7 Cell Structure and Function

Cellular Basis of Life, Homeostasis

Q: How are cell structures adapted to their functions?

WHAT I KNOW

7.1 Why is it important to study cells?

SAMPLE ANSWER: Cells make up living things.

WHAT I LEARNED

SAMPLE ANSWER: Cells are the basic units of structure and function in all living things. Cells work to maintain homeostasis. Specialized cells carry out particular functions, such as photosynthesis and energy conversion.

7.2 How do cell structures enable a cell to carry out basic life processes?

SAMPLE ANSWER: A cell is made up of cytoplasm that is surrounded by a cell membrane and carries out the basic life processes.

SAMPLE ANSWER: Every structure and organelle in a cell carries out certain processes, such as making or storing substances, that help the cell stay alive.

7.3 How does a cell transport materials across the cell membrane?

SAMPLE ANSWER: Materials must cross the cell membrane to enter or leave a cell.

SAMPLE ANSWER: A cell can transport materials across the membrane through passive transport, which does not require energy. A cell can move materials by active transport, which needs energy.

7.4 How does a cell maintain homeostasis both within itself and as part of a multicellular organism?

SAMPLE ANSWER: Cells are able to maintain homeostasis.

SAMPLE ANSWER: Cells, both by themselves and in multicellular organisms, maintain homeostasis by growing, responding to the environment, transforming energy, and reproducing.
7.1 Life Is Cellular

Lesson Objectives

- State the cell theory.
- Describe how the different types of microscopes work.
- Distinguish between prokaryotes and eukaryotes.

Lesson Summary

The Discovery of the Cell  The invention of the microscope in the 1600s enabled researchers to see cells for the first time.

- Robert Hooke named the empty chambers he observed in cork “cells.”
- Anton van Leeuwenhoek was the first to observe living microorganisms.
- Cells are the basic units of life.
- Discoveries by German scientists Schleiden, Schwann, and Virchow led to the development of the **cell theory**, which states:
  - All living things are made of cells.
  - Cells are the basic units of structure and function in living things.
  - New cells are produced from existing cells.

Exploring the Cell  Scientists use light microscopes and electron microscopes to explore the structure of cells.

- Compound light microscopes have lenses that focus light. They magnify objects by up to 1000 times. Chemical stains and fluorescent dyes make cell structures easier to see.
- Electron microscopes use beams of electrons focused by magnetic fields. They offer much higher resolution than light microscopes. There are two main types of electron microscopes—transmission and scanning. Scientists use computers to add color to electron micrographs, which are photos of objects seen through a microscope.

Prokaryotes and Eukaryotes  Cells come in an amazing variety of shapes and sizes, but all cells contain DNA. Also, all cells are surrounded by a thin flexible barrier called a **cell membrane**. There are two basic categories of cells based on whether they contain a nucleus. The **nucleus** (plural: nuclei) is a large membrane-enclosed structure that contains DNA.

- Eukaryotes are cells that enclose their DNA in nuclei.
- Prokaryotes are cells that do not enclose their DNA in nuclei.

The Discovery of the Cell

*For Questions 1–6, complete each statement by writing the correct word or words.*

1. The invention of the **microscope** made the discovery of cells possible.

2. Robert Hooke used the name **cells** to refer to the tiny empty chambers he saw when he observed magnified cork.
3. German botanist Matthias Schleiden concluded that **all plants** are made of cells.

4. German biologist Theodor Schwann concluded that **all animals** are made of cells.

5. Rudolph Virchow concluded that new cells are produced from **existing cells**.

6. The **cell theory** combines the conclusions made by Schleiden, Schwann, and Virchow.

### Exploring the Cell

For Questions 7–9, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

7. The size of the image formed by a light microscope is **unlimited** because light that passes through matter is diffracted.

8. Fluorescent dyes help scientists see the movement of **compounds and structures** in living cells.

9. **Transmission** electron microscopes form a 3-D image of the surface of a specimen.

10. **Think Visually** In the second row of the table, draw diagrams to show how a sample of three yeast cells would look in the types of micrographs indicated in the top row of the table. Then, in the third row, describe how each image would be formed.

