



## 10.3 Regulating the Cell Cycle

### Lesson Objectives

-  Describe how the cell cycle is regulated.
-  Explain how cancer cells are different from other cells.

### Lesson Summary

**Controls on Cell Division** Dozens of proteins regulate the cell cycle.

- ▶ **Cyclins** are proteins that regulate the timing of the cell cycle in eukaryotic cells.
- ▶ Regulatory proteins work both inside and outside of the cell.
  - Internal regulators allow the cell cycle to proceed when certain events have occurred within a cell.
  - External regulators called **growth factors** stimulate the cell cycle. Other external regulators cause the cell cycle to slow down or stop.
- ▶ **Apoptosis** is programmed cell death that plays a key role in the development of tissues and organs.

**Cancer: Uncontrolled Cell Growth** **Cancer** is a disorder in which cells divide uncontrollably, forming a mass of cells called a **tumor**.

- ▶ Cancers are caused by defects in genes that regulate cell growth.
- ▶ Treatments for cancer include:
  - removal of cancerous tumors.
  - radiation, which interferes with the copying of DNA in multiplying cancer cells.
  - chemotherapy, which is the use of chemicals to kill cancer cells.

### Controls on Cell Division

For Questions 1–6, write *True* if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

- |                   |   |
|-------------------|---|
| <u>stop</u>       | 1. Cells tend to <u>continue</u> dividing when they come into contact with other cells.   |
| <u>slows down</u> | 2. Cell division <u>speeds up</u> when the healing process nears completion.  |
| <u>cyclins</u>    | 3. Proteins called <u>growth factors</u> regulate the timing of the cell cycle in eukaryotic cells.   |
| <u>True</u>       | 4. If chromosomes have not attached to spindle fibers during metaphase, an <u>internal</u> regulatory protein will prevent the cell from entering anaphase. |
| <u>speed up</u>   | 5. Growth factors are external regulatory proteins that <u>slow down</u> the cell cycle.  |
| <u>True</u>       | 6. Once apoptosis is triggered, a cell proceeds to <u>self-destruct</u> .   |

7. Complete the cause-and-effect chart by giving an example of an effect caused by each type of regulatory protein.

Factors Affecting the Cell Cycle	
Cause	Effect
Cyclins	<i>SAMPLE ANSWER: Tell a cell when to begin steps of the cell cycle (e.g., growth, DNA synthesis, mitosis, cytokinesis).</i>
Internal regulatory proteins	<i>SAMPLE ANSWER: Stop a cell from going to the next stage of the cell cycle if internal events have not occurred (e.g., prevent a cell from entering mitosis until chromosomes are replicated).</i>
External regulatory proteins	<i>SAMPLE ANSWER: Speed up the cell cycle (e.g., for embryonic growth and wound healing) or slow down the cell cycle (e.g., so that one body tissue's growth does not disrupt another's).</i>

## Cancer: Uncontrolled Cell Growth

8. What is cancer?

*Cancer is a disorder in which some of the body's own cells lose the ability to control growth.*

9. What are the two basic types of tumors? Explain how they are different.

*Tumors may be malignant or benign. A malignant tumor is cancerous and will invade and destroy healthy tissue around it or in other parts of the body. A benign tumor is noncancerous and does not spread into surrounding tissues or to other parts of the body.*

10. Why can cancer be life threatening?

*Rapidly dividing cancer cells take nutrients away from healthy tissues. This leads to a disruption of the proper functioning of body organs that causes illness and may lead to death.*

11. What is the cause of cancer?

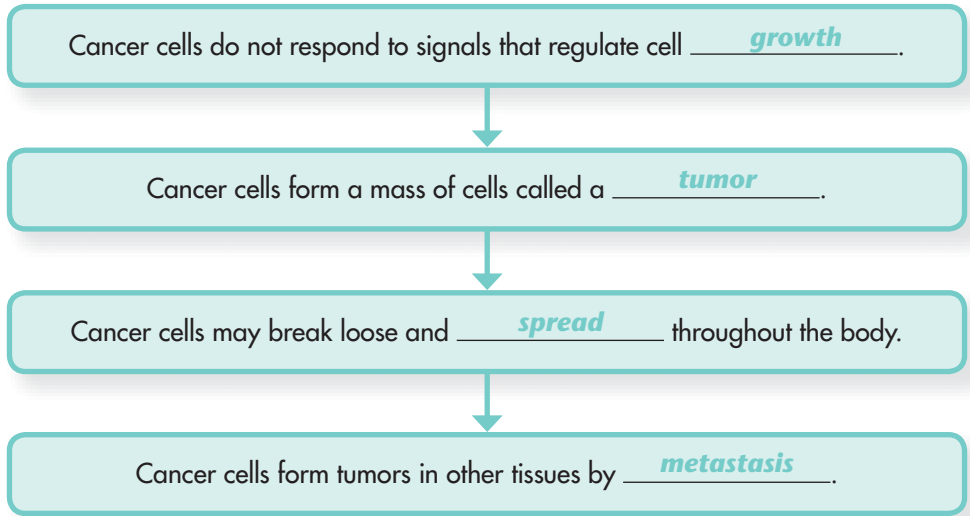
*Defects in genes that regulate cell growth and division cause cancer.*

