13 The Cell Cycle

INVESTIGATION • 1–2 CLASS SESSIONS

OVERVIEW

Students play a board game that simulates the cell cycle, with each student in a group of four taking the role of a specific type of cell. As they progress through the cycle, students learn about the phases and events of the cycle.

KEY CONTENT

1. Cell functions are regulated to control and coordinate cell growth and division.
2. The cell cycle is the complete sequence of phases from the end of one cell division to the end of the next.
3. When normal cell regulation is disrupted, serious consequences, such as cancer, result.
4. Some types of cells, including blood and skin cells, divide more often than other types, such as liver and nerve cells.

KEY PROCESS SKILLS

1. Students record observations and identify trends.

MATERIALS AND ADVANCE PREPARATION

For the teacher

Literary Transparency 2, "Read, Think, and Take Notes Guidelines" (optional)

transparency of Scoring Guide: GROUP INTERACTION (GI)

For the class

6 Cell Cycle Game Key: Cancer Cell

For each group of four students

Cell Cycle game board

4 9-ounce plastic cups, each containing a different color of modeling clay (red, green, yellow, and blue)

2 number cubes

set of four Cell Cycle game keys (blood, liver, nerve, and skin)

For each student

Student Sheet 13.1, "Cell Cycle Record Sheet"

empty 9-ounce plastic cup

Student Sheet 2.1, "Disease Information" from Activity 2

sticky notes

Scoring Guide: GROUP INTERACTION (GI) (optional)

Divide the four colors of clay into enough portions so that each group of four students receives one half-full cup of each color.

Masters for Scoring Guides are in Teacher Resources IV: Assessment.

TEACHING SUMMARY

Getting Started

- Introduce the importance of cell division and the cell cycle for normal growth and development of an organism.

Doing the Activity

- (GI ASSESSMENT) Students play the Cell Cycle simulation game.
- (GI ASSESSMENT)(LITERACY) Students discuss what happened to their cell types.
- (LITERACY) Students follow the Read, Think, and Take Note literacy strategy as they read a case study about cancer.

Follow-up

- (LITERACY) ✓ The class compares the five types of cells.

BACKGROUND INFORMATION

The cell cycle is the subject of intensive scientific and medical research because of its role in growth and cell differentiation, and because disruption of normal regulation of the cell cycle often leads to serious consequences, including cancer.

Cell Division

As an organism grows, its cells become more numerous, but not steadily larger. A cell cannot grow indefinitely because it cannot survive if its surface-area-to-volume ratio becomes too small. When this ratio is too small, there is not enough cell membrane surface to exchange nutrients and wastes and maintain cell homeostasis of the larger volume within. Growth of a multicellular organism, therefore, requires cells to divide. Cell division is the process by which a cell produces two genetically identical offspring, which scientists often refer to as daughter cells. Cell division includes mitosis, in which the replicated chromosomes divide and separate, and cytokinesis, in which the cytoplasm is divided. After division, each daughter cell has a complete set of chromosomes.

The Cell Cycle

Most cells in the human body have exited the cell cycle, and are in the G_0 phase. When protein growth factors or other molecular signals cause them to re-enter the cell cycle, they usually complete the cycle and divide. There are four main phases in the cell cycle. A newly formed cell progresses through these four phases in the following order: G_1, S, G_2, and M. G stands for growth or gap, and cell growth occurs during the two G phases. S is the synthesis phase in which DNA replication occurs. Both mitosis and cytokinesis take place during the M—mitosis—phase. Do not share this information with students until they have finished the game. One object of the game is for them to develop an understanding of these phases. The cell cycle is regulated by many factors, including a group of proteins called cyclins, which fluctuate in concentration and provide a sort of molecular clock for the cell cycle. Cancer results when cell division is no longer controlled. Some cells that have become cancerous do not respond to the protein regulators such as cyclin, and divide more frequently than needed. This kind of growth creates the masses of cells that become tumors, which damage, impinge on, or attach themselves to surrounding tissues. If these cells also lose the controls that determine where in the body they belong, they can migrate to other parts of the body (metastasize). Cancerous tumors, or malignant tumors, are those that grow without limitations, invade surrounding tissues, and metastasize. For example, lung cancer often metastasizes to the brain or bones. In contrast, benign tumors lack these characteristics and are not considered cancerous, although they can cause problems if they interfere with other tissues or organs. Some benign tumors can become cancerous.

