cancer rates. The incidence and mortality from stomach and colon cancer and cancers of the mouth and throat have also decreased over this period.

On the other hand, the incidence and mortality rates for certain cancers have not improved. From 1973 to 1999, the incidence rates for cancers of the breast, lung (in females), bladder, prostate, kidney, liver, esophagus, and brain increased, as did non-Hodgkin's lymphoma and melanomas of the skin. The larger percentage increase in lung cancer incidence rates for

women compared with men reflects the fact that women began smoking later in the last century than did men—few women smoked before the 1960s. Over that same 26-year period death rates for melanomas of the skin, non-Hodgkin's lymphoma, and liver, kidney, lung, and brain cancers also increased.

The more recent trends from 1992–2000 are shown in the graphs below. Today, for women, over half of the new cancer cases and deaths are due to breast, lung, and colon/rectal cancers. For men, more than half of the new cancer cases and deaths are from prostate, lung, and colon/rectal cancers. Scientists are eager to understand these trends as an aid in developing effective cancer-prevention strategies.

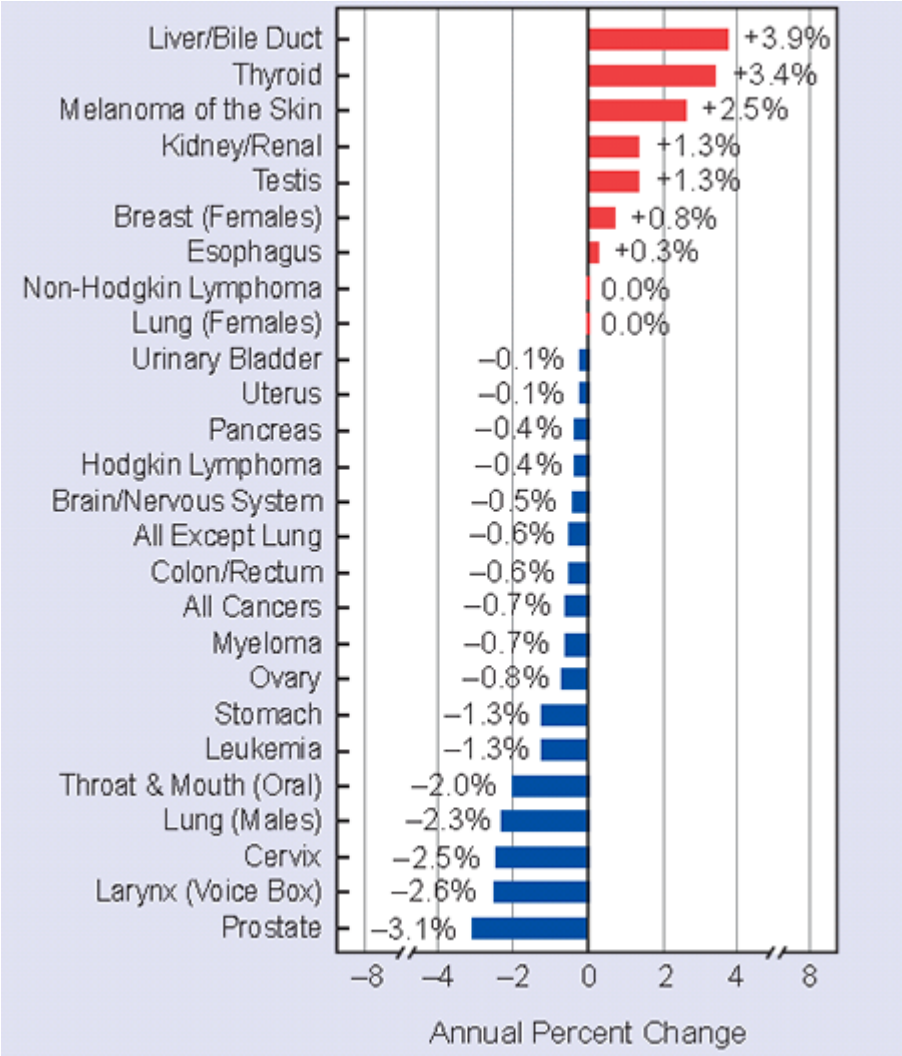


Figure 5. ***Rates of New Cancers: Annual Percent Change***.

U.S. Trends in Rates of New Cancers and Cancer Deaths: 1992-2000

How to read these charts: The charts show the percentage changes in

cancer rates for several cancers from 1992–2000. The chart on the left shows the percentage changes in the rates of new cancer cases; the one on the right shows the changes in the rates of cancer deaths. Cancer rates in blue have decreased over this time, while those in red have increased. For example, the incidence rates of liver, thyroid, and melanoma cancers had the greatest percentage increase; the death rates for liver cancer, lung cancer in women, and esophageal cancers showed the largest net increase. Note, however, that both the incidence and mortality rates for prostate and lung cancers (males) have decreased.

Source: SEER (**seer.cancer.gov**) and NCHS (**www.cdc.gov/nchs**).