12. How do radiation and chemotherapy affect cancer cells?

*Radiation disrupts the cancer cell cycle by interfering with the copying of DNA.*

*Chemotherapy kills cancer cells.*

13. Fill out the flowchart by completing each statement with the correct word or words.



**Apply the Big idea**

14. Hair grows from hair follicles, pockets of continually dividing cells in the outer layer of the skin. New cells are added to the base of a hair shaft, inside each follicle. Use what you have learned in this lesson to explain why cancer patients often lose their hair when receiving chemotherapy and grow more hair after chemotherapy stops.

*SAMPLE ANSWER: The chemicals stop cell division in both cancer cells and healthy cells, such as the ones that produce hair. When no new cells are being added to the hair shafts, the shafts break and the hairs fall out. When chemotherapy stops, cell division in the hair follicles resumes and hair starts to grow again.*




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## 10.4 Cell Differentiation

### Lesson Objectives

-  Describe the process of differentiation.
-  Define stem cells and explain their importance.
-  Identify the possible benefits and issues relating to stem cell research.

### Lesson Summary

**From One Cell to Many** Multicellular organisms produced via sexual reproduction begin life as a single cell.

- ▶ Early cell divisions lead to the formation of an **embryo**.
- ▶ Then, individual cells become specialized in both form and function through the process of **differentiation**.
- ▶ Once cells of a certain type, such as nerve cells or muscle cells, have formed, the cells cannot develop into a different type of cell.

**Stem Cells and Development** During an organism's development, some cells differentiate to become a wide variety of body cells.

- ▶ A fertilized egg and the first few cells in an embryo are able to form any kind of cell and tissue. Such a cell is termed **totipotent**.
- ▶ A **blastocyst** is an embryonic stage that consists of a hollow ball of cells. These cells are able to become any type of body cell. Such cells are termed **pluripotent**.
- ▶ Unspecialized cells that can develop into differentiated cells are called **stem cells**. Stem cells are found in embryos and in adults.
  - Embryonic stem cells are the pluripotent cells of an early embryo.
  - Adult stem cells are **multipotent**, which means they can produce many, but not all, types of differentiated cells.

**Frontiers in Stem Cell Research** Scientists want to learn about the signals that tell a cell to become either specialized or multipotent.

- ▶ Potential benefits of stem cell research include the repair or replacement of damaged cells and tissues.
- ▶ Research with human stem cells is controversial because it involves ethical issues of life and death.

### From One Cell to Many

For Questions 1–4, complete each statement by writing the correct word or words.

1. Humans, pets, and petunias all pass through an early stage of development called a(n) embryo.
2. Cells become specialized through the process of differentiation.

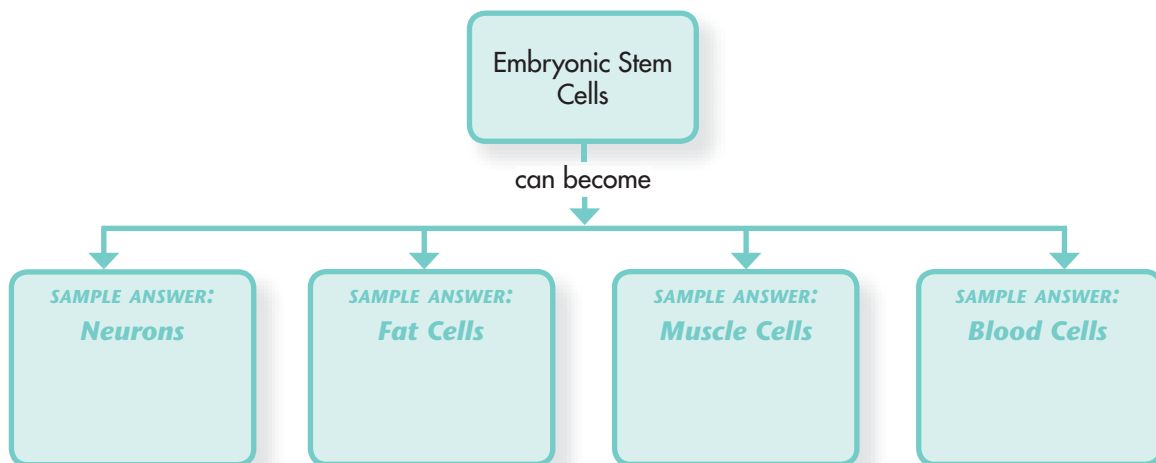
3. Scientists have mapped the outcome of every cell division that leads to differentiation in the development of the microscopic worm *C. elegans*.
4. Most cells in the adult body are no longer capable of differentiation.

