Chapter 6: A Tour of the Cell

6.1 Identify how common techniques of microscopy and biochemistry are used in cell biology.

6.2 Compare and contrast (1) prokaryotic and eukaryotic cells and (2) animal and plant cells.

6.3 Describe the structure of the nucleus, chromosomes, and ribosomes, and explain their functions.

6.4 Identify the parts of the endomembrane system and describe their roles in the cell.

6.5 Compare and contrast the structures and functions of mitochondria and chloroplasts.

6.6 Describe the subunits and structures of the three types of cytoskeletal fibers and list their functions.

6.7 Compare and contrast (1) the extracellular components of plant and animal cells and (2) the cell junctions of plant and animal cells.

6.8 Explain how the parts of a cell work together to enhance cellular function.

In high school biology, you probably learned all the cell parts and what they do. In this course, change your focus to understanding the importance of specialized organelles, how they function in normal cells, and what may occur if their function is disrupted.

Study Tip: Research clearly shows that when you make sketches, you remember details better. Follow the *Study Tip* suggestion, using an entire sheet of paper for an animal cell and another for a plant cell. Add structures and notes as you progress through each concept.

The diagram of the plant cell on the opening page of this chapter gives a visual overview of how plant cells are organized. Note that plant cells have a large central vacuole and may contain both chloroplasts and mitochondria. Draw a plant cell labeled with the structures mentioned in Figure 6.1 in the space below.

Concept 6.1 Biologists use microscopes and biochemistry to study cells

LO 6.1: Identify how common techniques of microscopy and biochemistry are used in cell biology.

1. The study of cells has been limited by their small size, and so they were not seen and described until 1665, when Robert Hooke first looked at dead cells from the bark of an oak tree. His contemporary, Antoni van Leeuwenhoek, crafted lenses and opened a new world with the improvements in optical aids. *Magnification* and *resolving power* limit what can be seen. Explain the difference.

2. The development of electron microscopes has further opened our window on the cell and its organelles. What is considered a major disadvantage of the electron microscope?

3. Study the electron micrographs in your text. Describe the different types of images obtained from:

   scanning electron microscopy (SEM)

   transmission electron microscopy (TEM)

4. In *cell fractionation*, whole cells are broken up in a blender, and this slurry is centrifuged several times. Each time, smaller and smaller cell parts are isolated. This will isolate different organelles and allow study of their biochemical activities. Which organelles are the smallest ones isolated in this procedure?

Concept 6.2 Eukaryotic cells have internal membranes that compartmentalize their functions

LO 6.2: Compare and contrast (1) prokaryotic and eukaryotic cells and (2) animal and plant cells.

5. Which two domains consist of prokaryotic cells?

6. A major difference between prokaryotic and eukaryotic cells is the location of their DNA. Describe this difference.

7. On the figure of a prokaryotic cell, label each of these features and give its function or description.

cell wall

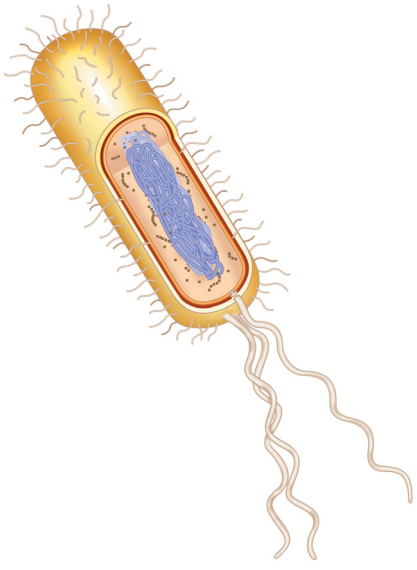
plasma membrane

bacterial chromosome

nucleoid

ribosomes

flagella



Surface area-to-volume ratio is an important concept as it determines the ability of a cell to exchange materials with the environment. It is important that you be able to both calculate this ratio and also understand its significance.

8. Why are cells so small? Explain the relationship of surface area to volume.

9. Exchange of materials across the plasma membrane requires a high surface-to-volume ratio. How do the *microvilli* of intestinal cells facilitate this?

