10 Cell Growth and Division

Growth, Development, and Reproduction

Q: How does a cell produce a new cell?

WHAT I KNOW

10.1 Why do cells divide?

SAMPLE ANSWER: Cells divide to produce more cells.

WHAT I LEARNED

SAMPLE ANSWER: Cells divide because the DNA in a large cell cannot meet the cell’s needs. Also, large cells have difficulty exchanging materials.

10.2 How do cells divide?

SAMPLE ANSWER: Cells divide by splitting into two cells.

10.3 How does a cell control the process of cell division?

SAMPLE ANSWER: Cell division is part of the cell cycle.

10.4 How does a single, undifferentiated cell lead to a complex multicellular organism?

SAMPLE ANSWER: A single, undifferentiated cell divides and leads to many cells that become specialized.

SAMPLE ANSWER: Specialized cells come from undifferentiated cells called stem cells. Embryonic stem cells are pluripotent and can become more types of cells than can adult stem cells, which are multipotent.

SAMPLE ANSWER: Proteins such as cyclins, internal regulators, and external regulators control the cell cycle and cell division.

SAMPLE ANSWER: Prokaryotic cells divide by binary fission. Eukaryotic cells divide by a process that includes mitosis, division of the nucleus, and cytokinesis, division of the cytoplasm.
10.1 Cell Growth, Division, and Reproduction

Lesson Objectives

- Explain the problems that growth causes for cells.
- Compare asexual and sexual reproduction.

Lesson Summary

Limits to Cell Size

There are two main reasons why cells divide:

- Information “overload”: The larger a cell gets, the more demands it places on its DNA. Eventually, the cell’s DNA cannot meet the cell’s needs.
- Exchange of materials: Cells take in nutrients and eliminate wastes through the cell membrane.
  - The larger a cell’s volume, the more materials it needs to function and the more waste it creates.
  - A cell’s volume increases at a faster rate than its surface area. As a cell grows, its surface-area-to-volume ratio becomes too small.
  - The larger a cell gets, the harder it is for enough materials to move across its cell membrane.
- Cell division solves the information overload and materials exchange problems.

Cell Division and Reproduction

Cell division is part of both types of reproduction:

- Asexual reproduction:
  - produces genetically identical organisms.
  - occurs in many single-celled organisms and in some multicellular organisms.
  - allows rapid reproduction of organisms in favorable environments.
- Sexual Reproduction:
  - produces organisms with genetic information from both parents.
  - occurs in most animals and plants and in many single-celled organisms.
  - increases genetic diversity, which aids species survival in changing environments.

Limits to Cell Size

For Questions 1–4, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

1. As a cell’s size increases, its amount of DNA also increases.  
   - Stays the same  
   - True  
   - Larger  
   - True

2. The amount of activity in a cell is related to its volume.
3. The smaller the cell, the smaller its ratio of surface area to volume.
4. The information crisis in a cell is solved by the replication of the DNA before cell division.
5. **VISUAL ANALOGY** In the visual analogy of the growing town, what does the library represent? Identify two characteristics that make it a good choice for this analogy.

SAMPLE ANSWER: The library represents the cell’s DNA. It is a good choice because a library contains information and typically there is only one per small town.

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### Cell Division and Reproduction

*For Questions 6–8, complete each statement by writing the correct word or words.*

6. **Reproduction** is the formation of new individuals.

7. For single-celled organisms, cell division is a form of **asexual** reproduction.

8. Most multicellular organisms reproduce by **sexual** reproduction.

9. Use the table to compare and contrast asexual and sexual reproduction.

<table>
<thead>
<tr>
<th>Asexual and Sexual Reproduction</th>
<th>Similarties</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both produce new organisms. Both involve the transfer of genetic material from parent to offspring.</td>
<td>The offspring of asexual reproduction are genetically identical to their parents. The offspring of sexual reproduction have some genetic information from each parent. In asexual reproduction, cells separate to form a new individual. In sexual reproduction, two cells fuse.</td>
<td></td>
</tr>
</tbody>
</table>

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### Apply the Big idea

10. Vascular tissue helps plants transport water against the force of gravity. Because of this, plants that lack vascular tissue do not grow very tall. How is this situation similar to the information you have learned in this lesson? Explain.

SAMPLE ANSWER: Plants that lack vascular tissue cannot grow very tall because they cannot transport water very far. A cell cannot grow very large because if it did, it would be unable to transport needed materials into the cell and transport wastes out.
10.2 The Process of Cell Division

Lesson Objectives

- Describe the role of chromosomes in cell division.
- Name the main events of the cell cycle.
- Describe what happens during the four phases of mitosis.
- Describe the process of cytokinesis.