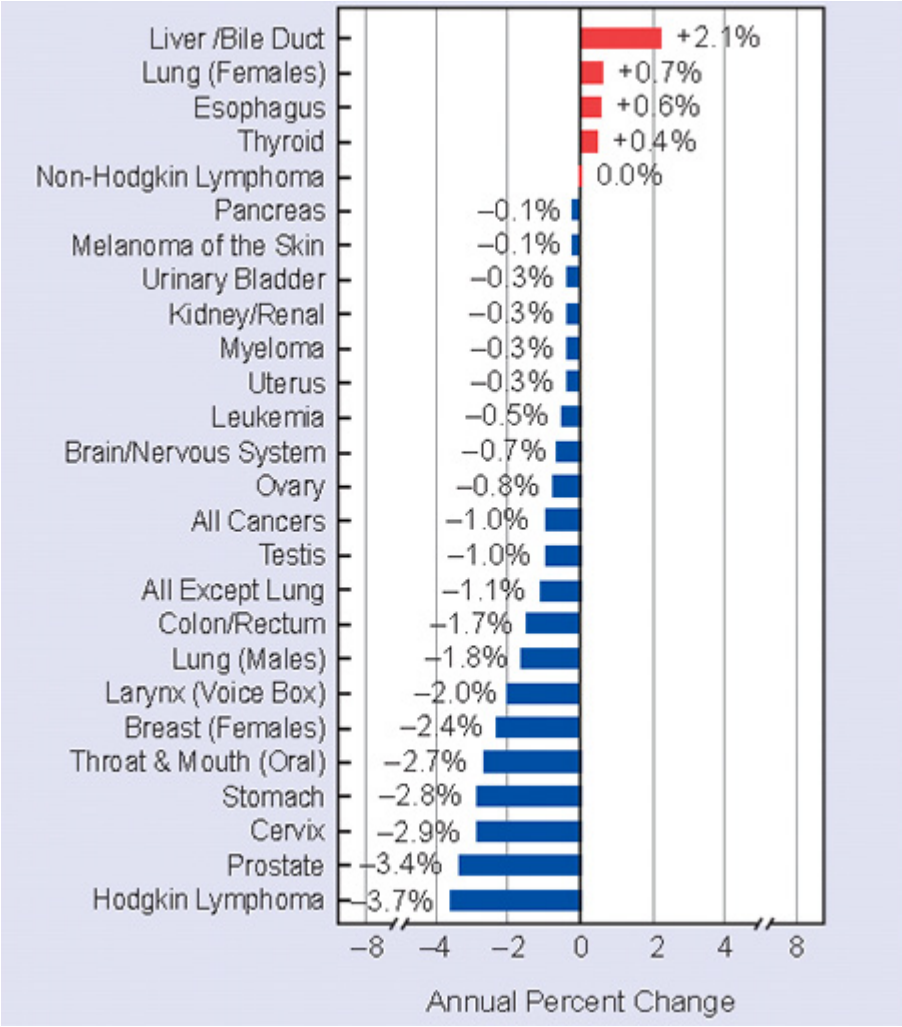


Figure 6. ***Rates of cancer deaths: Annual percent change***.

Key Points

- The yearly rate of new cancer cases increased between 1975 and 1992. Some evidence shows a decline after 1992 followed by stable rates since 1995.
- For cancer deaths, the rates increased steadily from 1975 to 1990, stabilized between 1990 and 1994, then declined from 1994 to 1998. Since 1998, the rates again stabilized.

- The incidence and mortality rates for some cancers have been declining.
- The incidence and mortality rates for certain other cancers are not improving.
- Today, for women, over half of the new cancer cases and deaths are due to breast, lung, and colon/rectal cancers.
- For men, more than half of the new cancer cases and deaths are from prostate, lung, and colon/rectal cancers.

Progress Check

Choose the best answer.

31. Which of the following statements concerning interpreting incidence rates of cancer is **INCORRECT**?

    A. An increase in new cancer cases may result from exposure to a harmful substance in the environment.
    B. An increase in new cancer cases may reflect certain changes in clinical practice in hospitals or doctors' offices resulting in detection of more cases.
    C. A decrease in cancer incidence may be due to a decreased exposure to harmful substances.
    D. A decrease in cancer incidence may be due to late detection and nonremoval of precancerous growths.

    To review relevant content, see "Introduction" under the "How have cancer trends changed over the past few years?" section.

32. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?

    A. The incidence and mortality rates have been declining for testicular, childhood, cervical, stomach, throat and cancers, and cancers of the mouth (lip, tongue, gums).
    B. The incidence and mortality rates are not improving for breast, lung (in females), bladder, prostate, kidney, liver, esophagus, and brain, non-Hodgkin's lymphoma and melanomas of the skin.
    C. The larger percentage increase in lung cancer incidence for women compared with men reflects the fact that women smoke more than do men.
    D. Improvements in treatment are thought to account for the reduction in childhood cancer deaths, while increased screening (i.e., Pap smears) accounts for the decrease in cervical cancer rates.

    To review relevant content, see "Changing Rates for Specific Cancers" under the "How have cancer trends changed over the past few years?" section.

33. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?

    A. The incidence rates of liver, thyroid, and melanoma cancers had the greatest percentage decrease between the years 1992 and

2000.

B. The death rates for liver cancer, lung cancer in women, and esophageal cancers showed the largest increase between the years 1992 and 2000.
C. The yearly rate of new cancer cases increased between 1975 and 1992. Some evidence shows a decline after 1992 followed by stable rates since 1995.
D. For cancer deaths, the rates increased steadily from 1975 to 1990, stabilized between 1990 and 1994, then declined from 1994 to 1998. Since 1998, the rates again stabilized.

To review relevant content, see "Introduction" and "Changing Rates for Specific Cancers" under the "How have cancer trends changed over the past few years?" section.

Where can I go for more information?

Federal Government Agencies That Regulate Exposures to Carcinogens

Several federal agencies are charged with establishing permissible levels of exposure to chemical substances in the general environment, home, and workplace, and in food, water, and pharmaceuticals. These include the Consumer Product Safety Commission (CPSC), Environmental Protection Agency (EPA), the U.S. Food and Drug Administration (USFDA), the Occupational Safety and Health Administration (OSHA), and the U.S. Department of Agriculture (USDA).

- **Consumer Product Safety Commission (CPSC)**: **www.cpsc.gov**

  CPSC is an independent Federal regulatory agency responsible for reducing the risk of injuries and deaths associated with consumer products. The consumer hotline is 1-800-638-2772 or the toll-free TTY number is 1-800-638-8270.