## Stem Cells and Development

For Questions 5–7, write the letter of the correct answer on the line at the left.

- C 5. Which is an example of a totipotent cell?
- A. blastocyst
  - B. bone cell
  - C. fertilized egg
  - D. lymphocyte
- D 6. Cells that are pluripotent are unable to develop into the tissue that
- A. forms the skin.
  - B. lines the digestive tract.
  - C. produces blood cells.
  - D. surrounds an embryo.
- A 7. Adult stem cells are best described as
- A. multipotent.
  - B. pluripotent.
  - C. totipotent.
  - D. unable to differentiate.
8. Complete the concept map by identifying some of the types of cells that embryonic stem cells give rise to. Then explain how stem cells are like the stem of a plant.

Many different types of cells can come from stem cells, like the branches emerging from a stem.



## Frontiers in Stem Cell Research

For Questions 9–11, write the letter of the correct answer on the line at the left.

- A   9. Which is not a new, potential benefit of stem cell research?
- A. growing new skin cells to repair a cut
  - B. replacing heart cells damaged by heart attacks
  - C. repairing breaks between nerve cells in spinal injuries
  - D. preventing suffering and death caused by cellular damage
- D   10. What is the main reason that embryonic stem cell research is considered ethically controversial?
- A. Embryos contain totipotent cells.
  - B. Embryos are the result of sexual reproduction.
  - C. Embryos from many different organisms must be used.
  - D. Embryos are destroyed in the process.
- B   11. What is one new technology that could make stem cell research less controversial?
- A. implanting skin cells instead of stem cells in damaged tissue
  - B. developing the ability to switch on the genes that make an adult cell pluripotent
  - C. replacing stem cells with cancer cells
  - D. using the Internet to get more people to accept stem cell research

### Apply the Big idea

12. Many plants such as orchids are grown by a technique called tissue culture. Small pieces of plant tissue from a leaf, stem, or root of a mature plant are placed in a medium that contains the proper nutrients. The cells first form a mass of undifferentiated cells, from which tiny roots, stems, and leaves eventually grow. How do the plant cells placed in a medium for tissue culture change in terms of their degree of specialization? What types of animal cells are most similar to the undifferentiated plant cells in a tissue culture? Explain your answer.

**SAMPLE ANSWER:** *The plant cells first placed in a medium for tissue culture are differentiated cells. The cells produce undifferentiated cells that are pluripotent, or able to develop into all the specialized cell types and structures of the plant. The embryonic stem cells of an animal are the most similar to the plant cells that first develop in a tissue culture because they can develop into all the different cell types and structures of a specific animal.*

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## Chapter Vocabulary Review

1. Describe how the following terms are related to one another.

asexual reproduction, sexual reproduction: Both produce a new organism: asexual reproduction involves one parent—offspring have same DNA; sexual reproduction involves two parents—offspring have a mix of DNA.

chromosome, centrioles: centrioles are structures in animal cells that organize spindle fibers so duplicated chromosomes can be separated during mitosis

centromere, chromatid: a centromere is an area on chromosomes where spindle fibers attach and pull apart sister chromatids during mitosis

binary fission, mitosis: Binary fission is the process by which duplicated DNA in prokaryotes is separated between two new cells/organisms. Mitosis is similar in that it involves the separation of duplicated DNA between dividing cells in eukaryotes; unlike binary fission, mitosis is not typically a form of reproduction.

For Questions 2–9, match the event with the phase of the cell cycle in which it takes place. A phase may be used more than once.

Event		Phase of the Cell Cycle
<u>F</u>	2. A nuclear envelope forms around chromosomes.	A. anaphase
<u>C</u>	3. The cell grows and replicates DNA.	B. cytokinesis
<u>E</u>	4. A spindle forms.	C. interphase
<u>D</u>	5. Chromosomes line up across the center of the cell.	D. metaphase
<u>E</u>	6. The genetic material condenses and chromosomes become visible.	E. prophase
<u>A</u>	7. Chromosomes move to opposite sides of the cell.	F. telophase
<u>B</u>	8. The cytoplasm divides.	
<u>A</u>	9. Sister chromatids separate.	

For Questions 10–13, complete each statement by writing the correct word or words.