GETTING STARTED

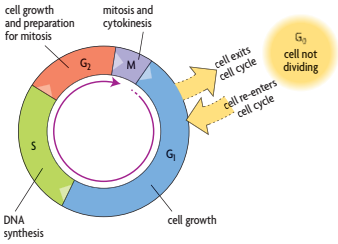
1 Begin by comparing a human zygote, embryo, and adult to each other. Explain that a zygote forms immediately upon fertilization. After four days, the human embryo has divided several times and is made of 64 cells. As these cells continue to divide, the embryo develops specialized cells, tissues, and organs. At about eight weeks the human embryo is called a fetus. The fetus develops until a baby is born at about 38 weeks after fertilization, and eventually an adult develops. Ask, *What happens during those days, months, and years to turn those early 64 cells of the embryo into a baby and then an adult?*

Students will likely say that the cells grow or divide and specialize. If not, bring out the idea that for a multicellular organism to grow its cells must divide, because cells cannot enlarge infinitely. Explain that the events that take place from the initial formation of one cell until it completes division to form two new daughter cells is called the cell cycle. Next ask, *Where in the body do you think cells must divide frequently in adults?*

13 The Cell Cycle

1 CELL DIVISION IS the basis of reproduction for all organisms, and also for the development and growth of multicellular organisms. The complete sequence of phases from the end of one cell division to the end of the next is called the **cell cycle.** The cell cycle is divided into a sequence of four phases, shown in the diagram below. One of these four phases, called **mitosis,** is the stage at which the cell divides to produce two new—or offspring—cells.

A group of cell-cycle control proteins regulates the phases of the cell cycle to ensure that all events needed for normal cell division take place before division begins. Cell-cycle regulation also ensures that specific cell types divide at the right time and place. For example, in the human body red blood cells must be replaced about every 120 days. If the stem cells that differentiate into red blood cells become under- or over-active, either too few or too many red blood cells are produced. Regulation of the cell cycle also ensures that a cell completes the growth and synthesis phases so that it will divide properly. When cell growth and division proceed abnormally, cancer might result.



Challenge

▶ What happens during each phase of the cell cycle, and how are the phases regulated?

MATERIALS

FOR EACH GROUP OF FOUR STUDENTS

- Cell Cycle game board
- 4 cups, each containing a different color of modeling clay (red, green, yellow, and blue)
- 2 number cubes
- set of four Cell Cycle game keys (blood, liver, nerve, and skin)

FOR EACH STUDENT

- Student Sheet 13.1, "Cell Cycle Record Sheet"
- Student Sheet 2.1, "Disease Information" from Activity 2
- empty plastic cup
- sticky notes

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Likely answers include the reproductive system, skin, and hair. Tell students that in adults, cells also divide frequently in other locations, for example to replace the linings of the digestive system and blood cells, which last only a few days or months, respectively. Ask, *What problems might result if certain cells in the body divide too slowly, or not at all?*

There will not be enough cells to replace those that die naturally or become damaged and die, and there will not be enough to perform those cells' specialized functions. For example, if red blood cell forming cells, called blood stem cells, did not divide to produce blood cells fast enough or not at all, there would not be enough blood cells to deliver oxygen to the organs and tissues of the body. Explain also that some tissues and organs rarely need replacement, and so their cells stop dividing. If cells divide too frequently, there may be more than are needed, and they might run out of space or crowd other cells or organs. Then ask, *What preparations do you think are necessary so that a cell can divide to form two daughter cells?*

The cell must have sufficient numbers of organelles and enough cytoplasm to split between two cells. Also, since every cell has a complete copy of DNA, the DNA must be doubled before the cell divides.