- **U.S. Environmental Protection Agency (EPA): www.epa.gov**

  U.S. EPA is a government regulatory agency charged with protecting human health and safeguarding the natural environment.

  - One-stop source for environmental information where you live: **www.epa.gov/enviro**
  - Learn about the environmental resources available in your community: **www.epa.gov/epahome/comm.htm**
  - EPA National Pesticide Information Center: **npic.orst.edu**. 1-800-858-7378
  - EPA Superfund Hotline for hazardous waste: 1-800-775-5037 or 703-413-0223. The toll-free TTY number is 1-800-553-7672.
  - General information about identifying and cleaning up hazardous waste sites: **www.epa.gov/superfund/about.htm**
  - A list of hazardous waste sites: **www.epa.gov/superfund/sites/index/htm**
  - A list of common contaminants in hazardous waste sites and their health effects: **www.epa.gov/superfund/programs/er/hazsubs/sources.htm**
  - For more information about radon in your home, visit the EPA radon Web site: **www.epa.gov/iaq/radon** or the National Radon Information line: 1-800-SOS-RADON (1-800-767-7236)
- **Food and Drug Administration (FDA)**: **www.fda.gov**

  FDA helps safe and effective products to reach the market in a timely way and monitors the products for safety after they are in use.

  - The National Center for Toxicological Research:

www.fda.gov/nctr
- FDA Information: **www.cfsan.fda.gov** or 1-888-463-6332

- **Occupational Safety and Health Administration (OSHA)**: **www.osha.gov**

  OSHA is a Federal regulatory agency under the U.S. Department of Labor whose mission is to prevent work-related injuries, illnesses, and deaths. To report accidents, unsafe working conditions, or safety and health violations call 1-800-321-6742. OSHA also has a toll-free TTY number: 1-877-889-5627. Office of Communications: 202-693-1999. Concerned persons can also contact their local area offices.

- **United States Department of Agriculture (USDA)**: **www.usda.gov/services.html**

  The USDA has several agencies and programs related to agricultural products including food safety inspection, animal and plant inspection service, nutrition programs, and agricultural research programs.

In many cases, more than one agency has the regulatory authority for a specific chemical, depending on its use and potential for human exposure. For example, pesticides are regulated by the EPA, FDA, USDA, and OSHA.

Other Federal Agencies

Other Federal agencies such as the ASTSDR, NIEHS, NCI, and Centers for Disease Control and Prevention—which includes the National Institute for Occupational Safety and Health and the National Center for Environmental Health—are charged with generating scientific information that helps regulatory agencies make sound regulatory decisions.

- **Agency for Toxic Substances and Disease Registry (ATSDR)**: **www.atsdr.cdc.gov**

  ATSDR is an agency of the U.S. Department of Health and Human Services (DHHS) and is the principal federal agency involved with hazardous waste issues and has fact sheets on various chemicals/agents. ATSDR Information Center: 1-888-422-8737.

- **National Institute of Environmental Health Sciences (NIEHS)**: **www.niehs.nih.gov**

  NIEHS was established to reduce human illness caused by unhealthy substances in the environment. Today, NIEHS supports extensive biomedical research, prevention, and intervention programs, as well as training, education, and community outreach efforts.

  - NIEHS Office of Communications for public inquiries: 1-919-541-3345.
  - National Toxicology Program (NTP): **ntp-server.niehs.nih.gov**

    The NTP is an interagency program that coordinates toxicology

research and testing activities within the U.S. Department of Health and Human Services. The NTP evaluates agents of public health concern by developing and applying tools of modern toxicology and molecular biology and publishes the biennial ***Report on Carcinogens***. To contact the NTP Office of Liaison and Scientific Review: 919-541-0530 (phone); 919-541-0295 (fax); **liaison@starbase.niehs.nih.gov** (e-mail).

- **National Cancer Institute (NCI)**: **www.cancer.gov**

  NCI coordinates the National Cancer Program, which conducts and supports cancer research, training, and health information dissemination throughout the country.

  - Fact Sheets available on: **cis.nci.nih.gov/asp/FactSheetPub/FactSheetLinks.asp**
  - NCI Publications. NCI's on-line ordering service: **cissecure.nci.nih.gov/ncipubs**
  - Press Releases are available on NCI's main Web site at **newscenter.cancer.gov** Press Office: 1-301-496-6641.
  - NCI's SEER Program is the most authoritative source of information on cancer incidence and survival in the United States. **seer.cancer.gov**
  - For geographic patterns of rates of cancer death from 1950–1994 for over 40 cancers: **www3.cancer.gov/atlasplus**
  - NCI's toll-free Cancer Information Service for information about cancer and to request publications: 1-800-4-CANCER (1-800-422-6237). The toll-free TTY number is 1-800-332-8615.
- **Centers for Disease Control and Prevention (CDC)**: **www.cdc.gov**

  CDC is an agency of DHHS that promotes health and quality of life by preventing and controlling disease, injury, and disability. Components of the CDC include:

  - National Institute for Occupational Safety and Health (NIOSH): **www.cdc.gov/niosh**

    A Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury. 1-800-356-4674

  - National Center for Environmental Health (NCEH) **www.cdc.gov/nceh** Health Line: 1-888-232-6789
  - National Report on Human Exposure to Environmental Chemicals: **www.cdc.gov/exposurereport/**