10. Imagine an elongated cell (such as a nerve cell) that measures 125 × 1 × 1 arbitrary units (cell A). Predict how the surface-to-volume ratio would compare with a cell that is 5 × 5 × 5 (cell B) and then calculate the ratio for both cells. A small sketch will help you visualize this. (Calculations will be found at the end of this chapter.)

11. Spend some time with the calculations of surface area and volume on p. 98 and the *Scientific Skills Exercise* on p. 99 of *Campbell Biology*, 12e. The following two questions will ensure you understand the central concept.

    a. As the size of a cell increases, what happens to the surface area to volume ratio?

    b. How would this affect traffic into and out of the cell?

Concept 6.3 The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes

LO 6.3: Describe the structure of the nucleus, chromosomes, and ribosomes, and explain their functions.

12. Describe the *nuclear envelope*. How many layers does it consist of? What connects the layers? How do molecules such as mRNA pass through the envelope?

13. What are the *nuclear lamina* and *nuclear matrix*? What function do they perform?

14. Found within the nucleus are the *chromosomes*. They are made of *chromatin*. What are the two components of chromatin? When do the thin chromatin fibers condense to become distinct chromosomes?

15. When are the *nucleoli* visible? What organelles are assembled here?

16. What is the function of *ribosomes*? What are their two components?

17. Ribosomes in any type of organism are all the same, but we distinguish between two types of ribosomes based on where they are found and the destination of the protein product made. Complete this chart to demonstrate this concept.

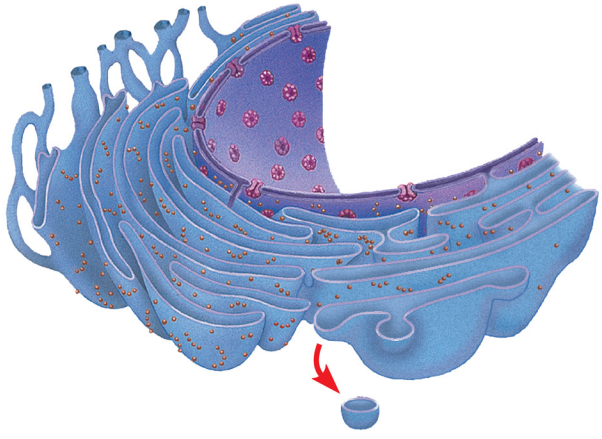
Type of Ribosome	Location	Product
Free ribosomes		
Bound ribosomes		

Concept 6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell

LO 6.4: Identify the parts of the endomembrane system and describe their roles in the cell.

18. List all the structures of the *endomembrane system*. (Use this list to update your *Study Tip* diagram)

19. The *endoplasmic reticulum (ER)* makes up more than half the total membrane system in many eukaryotic cells. Use this sketch to label and explain the *lumen, transport vesicles*, and the difference between *smooth* and *rough ER*.



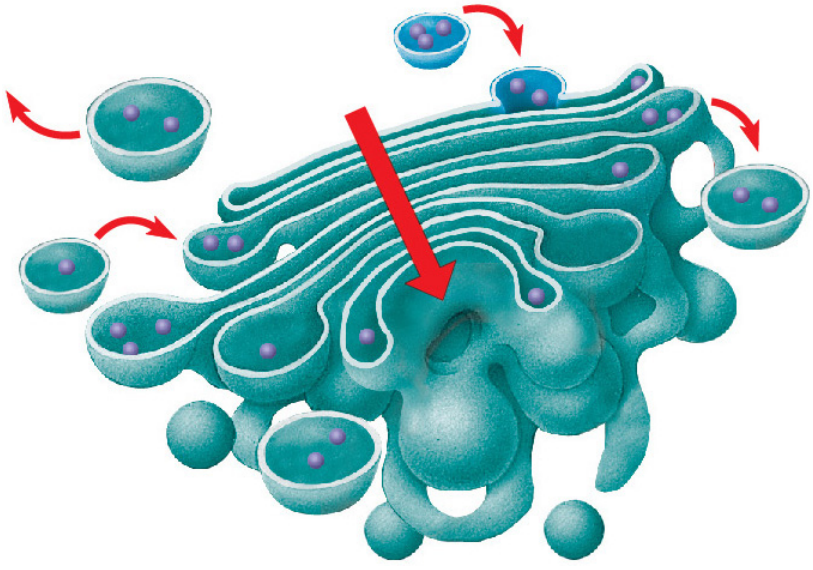
20. List and describe three major functions of the smooth ER.