DOING THE ACTIVITY

2 Demonstrate how to make a marble-sized piece of clay, and show how to enlarge it to 1.5 times its original size by adding a smaller piece of clay to simulate growth during G_1. Show how to enlarge it to 2 times its original size by adding more clay, should the cell grow again during G_2. When the cell is approximately twice its original size and its DNA has replicated, it is ready to divide. Demonstrate how students should pinch their cells into two approximately equal-sized daughter cells when the game key instructs them to do so.

3 (GI ASSESSMENT) Distribute the materials for the cell cycle simulation. Review the game board, which is an enlarged version of the cell cycle diagram in the Student Book. Be sure that each student in the group takes one of the four keys (blood, liver, nerve, or skin) and a cup of clay in the color that matches the key. Review the GROUP INTERACTION (GI) Scoring Guide. Tell students this activity is an opportunity for them to demonstrate their ability to work effectively in groups: groups will process and discuss information as they play the game and then meet to discuss their results as described below.

Monitor the groups or work with the whole class as they conduct Procedure Steps 1–5. Make sure each student is clear on the type of cell he or she has been assigned and has the appropriate color of clay according to the key in the Student Book. Allow them to continue working until they complete Procedure Step 9. Some students' cells will become cancerous, and they will ask you for a Cell Cycle game key for cancer. If two or more students in the group have cells that become cancerous, they can share the cancer cell key.

SCIENCE & GLOBAL ISSUES/BIOLOGY • CELL BIOLOGY

2 **3** *Procedure*

1. You will play the Cell Cycle game in your group of four. Each of you takes one of the four Cell Cycle game keys—blood, liver, nerve, or skin.
2. Based on your game key, you will play the game as a blood, liver, nerve, or skin cell. Record your cell type on Student Sheet 13.1, "Cell Cycle Record Sheet."
3. Distribute the cups of clay according to the key below, with each person taking the color for his or her assigned cell type.

Cell Cycle Game Key

CELL TYPE	CLAY COLOR
Blood	red
Liver	blue
Nerve	green
Skin	yellow

4. Prepare a clay model of your cell. It should be about the size of a marble.
5. Place your model cell on the game board at the beginning of the game, near the start of the G_1 phase. Each player's cell has just completed the mitosis phase (M) of the cell cycle, and is ready to begin another cycle.
6. Begin round one of the game, with the blood cell person going first, and the rest of the group proceeding clockwise around your group. When it is your turn, roll both number cubes.
7. Look at your Cell Cycle game key to find out what the number you rolled means, and follow that instruction.
8. On Student Sheet 13.1, "Cell Cycle Record Sheet," record what happened to your cell in this round of the game.
9. Tell your group members what happened to your cell.
10. Continue to play the game for at least 20 rounds of rolling the number cubes. Each round, roll the number cubes unless you were told by your Cell Cycle game key to skip the turn. Each time you roll, follow Steps 7, 8, and 9 to find out what happens to your cell, record the outcome, and share it with your group.

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4 (LITERACY, GI ASSESSMENT) Set up five areas of the classroom, one for each type of cell: blood, liver, nerve, skin, and cancer. Direct students who represent these cell types to the appropriate area where they can discuss in an Informal Meeting of the Minds what happened to their cell type, as explained in Procedure Step 11. Circulate around the room, and, as needed, ask such questions as: Based on the simulation, does your cell type divide frequently or infrequently? What factors or events controlled whether the cell moved along in the cell cycle? What kinds of things might occasionally go wrong as the cell progresses through the cycle?

5 Have students return to their original groups, and instruct them to work together to prepare a chart (or other format you suggest) to summarize what kinds of things happened to each cell type. A sample is shown on the following page.

6 (LITERACY) If necessary, project Literacy Transparency 2, "Read, Thin, and Take Notes" guidelines to review with students. If you wish to assign the cancer case study for homework, make sure students take sticky notes with them so they can follow the Read, Think, and Take Note literacy strategy. Begin the next class by having students discuss with their partners or groups what they wrote on their sticky notes and the main points of the reading. A sample response for Student Sheet 2.1, "Disease Information" is shown at the end of Activity 13.