	○ GIS (geographic information systems) and public health Web site: **www.cdc.gov/nchs/gis.htm** ○ National Center for Health Statistics (NCHS): **www.cdc.gov/nchs** NCHS collects data to monitor the nation's health. ○ CDC public inquiries: 1-800-311-3435 ○ National Program of Cancer Registries: **www.cdc.gov/cancer/npcr** Funds statewide cancer registries in 45 states, the District of Columbia, and several territories, and serves as a valuable resource for persons concerned about a possible increased occurrence of cancer in their communities. ○ The National Breast and Cervical Cancer Early Detection Program: **www.cdc.gov/cancer/nbccedp/index.htm** Provides free screening exams to poor, uninsured women in all 50 states. ○ Office of Smoking and Health: **www.cdc.gov/tobacco/mission.htm** ○ Division of Cancer Prevention and Control: **www.cdc.gov/cancer**
State and Local Health Departments	State government agencies also play a key role in establishing allowable exposure levels. The organizations dealing with environmental health issues vary widely among different states, but they usually include a Department of Health, a Department of the Environment, and an Occupational Health Department. For example, North Carolina has a Department of Environment and Natural Resources and a Department of Health and Human Services. In addition, most county health offices can direct you to the appropriate state officials for obtaining information about local emissions of chemicals and exposure prevention rules and guidelines. State and local health departments: **www.cdc.gov/mmwr/international/relres.html**
Cancer Statistics	Resources describing the trends over the past several years in new cases of cancer diagnosed or deaths due to cancer are listed below: • NCI's SEER Program is the most authoritative source of information on cancer incidence and survival in the United States: **seer.cancer.gov** • National Center for Health Statistics (NCHS): This branch of the CDC collects national statistics to monitor the nation's health: **www.cdc.gov/nchs** 301-458-4800. • National Program of Cancer Registries funds statewide cancer registries in 45 states, the District of Columbia, and several territories, and serves as a valuable resource for persons concerned

	about a possible increased occurrence of cancer in their communities: **www.cdc.gov/cancer/npcr** • For geographic patterns of rates of cancer death from 1950–1994 for over 40 cancers: **www3.cancer.gov/atlasplus**
General Cancer Information	• NCI's on-line library of cancer information: **cancer.gov/cancer_information/cancer_literature** • The National Library of Medicine, the world's largest medical library: **www.nlm.nih.gov**
Other Resources	• The **National Library of Medicine** has compiled a list of the ingredients in common household products and their health effects: **householdproducts.nlm.nih.gov** • **International Agency for Research on Cancer (IARC)**: **www.iarc.fr** IARC is part of the World Health Organization and its mission is to coordinate and conduct research on the causes of human cancer. IARC publishes a series of reports that focuses on the cancer risks associated with agents such as industrial chemicals, viruses, and ionizing radiation. • **World Health Organization's** document: "Diet, nutrition and the prevention of chronic diseases": **www.who.int/hpr/nph/docs/who_fao_expert_report.pdf** • **American Cancer Society's** nutrition and diet guidelines**:** **www.cancer.org/docroot/ped/ped_3_1x_acs_guidelines.asp** • **Mine Safety and Health Administration (MSHA)**: **www.msha.gov** An agency of the Department of Labor, MSHA's mission is to protect the health and safety of the miner.
General Health Information	• **National Institutes of Health (NIH)**: **www.nih.gov/health** A single access point for consumer health resources at the NIH, the DHHS agency responsible for biomedical research. Public inquiries: 301-496-4000 • **Healthfinder**: **www.healthfinder.gov** A Web site created by DHHS to help consumers quickly find health and human services information. • **Medline**: **medlineplus.gov/** The world's most extensive collection of published medical information, coordinated by the National Library of Medicine.

Glossary

Anal cancer	Cancer that begins in the anus, the opening at the end of the large intestine where the waste from the body's digestive system passes out of the body.
Asbestos	Hard, nonflammable fibers used for insulating buildings.
Bacteria	Made of a single cell, bacteria are the simplest organisms found in nature. Bacterial infections can often be treated with antibiotics.
Benign tumor	Not cancerous—a tumor that does not invade nearby tissue or does not spread to other parts of the body.
Cancer	Diseases in which abnormal cells divide without control. Cancer cells can invade nearby tissues and can spread through the bloodstream and lymphatic system to other parts of the body.
Carcinogen	A substance that causes cancer.
Carcinoma	A cancerous growth made up of epithelial cells: cells from tissues that form the covering around organs, such as lung, liver, or breast, or the lining of blood vessels.
Cell	The basic unit of all living things. Organs are made up of millions of cells. Each cell contains several smaller components enclosed in a membrane.
Coke	Solid black material similar to charcoal that remains after burning coal. Coke is used as fuel and in making steel.
Colorectal cancer	Cancers that begin in either the colon or the rectum are colorectal cancer. Together, the colon and rectum make up the large intestine, a long, muscular tube where the waste from the body's digestive system is stored until it passes out of the body through the anus. The colon makes up the first four to five feet of the large intestine and the rectum is the last four to five inches.
DNA	Deoxyribonucleic acid is the molecule inside the cell that carries genetic information and is passed on from one generation to the next.
Endometrium	Tissue lining the wall of a woman's uterus, the organ where a baby grows.
Epidemiology	The study of the patterns of diseases in human populations and the factors that influence the patterns.
Familial cancers	Cancers that occur frequently in certain cancer-prone families in which a mutated gene that is associated with a high risk of developing cancer is passed on from one generation to the next.
Focus group	A qualitative research technique in which an experienced moderator leads about 8–10 participants through a semi-structured discussion on a selected topic, allowing them to talk freely and spontaneously.
Fungicide	An agent that destroys fungi.
Gene	Pieces of DNA or heredity units found inside cells passed from parent to offspring. Genes contain the information for making proteins
Herbicide	An agent that destroys weeds.
Incidence	The number of persons who develop a disease divided by the number of persons at risk of developing the disease in a specific time period.
Insecticide	An agent that destroys insects.
Leukemia	A type of cancer that forms from cells in the blood and bone marrow, including leukocytes or white blood cells that help the body fight infections and other diseases.
Linear dose	A type of response in which the cancer risk changes at the same rate as