<table>
<thead>
<tr>
<th>A Comparison of Detail in Basic Types of Micrographs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Micrograph</strong> (LM 500x)</td>
</tr>
<tr>
<td><img src="image1" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>See the textbook for what this drawing should look like.</strong></td>
</tr>
<tr>
<td>A light microscope image is formed by <strong>two lenses focusing light</strong></td>
</tr>
</tbody>
</table>
11. To study cells with a light microscope, different types of stains are usually available. Why is it generally more useful to stain eukaryotic cells than prokaryotic cells?

Specific stains can reveal certain compounds or structures within a cell. Eukaryotic cells are more complex than prokaryotic cells and have more structures that can take in the stains.

Prokaryotes and Eukaryotes

12. Complete the table about the two categories of cells.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Size range</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prokaryotic cells</td>
<td>Cells that lack nuclei.</td>
<td>1–5 μm</td>
<td>bacteria</td>
</tr>
<tr>
<td>Eukaryotic cells</td>
<td>Cells that contain nuclei.</td>
<td>10–100 μm</td>
<td>cells of protists, fungi, plants, animals</td>
</tr>
</tbody>
</table>

13. Which category of cells—prokaryotic or eukaryotic—is your body composed of?

eukaryotic cells

Apply the Big idea

14. Recall that in science, a theory is a well-tested explanation that unifies a broad range of observations and hypotheses and enables scientists to make accurate predictions about new situations. How does the cell theory demonstrate this definition of theory?

Sample answer: The cell theory demonstrates the scientific definition of a theory in three ways. First, it has been tested extensively. Second, it summarizes the research and observations of many different scientists who worked at different times. Third, it allows researchers who observe evidence of cellular structure in unknown objects to make predictions about the object, such as “it is a living thing” and “it can reproduce itself.”
7.2 Cell Structure

Lesson Objectives

- Describe the structure and function of the cell nucleus.
- Describe the role of vacuoles, lysosomes, and the cytoskeleton.
- Identify the role of ribosomes, endoplasmic reticulum, and Golgi apparatus in making proteins.
- Describe the function of the chloroplasts and mitochondria in the cell.
- Describe the function of the cell membrane.

Lesson Summary

Cell Organization  Eukaryotic cells contain a nucleus and many specialized structures.

- **Cytoplasm** is the fluid portion of a cell.
- **Organelles** are structures that have specialized functions in eukaryotic cells.
- The nucleus contains DNA and controls the activity of a cell.

Organelles That Store, Clean Up, and Support  These structures include:

- **vacuoles**: membrane-enclosed saclike structures that store water, salts, and organic molecules
- **lysosomes**: small organelles filled with enzymes that break down large molecules and organelles that are no longer useful
- the **cytoskeleton**: a network of protein filaments; it helps the cell maintain its shape and is involved in movement
- **centrioles**: organelles made from tubulins; they help organize cell division in animal cells

Organelles That Build Proteins  Three kinds of organelles work with the nucleus to make and distribute proteins:

- **ribosomes**: small particles of RNA and protein found throughout the cytoplasm in all cells; they produce proteins by following coded instructions from DNA
- the **endoplasmic reticulum** (ER): an internal membrane system where lipid components of the cell membrane are assembled, along with proteins and other materials
- the **Golgi apparatus**: an organelle that appears as a stack of flattened membranes; it modifies, sorts, and packages proteins and other materials from the ER for storage in the cell or release outside the cell

Organelles That Capture and Release Energy  Two types of organelles act as power plants of the cells. Both types are surrounded by two membranes.

- **Chloroplasts** capture the energy from sunlight and convert it into food that contains chemical energy in a process called photosynthesis. Cells of plants and some other organisms contain chloroplasts, which contain chlorophyll.
- **Mitochondria** are found in nearly all eukaryotic cells; they convert the chemical energy stored in food to a usable form.
Cellular Boundaries  All cells are surrounded by a cell membrane. Many cells also have a cell wall. Both cell membranes and cell walls separate cells from the environment and provide support.

- **Cell walls** support, shape, and protect the cell. Most prokaryotes and many eukaryotes have them. Animals do not have cell walls. Cell walls lie outside the cell membrane. Most cell walls allow materials to pass through them.
- A cell membrane consists of a lipid bilayer, a strong but flexible barrier between the cell and its surroundings. The cell membrane regulates what enters and leaves the cell and also protects and supports the cell. Most biological membranes are selectively permeable, allowing some substances, but not others, to pass across them.