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11. Following your teacher's instructions, join a group of other students who had the same type of cell as yours. Discuss with these students, and record in your science notebook, what kinds of things happened to this cell type.

5

12. Rejoin your original group.
13. Work with your group to prepare a chart that summarizes what you learned about each of the four types of cells.

6

14. Follow your teacher's directions for reading the case study about cancer. As you read, use the Read, Think, and Take Note strategy.
15. Fill in the information for cancer on Student Sheet 2.1, "Disease Information," after you read the case study.

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Analysis

1. Of the cell types you investigated, which divide:
   a. frequently?
   b. occasionally, as needed?
   c. never, or almost never?
   d. more frequently than normal and without control?
2. What kinds of factors regulate a cell's progress through the cell cycle?
3. Beginning with G_1, list the four phases of the cell cycle in order, and describe what happens in each phase.
4. Why is it important for each of the following to be regulated?
   a. Entry into the cell cycle
   b. Progress from one phase of the cell cycle to the next
5. A cell in the liver divides. Its offspring and all of their offspring continue to divide as fast as they grow and synthesize DNA. Is this likely to be a problem? Why or why not?
6. Many of the drugs given to people to fight their cancers damage the cellular structures involved in mitosis. Explain:
   a. why these drugs kill a higher percentage of cancer cells than normal cells.
   b. whether you would expect the drugs to have more of an effect on normal white blood cells or on normal neurons.

FOLLOW-UP

7 ✓ Discuss the similarities and differences in the cell cycles of the five types of cells. Similarities include the phases of the cell cycle, cyclin's role as a regulatory factor, and coordination of cell cycle events and phases. For example, the chromosomes must be copied before a cell enters mitosis so that each daughter cell ends up with a complete copy of the chromosomes. Cells occasionally become cancerous because

Summary of Cell Events

Cell type	***Events that happened to the cell***		
Liver	• *Divided occasionally* • *Offspring cells often stayed in G_0.* • *Something went wrong with factors that regulate cell cycle, and cell got stuck in G_2.* • *Normal mitosis and cytokinesis produced two daughter cells.*	• *Sometimes mitosis did not work properly and was not completed (chromosomes did not separate) or cytokinesis was not completed. Cell was destroyed.* • *Cyclin accumulated.* • *Sometimes a cell became cancerous, and continued to divide.*	• *Sometimes a cell became cancerous, but was destroyed by the immune system.* • *Sometimes cancerous cells were destroyed when the chromosomes did not separate.*
Nerve	*Did not divide and was in G_0 permanently.*		
Skin	• *Cells grew and divided frequently, although some progressed through the phases faster than others.* • *Something went wrong with factors that regulate cell cycle, and cell got stuck in G_2.* • *Normal mitosis and cytokinesis produced two daughter cells.*	• *Sometimes mitosis did not work properly and stopped (chromosomes did not separate), or cytokinesis stopped. Cell was destroyed.* • *Cyclin accumulated.* • *Some skin cells became cancerous and continued to divide.*	• *A cell that became cancerous was destroyed by the immune system.* • *Sometimes cancerous cells were destroyed when their chromosomes did not separate.*
Blood-forming stem cell	• *Cells divided frequently, although some cells progressed through the phases faster than others.* • *Something went wrong with factors that regulate the cell cycle, and a cell got stuck in G_2.* • *Mitosis and cytokinesis usually proceeded normally to produce two offspring cells.*	• *Sometimes mitosis did not work properly and was stopped (chromosomes did not separate), or cytokinesis stopped. Cell was destroyed.* • *Cyclin accumulated.* • *Stem cells sometimes became cancerous and continued to divide without normal controls.*	• *A cell may have become cancerous, but was destroyed by the immune system.* • *Sometimes cancerous cells were destroyed when the chromosomes did not separate.*
Cancer cell	• *DNA replicated normally, or an error occurred that was either repaired or not. In both cases cell continued into G_2.*	• *Normal mitosis and cytokinesis occurred.* • *Mitosis occurred but cytokinesis did not work properly. Cancer cell was destroyed.*	• *One time all cancer cells were destroyed, and the cancer cell student started over as his or her original kind of cell.*