response	the exposure—if the exposure increases, the cancer risk increases at the same rate. A cancer risk is present at all levels of exposure, even very low ones.
Lymphatic system	The tissues and organs that produce, store, and carry white blood cells, which fight infection and other diseases. This system includes the bone marrow, spleen, thymus, and lymph nodes, and a network of thin tubes that carry lymph and white blood cells to all the tissues of the body.
Lymphoma	Cancer that arises in cells of the lymphatic system.
Malignant tumor	A cancerous growth with a tendency to invade and destroy nearby tissue and spread to other parts of the body.
Melanoma	A malignant form of skin cancer that arises in melanocytes, the cells that produce pigment. Melanoma usually begins in a mole.
Mortality	The number of people who die from a disease divided by the number of people at risk of dying from the disease in a specific time period.
Oncogene	An altered gene that normally directs cell growth. An oncogene promotes uncontrolled growth of cancer. Alterations can be inherited, occur randomly, or be caused by an environmental exposure to carcinogens.
Pesticide	An agent used to destroy pests of any sort; the term includes fungicides, herbicides, and insecticides.
Proteins	Molecules in the cell that perform a wide variety of functions, such as protection (skin), support/movement (muscles), transportation (e.g., hemoglobin transports oxygen), and activation of the chemical reactions that sustain life (e.g., enzymes for digesting food).
Sarcoma	A cancer of the bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue.
Smelters	Plants where valuable metals are extracted from rocks or minerals.
Susceptible	A term used to describe someone who is more likely to develop a disease.
Threshold dose response	A type of response in which, at very low exposures, no detectable increased risk of disease appears; a threshold is determined below which no risk is detected.
Tissue	A group or layer of cells, such as the skin, that together performs specific functions.
Tumor	An abnormal mass of tissue that results from too much cell division. Tumors perform no useful body function. They may be either benign (not cancerous) or malignant (cancerous).
Tumor suppressor gene	A gene whose normal function is to prevent abnormal cells from dividing. Certain mutations in tumor suppressor genes lead to cancer.
Virus	Viruses are smaller than a single cell or bacteria and cannot reproduce outside a living organism.

Agency for Toxic Substances and Disease Registry
Cancer and the Environment - *What You Need to Know. What You Can Do*

Posttest Instructions

Course: **WB1725**
CE Original Date: **April 1, 2010**
CE Expiration Date: **April 1, 2012**

Introduction	ATSDR seeks feedback on this course so we can assess its usefulness and effectiveness. We ask you to complete the assessment questionnaire online for this purpose. In addition, if you complete the Assessment and Posttest online, you can receive continuing education credits as follows: ***(coming soon)***

Disclaimer	In compliance with continuing education requirements, all presenters must disclose any financial or other relationships with the manufacturers of commercial products, suppliers of commercial services, or commercial supporters as well as any use of unlabeled product(s) or product(s) under investigational use. CDC/ATSDR, our planners, and the presenters for this seminar do not have financial or other relationships with the manufacturers of commercial products, suppliers of commercial services or commercial supporters. This presentation does not involve the unlabeled use of a product or product under investigational use.

Online Instructions	To complete the Assessment and Posttest, go to http://www2.cdc.gov/atsdrce and follow the instructions on that page. You can immediately print your continuing education certificate from your personal transcript online. No fees are charged.

Posttest Questions

Choose the best answer.

1. Which of the following statements concerning the development of cancer is **INCORRECT**?
   - A. Cancer develops over several years and has many causes.
   - B. Exposure to a wide variety of natural and manufactured substances in the environment accounts for at least two-thirds of all the cases of cancer in the United States.
   - C. Cancer rates **DO NOT** change when groups of people move from one country to another.
   - D. Different environmental exposures are linked to specific kinds of cancer.
2. Which of the following statements concerning factors inside the body that make some people more likely to develop cancer than others is **INCORRECT**?
   - A. Certain factors inside the body make some people more likely to develop cancer than others.
   - B. One of the ways scientists know that genes play an important role in the development of cancer is from studying certain rare families where family members over several generations develop similar cancers.
   - C. Gene alterations may also contribute to individual differences in susceptibility to environmental carcinogens.
   - D. Exposure to cancer-causing substances ALONE determines who will get cancer.
3. Which of the following statements concerning the interaction of environmental factors and genes in the development of cancer is **INCORRECT**?
   - A. Mechanisms to repair damage to our genes and healthy lifestyle choices help to protect us from harmful exposures.
   - B. The chance that a person will develop cancer in response to a particular environmental agent depends on length of exposure, alone.
   - C. Because of the complex interplay of many factors, it is not possible to predict whether a specific environmental exposure will cause a particular person to develop cancer.
   - D. Particular patterns of gene alterations and environmental exposures make people more susceptible or more resistant to cancer.
4. Which of the following statements concerning the development of cancer is **INCORRECT**?
   - A. When cancer develops, cells continue to divide even when new cells are not needed, and that growth or extra mass of cells called a tumor.
   - B. It takes many years for the development of a tumor and even more years until detection of a tumor and its spread to other parts of the body.
   - C. NOT MUCH EVIDENCE is available to suggest that permanent changes in our genes are responsible for tumor development.

D. One explanation for the fact that cancer occurs more frequently in older people may be that, for a tumor to develop, a cell must acquire several gene alterations that accumulate as we age.