Lesson Summary

Chromosomes  Packages of DNA called chromosomes hold a cell’s genetic information.
- Prokaryotic chromosomes consist of a single, circular strand of DNA.
- Eukaryotic chromosomes are highly organized structures.
  - The DNA winds around histone proteins, forming chromatin.
  - Chromosomes make the precise separation of DNA possible during cell division.

The Cell Cycle  The cell cycle is the series of events in the growth and division of a cell.
- In the prokaryotic cell cycle, the cell grows, duplicates its DNA, and divides by pinching in the cell membrane.
- The eukaryotic cell cycle has four stages (the first three of which are referred to as interphase):
  - In the G₁ phase, the cell grows.
  - In the S phase, the cell replicates its DNA.
  - In the G₂ phase, the cell produces organelles and materials for division.
  - In the M phase, the cell divides in two stages—mitosis, the division of the nucleus, and cytokinesis, the division of the cytoplasm.

Mitosis  The division of the nucleus, mitosis, occurs in four stages:
- Prophase: a cell’s genetic material condenses, a spindle starts to form, and the nuclear envelope breaks down.
- Metaphase: the duplicated chromosomes line up and spindle fibers connect to the centromeres.
- Anaphase: sister chromatids separate and move toward the centrioles.
- Telophase: the chromosomes begin to unwind and a nuclear envelope reforms.

Cytokinesis  Division of the cytoplasm differs in plant cells and animal cells.
- In animal cells, the cell membrane draws in and pinches off.
- In plant cells, a cell plate forms, followed by a new cell membrane, and finally a new cell wall forms.
**Chromosomes**

For Questions 1–5, complete each statement by writing the correct word or words.

1. Cells carry genetic information in packages of DNA called **chromosomes**.

2. Most **prokaryotes** have only one circular strand of DNA.

3. In eukaryotic cells, the genetic structure consists of DNA and a tightly wound protein, which together form a substance called **chromatin**.

4. The beadlike structures formed by DNA wrapped around **histone** molecules are called nucleosomes.

5. **Chromosomes** make possible the precise separation of DNA during cell division.

**The Cell Cycle**

6. What is the name of the type of cell division that occurs in the prokaryotic cell cycle?  
   *Cell division in prokaryotes is called binary fission.*

7. What happens during interphase?  
   *The cell grows, copies its DNA, and prepares for cell division.*

8. Complete the cell cycle diagram by writing the correct name of a phase on each line.

9. In eukaryotic cells, what happens in the G₁ phase that differs from the G₂ phase?  
   *In the G₁ phase, the cell grows. In the G₂ phase, the cell gets ready for mitosis.*

10. In eukaryotic cells, what are the two main stages of cell division?  
    *Mitosis and cytokinesis are the two main stages of cell division.*
Mitosis

11. During prophase, when cell chromosomes become visible, what are the duplicated strands of DNA called? What is the name for the area in which these duplicated strands are joined?

*Duplicated strands of chromosomal DNA are called chromatids, or sister chromatids, and they are joined by a centromere.*

12. What structures are spindle fibers attached to that help pull the paired chromosomes apart?

*The spindle fibers are attached to centrioles that move toward the poles of the cell, pulling the chromatids apart.*

For Questions 13–16, match the description of the event with the phase of mitosis in which it occurs. Each phase may be used more than once.

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Phase of Mitosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The chromosomes separate and begin to move to opposite sides of the cell.</td>
<td>A. Telophase</td>
</tr>
<tr>
<td>D</td>
<td>The chromosomes become visible. The centrioles take up positions on opposite sides of the nucleus.</td>
<td>B. Prophase</td>
</tr>
<tr>
<td>B</td>
<td>A nuclear envelope re-forms around each cluster of chromosomes. The nucleolus becomes visible in each daughter nucleus.</td>
<td>C. Metaphase</td>
</tr>
<tr>
<td>A</td>
<td>The chromosomes line up across the center of the cell.</td>
<td>D. Anaphase</td>
</tr>
<tr>
<td>C</td>
<td>The four circles below represent the nucleus of a cell going through mitosis. Draw four chromosomes as they go through each phase. Label each phase and describe what is happening to the DNA.</td>
<td></td>
</tr>
</tbody>
</table>
Cytokinesis

18. What is cytokinesis?

*Cytokinesis is the final step of cell division. It completes the M phase of the cell cycle by dividing the cytoplasm of the original cell between the two new cells.*

19. Use the Venn diagram to compare and contrast cytokinesis in animal cells with cytokinesis in plant cells.

20. During certain stages of their life cycle, some cells repeatedly undergo mitosis but do not undergo cytokinesis. What would you expect to see if you looked at such cells, or a tissue made up of such cells, under a microscope? Explain your answer.

*Under microscopic examination, a tissue whose cells complete all parts of the cell cycle except cytokinesis would appear to be made up of a mass of cytoplasm with many nuclei scattered in it.*