normal control mechanisms failed. These cancer cells are often destroyed by the immune system. The main difference between the cell types was how long they remained in G_1 (or moved into a permanent G_0) before continuing through the cycle. This rate depends on the body's need for and ability to replace this type of cell. A notable difference was the neuron's inability to divide. Analysis Question 5 is a Quick Check assessment for students' understanding that uncontrolled cell division often leads to formation of a tumor. Be sure to bring out that the cell cycle is regulated by proteins and other molecular factors, including the cyclin proteins. If the cell does not respond to these molecular signals or proceeds even when the cell is not fully prepared, the cell cycle becomes abnormal. This can damage the cell, leading to cell death or formation of cancer cells. Cancer cells lose the normal controls of cell division, which leads to the formation of tumors.

8 Woman 2 develops precancerous tissue at age 30 even though she was vaccinated for HPV at age 16. This is possible because the HPV vaccine does not protect against all types of HPV that can lead to cervical cancer.

8

7. Explain the main reasons why the outcomes at age 35 for the two women with cervical cancer vary in the following scenario:

Outcomes for Two Cervical Cancer Patients

AGE	WOMAN 1	WOMAN 2
16	No access to screening for abnormal cervical tissues with a Pap smear test or HPV test No access to vaccine for HPV	Begins regular screening for abnormal cervical tissues with a Pap smear test, and education from the doctor about the risks of cervical cancer Receives HPV vaccine that prevents infection by some types of HPV
30	Abnormal vaginal bleeding begins, indicating the likelihood of early stage cervical cancer. No access to adequate health care to detect and remove any abnormal cervical tissue	Pap smear reveals some precancerous cervical tissue from a type of HPV for which there is no vaccine. Precancerous tissue is removed with a simple surgical procedure to prevent progression to cancer.
35	A progression to advanced cervical cancer begins.	Leading a healthy life
36 and older	Advanced stages of cervical cancer No access to adequate health care, even to ease the pain associated with advanced stages of the cancer	Continues to get regular screening

8. Based on the cancer case study, how is cancer related to the social, economic, and environmental aspects of sustainability?

KEY VOCABULARY

cancer	cytokinesis
cell cycle	daughter cell
chromosome	**mitosis**
cyclin	replication

SAMPLE RESPONSES

1. a. blood stem cell, skin stem cell
   b. liver
   c. nerve
   d. cancer

2. The factors that control a cell's progress through the cell cycle include whether it has grown and replicated its DNA and the levels of a regulatory protein called cyclin.

3. Stage 1: G_1 (first gap or growth), the cell grows.

   Stage 2: S (synthesis), the cell's DNA replicates.

   Stage 3: G_2 (second gap or growth), the cell grows more, until it is about twice its original size.

   Stage 4: M (mitosis) and cytokinesis, the cell divides. This begins with separation of the chromosomes, and then the two daughter cells separate.

4. a. Cells should only be signaled to enter the cell cycle when the body needs more of them. Otherwise, there is no reason for them to prepare for division.
   b. At each stage of the cell cycle, certain things must happen for a cell to go on to the next stage. For example, the cell's DNA has to be copied so that when the cells divide, each cell has a complete copy of the DNA. Also, if cells don't grow before they divide, they will be too small and may lack needed structures.

5. ✓ The cells will grow and divide so rapidly that there will be too many of them, and they will form a tumor. Often the tumor interferes with the function of the organ.

CASE STUDY

Cancer

ONE IN EIGHT deaths worldwide is caused by cancer—more deaths than caused by AIDS, tuberculosis, and malaria combined. Scientists have made great progress in understanding, treating, and curing many types of cancer, but much about cancer is still unknown.

Cancer affects people living in all areas of the world, at all income levels. It usually develops over several years and has various causes, some environmental and some internal.