5. Which of the following statements concerning the different types of tumors **INCORRECT**?
    A. Benign tumors are not cancerous.
    B. Benign tumors spread to other parts of the body.
    C. A malignant tumor can metastasize and spread to nearby parts of the body and eventually to sites far away from the original tumor.
    D. Most cancers are named for the organ or type of cell in which they begin to grow.
6. Which of the following statements concerning different types of cancers is **INCORRECT**?
    A. Melanoma is a cancer of cells in the skin, eyes, and some other tissues, known as melanocytes.
    B. Leukemias are cancers of the blood cells.
    C. Lymphomas are cancers that develop in the lymphatic system.
    D. Carcinomas are cancers that develop in the connective tissue of certain organs, such as the lung, liver, skin, or breast.
7. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?
    A. Exposure to carcinogens in tobacco products accounts for about one-third of all cancer deaths in the United States each year.
    B. Several studies show that heavy consumption of red and preserved meats, salt-preserved foods, and salt probably increase the risk of colorectal and stomach cancers.
    C. Being overweight or obese appears to be one of the most important, modifiable causes of cancer, after tobacco.
    D. Heavy drinkers (more than two drinks/day) have a lesser risk of cancer, particularly among those who also smoke.
8. Which of the following statements concerning substances that are either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?
    A. Of the nearly 900 active ingredients in registered pesticides in the United States, most have been found to be carcinogenic in animals, although not all have been tested.
    B. Some drugs used to treat cancer have been shown to increase the occurrence of second cancers.
    C. Several solvents used in paint thinners, paint and grease removers, and in the dry cleaning industry are known or suspected in animal studies of causing cancer.
    D. Infectious agents such as viruses and bacteria contribute to the development of several types of cancer.
9. Which of the following statements concerning substances either known to cause cancer or suspected of causing cancer in humans is **INCORRECT**?

A. Radiation from cosmic rays may account for a very small percentage (about 1 percent) of our total cancer risk.
B. It is estimated that about 20,000 lung cancer deaths every year are caused by radon exposure in homes.
C. People exposed to radioactive fallout in the form of Iodine-131 may have an increased risk of thyroid disease, including thyroid cancer.
D. Most studies on the long-term effects of exposure to radiation (for example, X-Rays) used to diagnose or screen for cancers or other diseases have shown an elevated cancer risk.

10. Which of the following statements concerning fibers, fine particles, and dust is **INCORRECT**?
    A. Asbestos fibers and all commercial forms of asbestos are human carcinogens.
    B. Asbestos exposures account for the largest percentage of occupational cancer, with the highest risks among workers who smoke.
    C. Increased rates of mesothelioma—a rare cancer of the lining of the lung and abdominal cavity—and cancer of the lung have been consistently observed in a variety of occupations involving asbestos exposure.
    D. Ceramic fibers are now used as insulation materials and are a replacement for asbestos. These fibers are not carcinogenic.
11. Which of the following statements concerning dioxins is **INCORRECT**?
    A. Dioxins are chemical products synthesized for commercial purposes.
    B. Dioxins are widespread environmental contaminants.
    C. The general population is exposed to low levels of TCDD primarily from eating dairy products, fish, and meat, including poultry.
    D. Modifications of industrial processes such as bleaching and incineration have resulted in reduced dioxin emissions and have lowered dioxin levels in people.
12. Which of the following statements concerning vinyl chloride is **INCORRECT**?
    A. Vinyl chloride, a colorless gas, is a human carcinogen associated with lung cancers and angiosarcomas (blood vessel tumors) of the liver and brain.
    B. The major source of releases of vinyl chloride into the environment is believed to be from the plastics industries.
    C. People living near a plastics plant are exposed to possible carcinogens by breathing contaminated air.
    D. The general population away from the plant also shows levels of exposure.
13. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?
    A. At least two-thirds of the cases of cancer are caused by environmental factors.
    B. One-third of all the cancer deaths in this country could be

prevented by eliminating the use of tobacco products.
   C. After tobacco, exposure in the home and workplace appears to be the most important preventable cause of cancer.
   D. Precautions can be taken in the home and workplace to reduce exposure to other harmful exposures.

14. Which of the following statements concerning the association of environmental factors and cancer is **INCORRECT**?
   A. The use of tobacco products is linked to many cancers.
   B. Obesity is strongly linked to breast cancer in older women and cancers of the endometrium, kidney, colon, and esophagus.
   C. Inherited traits from parents are the chief causes of obesity.
   D. Large amounts of red and preserved meats, salt, and salt-preserved foods may increase the risk of colorectal and stomach cancers.
15. Which of the following statements concerning reducing the risk of developing cancer associated with viral or bacterial infections is **INCORRECT**?
   A. HIV, HPV, hepatitis B, or hepatitis C viral infections increase the risk of developing certain cancers.
   B. The use of recreational injection drugs such as heroin or cocaine may result in HIV, hepatitis B, or hepatitis C infection.
   C. Unprotected or otherwise unsafe sexual intercourse may result in HIV, HPV, hepatitis B, or hepatitis C infection.
   D. Vaccines can prevent HIV, HPV, hepatitis B, or hepatitis C infections.
16. Which of the following statements concerning detecting cancers at an early stage is **INCORRECT**?
   A. Men and women (as applicable) should get regular screening tests for breast, cervix, colon and rectum cancers.
   B. Changes in bowel or bladder habits, indigestion or difficulty swallowing and unexplained changes in weight are sure signs of cancer.
   C. You should tell your health care provider about the chemicals you use at work or at home.
   D. You should ask your health care provider if increased cancer risks are associated with your family's or your personal medical history or medical drugs you are taking.
17. Which of the following statements concerning detecting cancer at an early stage is **INCORRECT**?
   A. A mammogram is the best method of finding breast cancer before symptoms appear.
   B. The Pap test or Pap smear is the most successful tool to screen for cancer of the cervix.
   C. A fecal occult blood test, a sigmoidoscopy, or a colonoscopy are screening tests used to find colon and rectal cancer.
   D. With a fecal occult blood test, a sigmoidoscopy or a

colonoscopy, abnormal tissue can be removed and examined under a microscope.

