A Tour of the Cell

4

A sampling of the diversity of life on Earth might include a redwood tree, a jellyfish, a bacterium, a tiger, and a mushroom. At one time, living things seemed so varied that the only characteristic they were thought to have in common was a mysterious "vital force" that made them all alive. Then, with the invention of the microscope, biologists discovered cells. By the late nineteenth century, they realized that all living things are made of cells and that an organism is alive because its cells are alive. Even though the life of a redwood tree and that of a jellyfish seem quite different, these two organisms look and function much the same on the cellular level. Now we have electron microscopes, and we can zoom in on the intricate structures within a single cell. We can take cells apart and analyze their chemistry, or probe them with radioactive isotopes, antibodies, lasers, or fluorescent dyes. This chapter describes what these techniques have revealed about the life of a cell.

Organizing Your Knowledge

Exercise 1 (Modules 4.1 - 4.2)

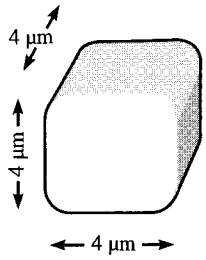
Web/CD Activity 4A *Metric System Review*

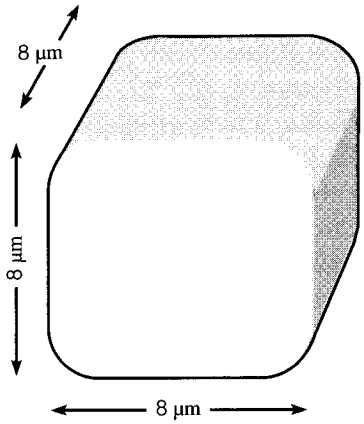
Use the information in the two modules and the chart in Module 4.2 to complete the following table comparing microscopes and the unaided human eye.

	Unaided Eye	*Light Microscope*	*Electron Microscope (SEM or TEM)*
Kind of radiation (beam) used	1.	2.	3.
Parts that focus beam	4.	5.	6.
Maximum magnification	7.	8.	9.
Smallest objects visible	10.	11.	12.
Size of smallest objects visible (resolving power)	13.	14.	15.
Limitations	16.	17.	18.

Exercise 2 (Module 4.3)

We need to use a microscope to see cells because cells are so small. Why can't a cell be as big as a house, or at least as big as a baseball? Compare the two cells diagrammed below. **For each cell, calculate the surface area, volume, and ratio of surface area to volume. Then answer the questions.**





Cell 1	*Cell 2*
Surface area: $s = 6 \times (l \times l) =$	Surface area: $s = 6 \times (l \times l) =$
Volume: $v = l \times l \times l =$	Volume: $v = l \times l \times l =$
Surface/volume: $s/v =$	Surface/volume: $s/v =$

1. Which cell has the greater surface area?

2. Which cell has the greater volume?

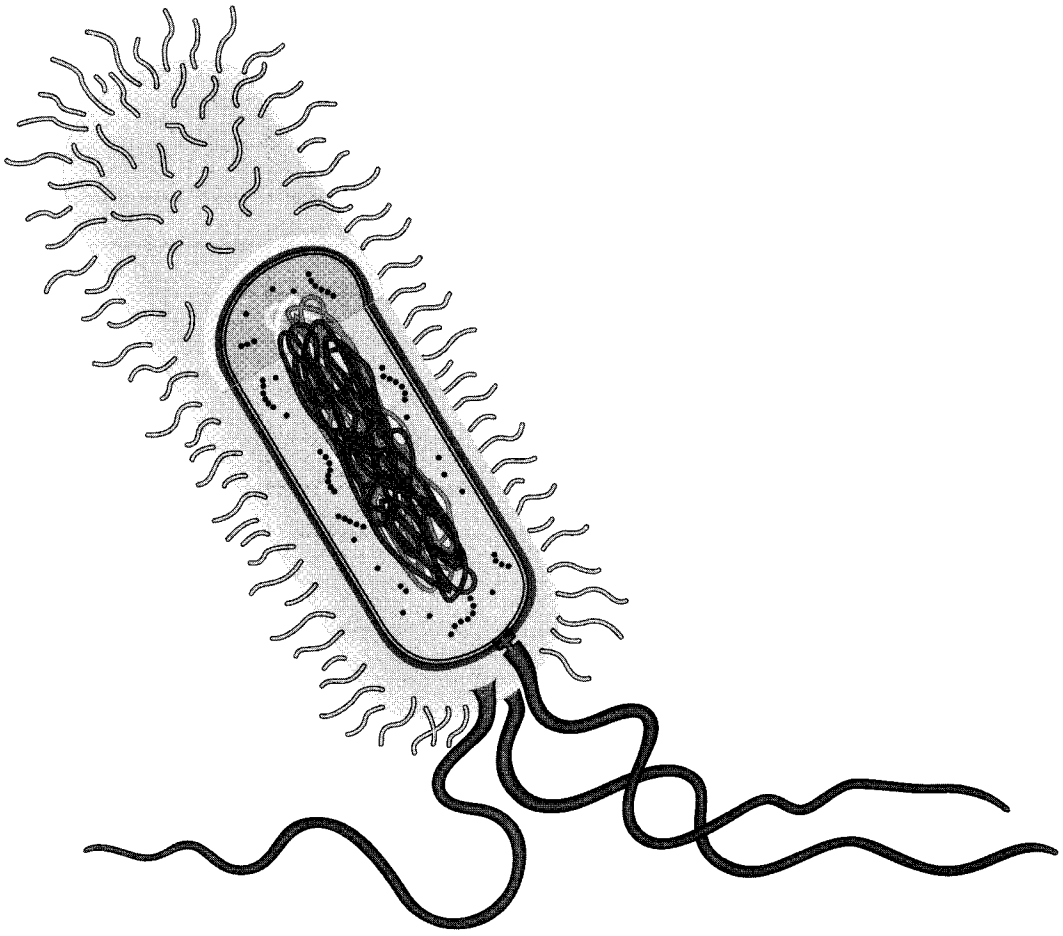
3. Which cell has the greater ratio of surface area to volume?