Burden of Disease

	NUMBER OF NEW CASES PER YEAR	NUMBER OF DEATHS PER YEAR
Worldwide	12 million	7 million
United States	1.7 million	570,000

SYMPTOMS AND DISEASE MECHANISM

The term cancer refers to more than 100 diseases that result when cells lose the normal controls that regulate their growth and division in the cell cycle. These cells continuously divide even when no new cells are needed. In most types of cancer, as an original cancer cell divides through multiple cell cycles, a mass of cells develops to form a tumor. However, some types of cancer, such as leukemia, rarely produce tumors. Leukemia results when abnormal white blood cells are produced too rapidly or do not die within the normal lifetime of white blood cells. These cells crowd the blood and prevent normal blood cells from performing their functions.

Mutations, or errors, in some genes can cause cancer. Some of these genes normally stimulate cell division, while others normally stop cell division. Mutations in these genes can lead to unregulated cell growth and division that result in tumors.

Cervical cancer is an example of a cancer that is linked to an infection from a virus, in this case human papillomavirus (HPV). Women worldwide are at risk of being infected by this sexually transmitted virus. There are more than 100 types of HPV, about 30 types infect the genital regions of men and women, and a few have been shown to cause cervical cancer in women.

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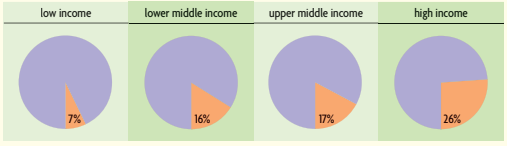

Projected deaths from cancer as a percentage of all deaths for all ages at four income levels, 2005 (left)

Normal skin (below left) and cancerous skin (below right)

6. a. The drugs will kill a higher percentage of cancer cells because cancer cells divide more frequently. The drugs will kill them by interfering with the structures that are used for mitosis.
   b. Because white blood cells have to be replaced, the blood stem cells have to divide often, so the drugs will have more of an effect on white blood cells.

7. The two women in the case study had different outcomes because one had adequate health care and the other one did not. Specifically, the girl with access to health care was offered preventive measures: she was screened and vaccinated early to reduce the risk of developing cervical cancer. When she developed precancerous cervical tissue, it was removed and prevented from developing into cancer.
8. Cancer causes anxiety, pain, suffering, and sometimes death, and takes a heavy toll on patients and their families. This is one social impact of the disease. Social factors, such as lifestyle choices and behaviors, can also increase the risk for some cancers, such as smoking, drinking alcohol, dietary selections, being obese, lack of exercise, and engaging in unprotected sex. Cancer has an economic impact on families and society due to the high cost of care, and the lack of productivity if people with cancer cannot work. Environmental factors, such as exposure to tobacco smoke or air and water pollution, increase cancer risk. People may be exposed to these environmental factors based on where they live or work.

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Cancer sometimes develops when environmental factors or viruses interact with certain genes to cause mutations. Environmental factors that lead to cancer include exposure to such chemicals as tobacco smoke, air pollutants, and asbestos. The chemicals produced when tobacco burns put people who smoke, and who are regularly exposed to tobacco smoke, at a higher risk of developing lung cancer than nonsmokers. In fact, approximately 10%–15% of smokers develop lung cancer, and smokers are 10–20 times more likely to get lung cancer than nonsmokers. Other environmental factors, including various kinds of radiation, also cause cancer.

CANCER PREVENTIONS AND TREATMENT

The World Health Organization reports that approximately 30% of cancer cases could be prevented by addressing such risk factors as:

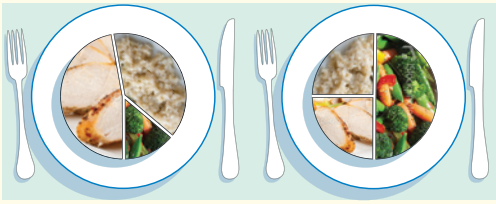
- tobacco use
- being overweight or obese
- lack of physical activity
- lack of fruits and vegetables in the diet
- alcohol abuse
- sexually transmitted HPV infection
- urban air pollution
- indoor smoke from household use of solid fuels, such as wood

There are a number of programs and a few vaccines that help people reduce or eliminate their risk factors for cancer. The table below shows examples.