21. Why does alcohol abuse increase tolerance to other drugs such as barbiturates?

22. The rough ER is studded with ribosomes. As proteins are synthesized, they are threaded into the lumen of the rough ER. Some of these proteins have carbohydrates attached to them in the ER to form *glycoproteins*. What does the ER then do with these secretory proteins?

23. What is another major function of the rough ER?

24. The transport vesicles formed from the rough ER fuse with the Golgi apparatus. Use this sketch to label the *cisterna* of the Golgi apparatus, and its *cis* and *trans* faces. Describe all that can happen to a transport vesicle and its contents after it arrives in the Golgi apparatus.



25. What is a *lysosome*? What does it contain? What is the pH range inside a lysosome?

26. One function of lysosomes is intracellular digestion of particles engulfed by *phagocytosis*. Describe this process of digestion. Which human cells carry out phagocytosis?

27. A second function of lysosomes is to recycle cellular components in a process called *autophagy*. Describe this process using Figure 6.13 in your text.

28. Explain what occurs in lysosomes to cause Tay-Sachs disease.

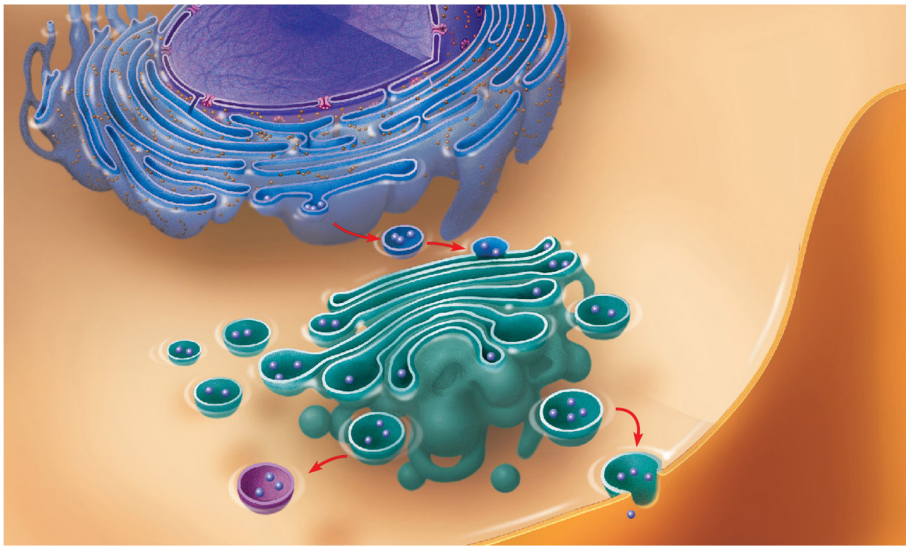
29. There are many types of vacuoles. Briefly describe each type of vacuole below.

food vacuoles

contractile vacuoles

central vacuoles in plants

30. Label and use this figure to explain how the elements of the endomembrane system function together to secrete a protein and to digest a cellular component.



Concept 6.5 Mitochondria and chloroplasts change energy from one form to another

LO 6.5: Compare and contrast the structures and functions of mitochondria and chloroplasts.

31. What is the *endosymbiont theory*? Summarize three lines of evidence that support the model of endosymbiosis.

32. Mitochondria and chloroplasts are not considered part of the endomembrane system, although they are enclosed by membranes. Sketch a mitochondrion here and label its *outer membrane*, *inner membrane*, *inner membrane space*, *cristae*, *matrix*, and *ribosomes*.

33. Now sketch a chloroplast and label its *outer membrane*, *inner membrane*, *inner membrane space*, *thylakoids*, *granum*, and *stroma*. Notice that the mitochondrion has two membrane compartments, whereas the chloroplast has three compartments.