4. In which cell would the surface area of the membrane most efficiently service the cytoplasm?

Exercise 3 (Module 4.4)

Web/CD Activity 4B *Prokaryotic Cell Structure and Function*

Label the following on this diagram of a prokaryotic cell: **capsule, cell wall, plasma membrane, nucleoid region, ribosome, prokaryotic flagella, pili.** Briefly state the function of each structure next to its label.



Exercise 4 (Modules 4.4 – 4.5)

Web/CD Activity 4B *Prokaryotic Cell Structure and Function*
Web/CD Activity 4C *Comparing Prokaryotic and Eukaryotic Cells*
Web/CD Activity 4D *Build an Animal Cell and a Plant Cell*

Examine the diagrams and text, and then compare the structures of the cells of prokaryotes, plants, and animals by checking off their characteristics below. You may want to revise or refer to this checklist as you complete the chapter.

Characteristic	*Prokaryote Cell*	*Plant Cell*	*Animal Cell*
Prokaryotic structure			
Eukaryotic structure			
Relatively large size			
Relatively small size			
Membranous organelles			
Plasma membrane			
Cell wall			
Cytoplasm			
Ribosomes			
Bacterial flagellum			
Nucleus			
Rough endoplasmic reticulum			
Smooth endoplasmic reticulum			
Golgi apparatus			
Lysosome			
Peroxisome			
Mitochondrion			
Chloroplast			
Central vacuole			
Cytoskeleton			
Flagellum			
Centriole			

Exercise 5 (Modules 4.6 – 4.14)

Web/CD Activity 4E *Role of the Nucleus and Ribosomes in Protein Synthesis*
Web/CD Activity 4F *The Endomembrane System*

Review the nucleus and the various structures that make up the endomembrane system by matching each phrase on the right with a structure from the list on the left. Answers can be used more than once.