18. Which of the following statements concerning challenges for scientists in identifying substances that cause cancer is **INCORRECT**?
    A. Americans commonly use more than 100,000 different chemicals.
    B. During the synthesis or combustion of other chemicals, cancer-causing substances are sometimes created.
    C. All cancer-causing substances are manufactured as opposed to natural.
    D. Every year, manufacturers introduce another 1,000 or so new chemicals.
19. Which of the following statements concerning sources of evidence for identifying cancer-causing substances is **INCORRECT**?
    A. Evidence for identifying cancer-causing substances is derived IN PART from human studies.
    B. Evidence for identifying cancer-causing substances is derived IN PART from animal studies.
    C. Evidence for identifying cancer-causing substances is derived IN PART from laboratory experiments with human cells.
    D. Evidence for identifying cancer-causing substances is derived IN PART from theoretical chemical computational calculations.
20. Which of the following statements concerning the role animal studies play in identifying causes of cancer in humans is **INCORRECT**?
    A. Nearly all of the approximately 200 agents known to cause cancer in humans have also been shown to cause cancer in rats or mice.
    B. We do not know how many of the several hundred other chemicals that cause cancer in animals are also human carcinogens.
    C. Public health officials do not have to heed the warnings provided by animal tests.
    D. Positive tests in animals are often used as a basis for reducing or eliminating human exposure to probable cancer-causing agents.
21. Which of the following statements concerning dosage levels given to animals in testing possible cancer-causing substances is **INCORRECT**?
    A. Mice or rats are given dosages much higher than those to which humans normally would be exposed.
    B. Large numbers of people are exposed to low doses of chemicals, but the total effect may not be small at all.
    C. Using high dosages, any potential cancer-causing effects are more likely to be detected—even in small groups of rodents.
    D. We have greater assurance that the chemical will not cause cancer in people when LOW doses do not cause cancer in animals.

22. Which of the following statements concerning use of human cells grown in the laboratory in testing for cancer is **INCORRECT**?
    A. Experiments with human cells grown in the laboratory are not useful when evaluating whether to perform studies in rats and mice.
    B. For epidemiologists, results from experiments with human cells grown in the laboratory provide clues regarding hypotheses to test in human population studies.
    C. Although in toxicology research experiments with human cells grown in the laboratory might reduce reliance on animal testing, rodent testing of potential carcinogens remains an important part of cancer prevention strategies.
    D. The combination of human studies, animal studies, and laboratory experiments provide scientists with the most complete understanding of the chemical risks of cancer.
23. In deciding which substances should be selected for testing in animals or with human cells, scientists **DO NOT** use
    A. Chemicals that affect a large number of persons or chemicals for which exposure levels have been unusually high.
    B. Chemicals that in laboratory cells cause human DNA alterations.
    C. Reports that people exposed to a particular chemical in the workplace develop certain cancers at rates similar to the general population.
    D. Chemicals that concerned citizens groups first brought to the attention of public health officials.
24. Which of the following factors **ARE NOT TAKEN INTO CONSIDERATION** by epidemiologists when beginning large population studies?
    A. Data from animal studies suggesting a cancer-exposure link.
    B. Cancer trends or rates that do not change over time or with location.
    C. Changes in cancer rates within a population after that population has migrated to new area.
    D. Pockets of cancers that cluster in a particular town or place or that are the subjects of unusual case reports.
25. Public health agencies classify substances as known or suspected human carcinogens based on evidence of cancer from at least one type of exposure, **EXCEPT FOR**
    A. Either high short- or long-term workplace exposures.
    B. Continuous low-level exposure or occasional exposure to carcinogens in the environment.
    C. Continuous low-level exposure or occasional exposure to carcinogens in the workplace.
    D. Single, acute exposures following industrial accidents or similar incidents.
26. Which of the following statements concerning acceptable risk levels by regulatory agencies is **INCORRECT**?
    A. Acceptable risks are generally LOWER for exposure in the workplace than for exposure in the general environment.

B. Acceptable risks are generally HIGHER for exposure in the workplace than for exposure in the general environment.
C. The range of the risk level considered acceptable by regulatory agencies for a linear dose response starts at one cancer in every million persons exposed.
D. The risk level range considered acceptable by regulatory agencies for a linear dose response ends at one cancer in every 1,000 persons exposed.

27. Which of the following statements concerning dose-response levels and risk of cancer is **INCORRECT**?
    A. In a linear dose response, the risk decreases as the exposure decreases—all the way to zero.
    B. In a linear dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
    C. In a threshold-dose response, a minuscule risk of cancer is predicted for any exposure, no matter how limited the exposure might be.
    D. A threshold dose response may include an exposure level below which an increase in risk is not detectable.
28. Which of the following statements concerning the setting of acceptable exposure levels for environmental chemicals is **INCORRECT**?
    A. One of the first considerations by regulatory agencies is to determine whether a carcinogen exhibits linear or threshold-like dose-response behavior.
    B. Absent compelling evidence for a linear response, agencies assume that to protect public health, the dose response is threshold-like.
    C. Absent compelling evidence for a threshold-like mechanism, to protect the public health agencies assume that the dose response is linear.
    D. Absent compelling evidence to the contrary, agencies assume that any exposure—no matter how small—has some risk.
29. Which of the following statements concerning threshold-like dose responses is **INCORRECT**?
    A. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are EQUALLY AS SENSITIVE AS are rats or mice to a particular chemical's cancer-causing effects.
    B. If carcinogens exhibit threshold-like dose responses, and if the cancer testing is done in rats and mice, scientists consider the possibility that people are MORE SENSITIVE THAN are rats or mice to a particular chemical's cancer-causing effects.
    C. If carcinogens exhibit threshold-like dose responses, the potentially greater health effects on children of pesticide residues in food are taken into consideration when setting acceptable pesticide exposure levels.
    D. If carcinogens exhibit threshold-like dose responses, and if

the cancer testing is done in rats and mice, acceptable levels of exposure are set as much as 1,000 times below the level that causes a substantial increase in cancer in rodents.