10. Cyclins and growth factors are examples of regulatory proteins that control the cell cycle.
11. Apoptosis is the controlled series of steps that lead to cell death.
12. The first few cells that form a(n) embryo are said to be totipotent because they can become any type of cell.
13. The hollow ball of cells that forms in early embryonic development is called the blastocyst.

## CHAPTER MYSTERY

### PET SHOP ACCIDENT

21st Century Learning



In the Chapter Mystery, you learned that stem cells make it possible for salamanders to regrow limbs. Developments in stem cell research tend to produce excitement in the media, particularly when the research might lead to a remedy for human health problems.

## Stem Cells in the Media

When you read an article about stem cells, as with any scientific topic, you need to consider the source and whether the reporter is giving an accurate account of the facts. You should also try to determine whether the article shows bias. Bias is a preference for a particular point of view, and it may involve distorting facts or slanting information so that it seems to support the preferred point of view.

*Read the following two articles. Determine to what degree each article uses facts to back up its conclusions. Also look for evidence of bias or distorted facts.*

### World News Daily

#### Stem Cells Improve Memory in Brain-Damaged Mice

FROM THE SCIENCE DESK—A research team at Watson University today announced that stem cells can improve the memory of mice with brain injuries. The researchers were interested in how an injection of stem cells might affect mice that had injuries in the area of the brain involved in memory.

Working with 100 mice, the scientists injected 50 of the mice with stem cells known to give rise to mouse nerve cells. The other 50 mice did not receive any treatment. After three months, the scientists tested the memory of both groups of mice by seeing whether they recognized objects. The group that did not receive the stem cells remembered the objects about 40 percent of the time. In contrast, the group that received the stem cells remembered the objects about 70 percent of the time.

The scientists hope that their research will one day lead to a treatment for human diseases and conditions, such as Alzheimer's disease, in which people suffer significant memory loss. "We are very excited by our results," said Diane Brandon, the leader of the research team. "But we are not ready to try this treatment with humans."



### LOOKING AHEAD

*A Weekly Guide for People in the Know*

#### Alzheimer's Disease— Is a CURE for Memory Loss Just Around the Corner?

Don't look now, but those mice that you hate to see scurry across the kitchen floor might just provide a cure for the thousands of people afflicted with Alzheimer's Disease. Scientists at Watson University are reporting that stem cells injected into brain-damaged mice can cure memory loss. The researchers suspected that the stem cells would give rise to new mouse nerve cells. Indeed, the mice that received the stem cells were found to have greatly improved memories. "We are very excited by our results," said Diane Brandon, the leader of the research team. The scientists are confident that, since stem cells can treat memory loss in mice, stem cells can also be used to cure Alzheimer's disease in humans.

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## 21st Century Themes Science and Health Literacy

1. Which article provides the reader with the most facts that describe the procedure of the research team and the result of the experiment? Give examples.

*The first article provided more facts. It explained that the researchers tested two groups of mice, injecting only one group with the stem cells. Also, it detailed how the mice were tested for their ability to remember things. Finally, for both groups, it gave the percentages of the times that mice remembered objects.*

2. Carefully look at the words that each article uses to describe the results of the research. According to the first article, how did the injected stem cells affect memory loss in mice?

*The stem cells improved the memory of the mice.*

According to the second article, how did the injected stem cells affect memory loss in mice?

*The stem cells cured the memory loss.*

3. Compare the titles of both articles. Which of the two titles more accurately describes the results of the research? Explain your answer.

*The title of the first article is more accurate, because the scientists did not discover a cure for human Alzheimer's disease, but they did see improvement from the stem cells.*

4. Both articles use quotations from one of the scientists. Compare the use of quotations in the two articles. Which of the two articles omits something important that the scientist said? How does this omission affect the reader's impression of the implication of this research for humans?

*The second article omits the quotation that says that the scientists are not ready to test the procedure on humans. This omission implies that the researchers are on the verge of discovering a cure for Alzheimer's disease.*

5. Which of the two articles do you trust more? Which would attract more attention?

Explain your answers. *Students will probably choose the first article as being the more trustworthy, because it provides specific numbers and does not distort the results. However, they may choose the second article as attracting more attention given the claim it makes in its title.*

## 21st Century Skills Comparing Articles

The skills used in this activity include **information and media literacy** and **critical thinking and systems thinking**.

Use Internet or library resources to find two articles that evaluate the treatments for a specific type of cancer, such as leukemia or prostate cancer. Compare the articles by answering the following questions: How easy is the article to understand? Are opinions supported by facts? Is there evidence of bias? Does the article omit important information? On the basis of your analysis, write an essay comparing the effectiveness of the two articles.

*Evaluate students' essays based on the quality of their resources, the effectiveness of their writing, and their attention to the content of the two articles.*