The main ways that cancers are treated are surgery, chemotherapy, radiation therapy, or a combination of those. Surgeries to treat cancer include removing the tumor and surrounding tissues, removing the tumor and the organ it is in, and sometimes removing lymph nodes where the cancer may have spread. Surgeons also might remove just part of a tumor to relieve pain or open any blockages the tumor is causing. Chemotherapy involves taking certain drugs that kill cells, including cancer cells. Chemotherapy might follow surgery or be used alone or in combination with radiation therapy,

Some Preventive Measures for Cancer

PREVENTIVE MEASURE	EXAMPLES
Vaccines	Vaccination for the hepatitis B virus that can cause liver cancer
	Vaccination for HPV, which causes cervical cancer
Tobacco and alcohol-abuse programs	Increase taxes on tobacco and alcohol
	Educate the public about health risks
	Ban smoking in public and commercial areas
Health education in schools and the workplace	Promotion of healthy diet and exercise
Screening	HPV test and pap smear for cervical cancer
	Colonoscopy or other screening for colon and rectal cancer



A diet high in fat and calories and low in fruits and vegetables, as shown at far left, increases a person's risk of developing some cancers, as compared to the diet shown at near left.

REVISIT THE CHALLENGE

Review the phases of the cell cycle with the class. Make sure they understand key events of each phase and their importance in producing normal daughter cells. Emphasize the importance of the role of proteins in coordinating all steps of the cell cycle.

THE CELL CYCLE • ACTIVITY 13

depending on the cancer. Radiation therapy directs X-rays or other high-energy particles to the area of the tumor to damage the genetic material inside the cancer cells and kill them. Normal cells in the radiated area are sometimes damaged but are usually replaced by division of the normal cells that remain.

CHALLENGES TO PREVENTION AND TREATMENT

Challenges vary depending on the type of cancer. It is often difficult for people to avoid or control environmental risk factors for cancer simply because some of these factors are found in the environment. For example, several industrial chemicals have been associated with increased lung cancer risk, including asbestos, arsenic, nickel, chromium, zinc, and radon. People might be exposed to these chemicals in their work environment or home. Research suggests that up to 15% of lung cancer cases in men and 5% in women are due to occupational hazards. Also, many people cannot avoid exposure to air pollution if they live in urban areas where pollution levels are high. And for many people, making a behavioral change, such as quitting smoking, is very hard to do.

While screening may detect cancer early, it can only be effective if there is a treatment strategy for that cancer. Also, for many cancers, cost-effective early diagnostic tests have not yet been developed. The drawbacks of chemotherapy and radiation therapy are that they kill many normal cells, not just cancer cells. Fatigue, nausea, diarrhea, loss of appetite, and hair loss are just some of the side effects that might be mild or severe, depending on the drugs and course of radiation.

Although cancer might strike anyone, poor people in low-income developing countries have a lower chance of surviving the disease than those in higher-income countries. The preventions and treatments available for cancer are often too expensive in the lower-income countries, and there may be few, if any, accessible hospitals or health care professionals capable of providing the care needed. ■

NAME *Sample Student Response* DATE _____

Disease Information

Disease	*Cancer*
Description of disease and symptoms	*People all over the world, at all income levels get cancer. Cancer refers to any of more than 100 diseases that occur when cells lose the normal controls that regulate growth and division in the cell cycle.*
Cellular mechanism of disease	*Most cancers grow through a number of cell cycles that results in a mass of cells called a tumor. Mutations in genes that stimulate or stop cell division can cause cancer through unregulated cell growth and division that lead to tumors.*
Social factors	*Some risk factors for cancer are: tobacco use, being obese, lack of physical activity, diet, alcohol use, infection with a certain virus, urban air pollution, and indoor smoke from burning fuels. Some of these can be difficult to avoid depending on where people live. Behavior can be difficult to change. Screening, education, tobacco/alcohol programs, and vaccination can prevent some cancers.*
Economic factors	*Preventions and treatments can be expensive for people in developing countries. Some countries may not have hospitals or health care professionals to provide proper treatment or screening.*
Environmental factors	*Toxicants, tobacco smoke, pollution, asbestos, and viruses in the environment can cause mutations*