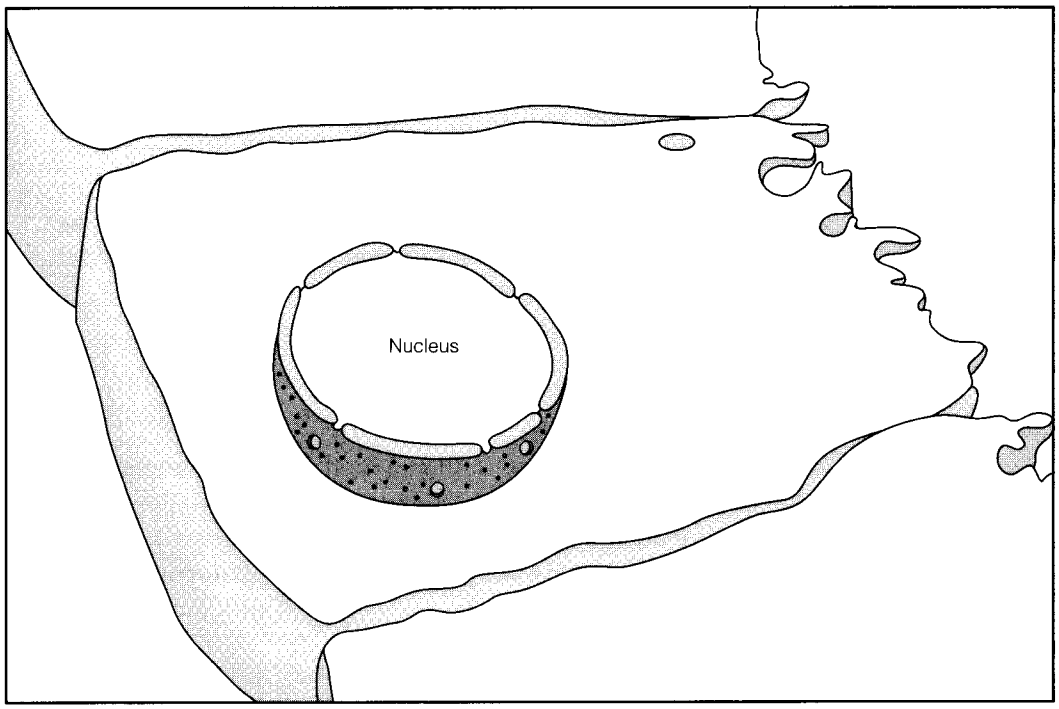
A. Nucleus
B. Transport vesicle
C. Central vacuole
D. Smooth ER
E. Lysosome
F. Golgi apparatus
G. Rough ER
H. Contractile vacuole
I. Ribosome

____ 1. Lipids manufactured here
____ 2. Small structure that makes protein
____ 3. Contains chromatin
____ 4. Sac of enzymes that digest things
____ 5. Carries secretions for export from cell
____ 6. Breaks down drugs and toxins in liver
____ 7. Makes cell membranes
____ 8. Cell control center
____ 9. Numerous ribosomes give it its name
____ 10. "Ships" products to plasma membrane, outside, or other organelles
____ 11. May store water, needed chemicals, wastes, pigments in plant cell
____ 12. Buds off from Golgi apparatus
____ 13. Defective in Pompe's disease and Tay-Sachs disease
____ 14. Proteins made here for secretion from cell
____ 15. Pumps out excess water from some cells
____ 16. Nonmembranous organelle
____ 17. Takes in transport vesicles from ER and modifies their contents
____ 18. Digests food, wastes, foreign substances
____ 19. Surrounded by double layer of membrane with pores
____ 20. How proteins, other substances get from ER to Golgi apparatus

Exercise 6 (Modules 4.7 - 4.14)

Web/CD Activity 4E *Role of the Nucleus and Ribosomes in Protein Synthesis*
Web/CD Activity 4F *The Endomembrane System*

Sketch and label the endomembrane system on this diagram. Include **rough ER, smooth ER, ribosomes, Golgi apparatus, lysosome, nuclear envelope,** and **transport vesicles**. (1) Trace the path of a protein from its site of manufacture to the outside of the cell with a red arrow. (2) Trace the path of a protein incorporated into a lysosome in blue. (3) Trace the path of a protein incorporated into the plasma membrane in green. (4) Trace the path of a lipid secreted from the cell in yellow.



Exercise 7 (Modules 4.15 - 4.16)

Web/CD Activity 4G *Build a Chloroplast and a Mitochondrion*

Both mitochondria and chloroplasts are energy converters, but their functions are quite different. Compare them by filling in the chart below.

	Chloroplast	*Mitochondrion*
Found in the following organisms . . .		
Carries out process of . . .		
Converts energy of . . .		
Into chemical energy in . . .		

Exercise 8 (Modules 4.17 – 4.18)

Web/CD Activity 4H *Cilia and Flagella*

Compare the components of the cytoskeleton by indicating with a checkmark which of the following are characteristics of microfilaments, intermediate filaments, or microtubules.

	Microfilaments	*Intermediate Filaments*	*Microtubules*
Hollow tubes			
Solid rods			
Ropelike structure			
Made of tubulin			
Made of actin			
Made of fibrous proteins			
Help cell change shape			
Reinforcing rods, anchor organelles			
Act in muscle cell contraction			
Move chromosomes			
Act as tracks for organelle movement			
Give cell rigidity, shape			
In cilia			
In flagella			
In centrioles			
9 + 2 pattern			

Exercise 9 (Module 4.19)

Web/CD Activity 4I *Cell Junctions*

Match each of the cell surface characteristics or structures on the left with a phrase on the right.