Cell Organization

1. Describe the relationship between the cytoplasm and the nucleus of a cell.
   
   **The nucleus of a cell is found in the cytoplasm, but is not part of the cytoplasm. The nucleus and cytoplasm work together to keep a cell alive.**

2. What does the term organelle mean literally?
   
   **little organ**

For Questions 3–5, refer to the Visual Analogy comparing the cell with a factory.

3. In the visual analogy of a cell as a factory, what two functions of the nucleus are represented? How are these functions illustrated?
   
   **The nucleus acts as the office, or control center, as illustrated by the people at the desk. The nucleus is the source of messages, instructions, and blueprints, as illustrated by the two workers helping the chain (of RNA) leave the nucleus.**

4. Which feature of the nucleus is not clearly shown by the visual analogy?
   
   **Sample answer: The chromatin is not shown.**

5. What is another possible analogy that could be compared with the structure and function of a cell? **Sample answer: The structure and function of an airport control tower could be compared to the structure and function of a cell.**
Organelles That Store, Clean Up, and Support

6. What are vacuoles?
   *Vacuoles are membrane-enclosed sac-like structures that store materials such as water, salts, proteins, and carbohydrates.*

7. What are the two roles of the central vacuole in plant cells?
   *storage of materials and support of the cell*

8. How are contractile vacuoles different from other types of vacuoles?
   *Contractile vacuoles pump excess water out of the cell, while other types of vacuoles hold materials inside of cells.*

9. In the diagrams of the animal cell and the plant cell, label the structures indicated by the lines.

10. What is the role of lysosomes in the cell? Why is this a vital role?
    *Lysosomes break down large molecules and waste. Without them, clutter could accumulate in the cell, which has been linked to serious human diseases.*

11. Which structures of the cytoskeleton are found in animal cells but not in plant cells?
    *centrioles*

12. What other structures of the cytoskeleton would show the same pattern of microtubules as a flagellum?
    *cilia*
**Organelles That Build Proteins**

13. What are ribosomes? What do they do?

*Ribosomes are small particles of RNA and protein found throughout the cytoplasm.*

*They are involved in the synthesis of proteins.*

14. In which organelle are the lipid components of the cell membrane assembled?

*endoplasmic reticulum*

15. What is the difference between rough ER and smooth ER?

*Ribosomes are found on the surface of rough ER. Smooth ER has no ribosomes on its surface.*

16. Using the cell as a factory analogy, describe the role of the Golgi apparatus in cells.

*The Golgi apparatus is like a customization shop in a factory. It puts the finishing touches on proteins before they leave the factory.*

17. Suppose a cell’s Golgi apparatus does not function properly. How might this problem affect other cells?

*Sample answer: If the cell manufactures proteins that are normally released to travel to other cells, those cells would not receive the proteins. The loss of these proteins might cause the “receiver” cells to function poorly.*

**Organelles That Capture and Release Energy**

18. Complete the Venn diagram to compare and contrast chloroplasts and mitochondria.

**Chloroplasts**

- Only in plant and algae cells
- Capture energy
- Chlorophyll
- Photosynthesis

**Mitochondria**

- Double membrane
- Own genetic info
- Descended from microorganisms
- In all eukaryotic cells
- Release energy
- Cellular respiration
For Questions 19–22, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

19. Chloroplasts are never found in animal cells.  
   **True**

20. Unlike chloroplasts, mitochondria are surrounded by a double membrane.  
   **True**

21. Nearly all of the mitochondria in your cells were inherited from your mother.  
   **Like**

22. Both chloroplasts and mitochondria lack genetic information in the form of DNA.  
   **True**

**Cellular Boundaries**

For Questions 23–25, complete each statement by writing the correct word or words.

23. Most cell **walls** are porous to water and other materials but strong enough to support and protect cells.

24. Nearly all of the plant tissue called **wood** is made up of cell walls.

25. Besides supporting and protecting a cell, the cell membrane **regulates** what enters and leaves the cell.

26. Complete the diagram of a section of a cell membrane. Then, on the line below the diagram, write the name of the model that describes the cell membrane’s structure.

27. What is the function of vesicles in the synthesis of proteins and the release of those proteins outside the cell?

   **Vesicles transport newly synthesized proteins to the Golgi apparatus. After the Golgi apparatus modifies the proteins, vesicles transport the modified proteins to the cell membrane, where they are released.**