30. Which of the following statements about risk versus benefit when regulating environmental chemical exposure is **INCORRECT**?
    A. Many substances that may cause cancer in people also have some benefits.
    B. Tamoxifen, effective in preventing the recurrence of breast cancer in many women, also increases the risk of uterine cancer, blood clots, and strokes.
    C. The serious risks associated with tamoxifen for women who have had breast cancer or for a relatively small number of women who are at high risk of developing breast cancer strongly outweigh the drug's benefits.
    D. Tamoxifen benefits strongly outweigh its serious risks for women who have had breast cancer or for the relatively small number of women who are at high risk of developing breast cancer.
31. Which of the following statements concerning interpreting incidence rates of cancer is **INCORRECT**?
    A. An increase in new cancer cases may result from exposure to a harmful substance in the environment.
    B. An increase in new cancer cases may reflect certain changes in clinical practice in hospitals or doctors' offices resulting in detection of more cases.
    C. A decrease in cancer incidence may be due to a decreased exposure to harmful substances.
    D. A decrease in cancer incidence may be due to late detection and nonremoval of precancerous growths.
32. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?
    A. The incidence and mortality rates have been declining for testicular, childhood, cervical, stomach, throat and cancers, and cancers of the mouth (lip, tongue, gums).
    B. The incidence and mortality rates are not improving for breast, lung (in females), bladder, prostate, kidney, liver, esophagus, and brain, non-Hodgkin's lymphoma and melanomas of the skin.
    C. The larger percentage increase in lung cancer incidence for women compared with men reflects the fact that women smoke more than do men.
    D. Improvements in treatment are thought to account for the reduction in childhood cancer deaths, while increased screening (i.e., Pap smears) accounts for the decrease in cervical cancer rates.
33. Which of the following statements concerning changing rates for specific cancers is **INCORRECT**?
    A. The incidence rates of liver, thyroid, and melanoma cancers had the greatest percentage decrease between the years 1992 and 2000.
    B. The death rates for liver cancer, lung cancer in women, and

esophageal cancers showed the largest increase between the years 1992 and 2000.

C. The yearly rate of new cancer cases increased between 1975 and 1992. Some evidence shows a decline after 1992 followed by stable rates since 1995.
D. For cancer deaths, the rates increased steadily from 1975 to 1990, stabilized between 1990 and 1994, then declined from 1994 to 1998. Since 1998, the rates again stabilized.

Relevant Content To review content relevant to the posttest questions, see

Question	Subsection(s)	Section
1	Introduction and Environmental Factors	What causes cancer?
2	Factors inside the Body	What causes cancer?
3	Interaction of Environmental Factors and Genes	What causes cancer?
4	Introduction	The Nature of Cancer
5	Types of Tumors	The Nature of Cancer
6	Types of Tumors	The Nature of Cancer
7	Tobacco, Diet, Weight, Physical Inactivity and Alcoholic Drinks	What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?
8	Viruses and Bacteria', Pesticides, Solvents, and Medical Drugs	What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?
9	Ionizing Radiation	What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?
10	Fibers, Fine Particles and Dust	What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?
11	Dioxins	What substances in the environment are known to cause or

		are likely to cause cancer in humans? Where are they found?
12	Vinyl Chloride	What substances in the environment are known to cause or are likely to cause cancer in humans? Where are they found?
13	Introduction	What are some ways to reduce the risk of developing cancer?
14	Risk Reduction	What are some ways to reduce the risk of developing cancer?
15	Risk Reduction	What are some ways to reduce the risk of developing cancer?
16	Detecting Cancers at an Early Stage	What are some ways to detect cancer at an early stage?
17	Detecting Cancers at an Early Stage	What are some ways to detect cancer at an early stage?
18	Introduction	How do scientists identify cancer-causing substances?
19	Introduction	How do scientists identify cancer-causing substances?
20	How well do animal tests predict whether a substance can cause cancer in humans?	How do scientists identify cancer-causing substances?
21	We often read about mice or rats being given dosages much higher than those to which humans normally would be exposed. Are high doses really used and, if so, why?	How do scientists identify cancer-causing substances?
22	Experiments with Human Cells Grown in the Laboratory	How do scientists identify cancer-causing substances?
23	Strategies for Testing in Animals or Human Laboratory Cells	How do scientists decide which substances to test in animals, human laboratory cells, or human population studies?
24	Strategies for Carrying out Large Population Studies	How do scientists decide which substances to test in animals,

		human laboratory cells, or human population studies?
25	Type of Exposure	What factors do scientists consider in determining the risk associated with different cancer-causing substances?
26	Acceptable Risk Levels	What factors do scientists consider in determining the risk associated with different cancer-causing substances?
27	Dose Response	What factors do scientists consider in determining the risk associated with different cancer-causing substances?
28	Linear Dose Response	How do public health officials set acceptable exposure levels for environmental chemicals?
29	Threshold-Like Dose Response	How do public health officials set acceptable exposure levels for environmental chemicals?
30	Risks versus Benefits	How do public health officials set acceptable exposure levels for environmental chemicals?
31	Introduction	How have cancer trends changed over the past few years?
32	Changing Rates for Specific Cancers	How have cancer trends changed over the past few years?
33	Introduction and Changing Rates for Specific Cancers	How have cancer trends changed over the past few years?