A. Tight junction
B. Plasmodesma
C. Anchoring junction
D. Cell wall
E. Communicating junction
F. Extracellular matrix

____ 1. Channel between animal cells
____ 2. Rigid cellulose covering of plant cell
____ 3. Link animal cells in leakproof sheet
____ 4. Channel between plant cells
____ 5. Connects animal cells, leaving space between them
____ 6. Sticky layer holds animal cells together

Exercise 10 (Module 4.20 and Summary)

Web/CD Activity 4J *Animal Cell Structure and Function*
Web/CD Activity 4K *Plant Cell Structure and Function*

Label the organelles listed in Module 4.20 on these diagrams of animal and plant cells. (If you get stuck, refer to Module 4.5.) Try to group your labels according to the functional categories in Module 4.20 so that you can circle and label each category. Complete your diagrams by putting red boxes around the names of structures found in animal cells but not in most plant cells. Put green boxes around the names of structures found in plant cells but not in animal cells.

Testing Your Knowledge

Multiple Choice

1. To enter or leave a cell, substances must pass through
   a. a microtubule.
   b. the Golgi apparatus.
   c. a ribosome.
   d. the nucleus.
   e. the plasma membrane.
2. Which of the following would *not* be considered part of a cell's cytoplasm?
   a. a ribosome
   b. the nucleus
   c. a mitochondrion
   d. a microtubule
   e. fluid between the organelles
3. Which of the following consist of prokaryotic cells?
   a. plants and animals
   b. bacteria
   c. plants, fungi, and bacteria
   d. animals
   e. plants and bacteria
4. Organelles involved in energy conversion are the
   a. rough ER and Golgi apparatus.
   b. nucleus and smooth ER.
   c. nucleus and chloroplast.
   d. lysosome and ribosome.
   e. mitochondrion and chloroplast.
5. The maximum size of a cell is limited by
   a. its need for enough surface area for exchange with its environment.
   b. the number of organelles that can be packed inside.
   c. the materials needed to build it.
   d. the amount of flexibility it needs to be able to move.
   e. the amount of food it needs to survive.
6. You would expect a cell with an extensive Golgi apparatus to
   a. make a lot of ATP.
   b. secrete a lot of material.
   c. move actively.
   d. perform photosynthesis.
   e. store large quantities of food.
7. Which of the following correctly matches an organelle with its function?
   a. mitochondrion—photosynthesis
   b. nucleus—cellular respiration
   c. ribosome—manufacture of lipids
   d. lysosome—movement
   e. central vacuole—storage
8. Cellular metabolism is
   a. a type of cell division.
   b. the process by which certain parts cause a cell to "self-destruct."
   c. the chemical activity of a cell.
   d. movement of a cell.
   e. control of the cell by the nucleus.
9. Which of the following stores calcium, important in muscle contraction?
   a. mitochondria
   b. smooth ER
   c. the Golgi apparatus
   d. contractile vacuoles
   e. rough ER
10. Of the following organelles, which group is involved in manufacturing substances needed by the cell?
    a. lysosome, vacuole, ribosome
    b. ribosome, rough ER, smooth ER
    c. vacuole, rough ER, smooth ER
    d. smooth ER, ribosome, vacuole
    e. rough ER, lysosome, vacuole
11. The internal skeleton of a cell is composed of
    a. microtubules, intermediate filaments, and microfilaments.
    b. cellulose and intermediate filaments.
    c. cellulose, microtubules, and centrioles.
    d. microfilaments.
    e. microfilaments and cellulose.

Essay

1. What are the advantages of an electron microscope over a light microscope? For what tasks would it be preferable to use a light microscope?
2. Briefly describe the major differences between prokaryotic and eukaryotic cells.
3. Name the structures present in plant cells but lacking in animal cells, and describe their functions.

4. Explain the advantages eukaryotic cells derive from being compartmentalized by many internal membranes.
5. Compare the functions of chloroplasts and mitochondria in a plant cell.

Applying Your Knowledge

Multiple Choice

1. A cell has mitochondria, ribosomes, smooth ER, and other parts. Based on this information, it could *not* be
   a. a cell from a pine tree.
   b. a grasshopper cell.
   c. a yeast (fungus) cell.
   d. a bacterium.
   e. Actually, it could be any of the above.
2. Dye injected into a cell might be able to enter an adjacent cell through a
   a. tight junction.
   b. microtubule.
   c. vacuole.
   d. plasmodesma.
   e. lysosome.
3. If a cell's chromatin were damaged, the cell would
   a. swell up and burst.
   b. run out of energy needed for its activities.
   c. go out of control.
   d. not be able to absorb light.
   e. divide immediately.
4. A researcher made an interesting observation about a protein made by the rough ER and eventually used to build a cell's plasma membrane. The protein in the membrane was actually slightly different from the protein made in the ER. The protein was probably changed in the
   a. Golgi apparatus.
   b. smooth ER.
   c. mitochondrion.
   d. nucleus.
   e. chloroplast.
5. If the nucleus is a cell's "control center," and chloroplasts its "solar collectors," which of the following might be called the cell's combination "food processor" and "garbage disposer"?
   a. lysosome
   b. Golgi apparatus
   c. flagellum
   d. ribosome
   e. nucleolus
6. When elongated, tube-shaped cells from the lining of the intestine are treated with a certain chemical, the cells sag and become round blobs. The internal structures disrupted by this chemical are probably
   a. cell junctions.
   b. microtubules.
   c. smooth and rough ER.
   d. mitochondria.
   e. microfilaments.
7. The electron microscope has been particularly useful in studying prokaryotes, because
   a. electrons can penetrate tough prokaryotic cell walls.
   b. prokaryotes are so small.
   c. prokaryotes move so quickly they are hard to photograph.
   d. they aren't really alive, so it doesn't hurt to "kill" them for viewing.
   e. their organelles are small and tightly packed together.
8. A cell possesses ribosomes, a plasma membrane, a cell wall, and other parts. It could *not* be
   a. a bacterium.
   b. a cell from a fungus.
   c. a cell from a mouse.
   d. an oak tree cell.
   e. a bacterium or a plant.
9. A mutant plant cell unable to manufacture cellulose would be unable to
   a. build a cell wall.
   b. divide.
   c. capture sunlight.
   d. move.
   e. store food.

10. A plant cell was grown in a test tube containing radioactive nucleotides, the parts from which DNA is built. Later examination of the cell showed the radioactivity to be concentrated in the
    a. rough ER.
    b. Golgi apparatus.
    c. smooth ER.
    d. central vacuole.
    e. nucleus.

Essay

1. Explain whether you would use a light microscope, a transmission electron microscope (TEM), or a scanning electron microscope (SEM) to perform each of the following tasks, and explain why: examining fine structural details within cell organelles, observing how a cell changes shape as it moves, studying tiny bumps on the cell surface, filming changes in the shape of the nucleus as a cell prepares to divide.
2. Imagine a cell shaped like a cube, 5 μm on each side. (Cells are not perfect cubes, but this assumption simplifies the question.) What is the surface area of the cell, in μm^2? What is its volume, in μm^3? What is the ratio of surface area to volume for this cell? (Sketches may help.) Now imagine a second cell, this one 10 μm on each side. What are its surface area, volume, and surface-to-volume ratio? Compare the surface-to-volume ratios of the two cells. How is this comparison significant to the functioning of cells? How could the surface-to-volume ratio of the larger cell be increased?
3. An enzyme (a type of protein) called salivary amylase is manufactured in the cells of your salivary glands and secreted as part of saliva. Explain how these parts of the cell cooperate to produce and secrete salivary amylase: transport vesicles, rough ER, plasma membrane, nucleus, Golgi apparatus, ribosomes.
4. A chemical that acts specifically on mitochondria was found to interfere with the movement of cilia, slow down protein synthesis, reduce the frequency of cell division, and slow down the manufacture of lipids. Explain how one chemical could affect so many different cell activities.
5. When you work harder, your muscle cells work harder and increase in size. How might various organelles in a muscle cell increase in size, number, or activity to respond to the challenge of an increased workload?

Extending Your Knowledge

1. Analogies can be helpful in learning and understanding a new topic. For example, the cell can be thought of as a chemical factory, and the nucleus as its main office or control center. Can you compare the functions of other cell parts to the parts of a factory? What might be the factory doors? The power plant that provides energy for running the factory? The warehouse where raw materials or products are stored? Can you think of other comparisons? How does the cell differ from a factory?
2. Basic research is scientific investigation aimed at figuring out how something works, without thought for the immediate usefulness of the information obtained. The goal of applied research, on the other hand, is to put scientific knowledge to work. Much of cell biology is basic research—simply figuring out what the parts of a cell are and how they work. Nevertheless, the recent explosion of knowledge about cells has been immensely useful. For example, understanding lysosomes has helped us to understand disorders such as Tay-Sachs disease. Can you think of other examples where our understanding of cells has made our lives more healthy, comfortable, or productive?