34. What is the function of the mitochondria?

35. What is the function of the chloroplasts?

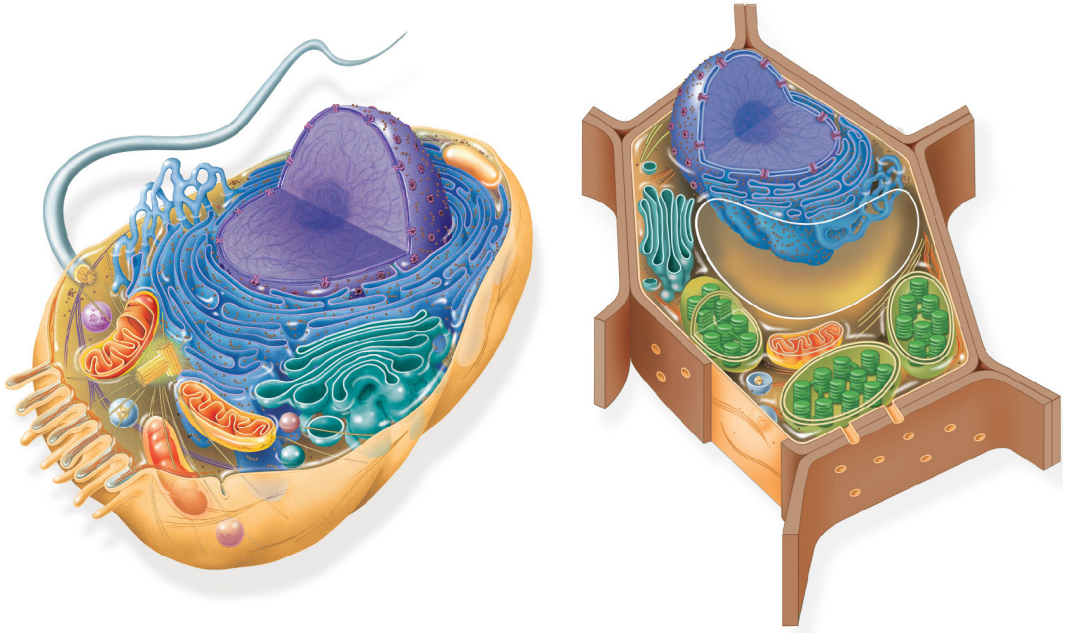
36. Recall the relationship of structure to function. Why is the inner membrane of the mitochondria highly folded? What role do all the individual thylakoid membranes serve? (Notice that you will have the same answer for both questions.)

37. Explain the important roles played by *peroxisomes*.

38. Use peroxisomes as an example to explain the value of compartmentalization in cells.

STUDY TIP SUMMARY

A favorite essay question of many teachers would be to ask you to determine the primary function of a cell type, based on its organelles. It is important for you to consider not just the function of an organelle, but *in what cell types* specialized organelles might be found (or absent). Your *Study Tip* diagrams should now resemble the animal and plant cells included here. This is a good point to make sure your diagrams are updated and labeled with a brief statement of function. The final task with the diagrams is for you to cite a tissue where cells might have many of these organelles. For example: Chloroplasts capture light energy and can be found in green leaves. Cilia move materials across the surface of a cell and can be found in epithelial cells lining the trachea.



Concept 6.6 The cytoskeleton is a network of fibers that organizes structures and activities in the cell

LO 6.6: Describe the subunits and structures of the three types of cytoskeletal fibers and list their functions.

39. What is *cytoskeleton*?

40. There are three main types of fibers that make up the cytoskeleton. Name them.

41. What are three functions of the cytoskeleton?

42. *Microtubules* are hollow rods made of a globular protein called tubulin. Each tubulin protein is a dimer made of two subunits. These are easily assembled and disassembled. Describe several functions of microtubules.

43. Animal cells have a *centrosome* that contains a pair of *centrioles*. Plant cells do not have centrioles. What is believed to be the role of centrioles?

44. *Compare* and *contrast* cilia and flagella. For both, select a human cell that has this feature, and describe the role for that cell.

45. On your *Study Tip* diagram of an animal cell, add the *primary cilium*. What is the function of the primary cilium? What are two examples of the important role of the primary cilium?

46. How do motor proteins called *dyneins* cause movement of cilia? What is the role of ATP in this movement?

47. *Microfilaments* are solid, and they are built from a double chain of *actin*. Study Figure 6.26 in your text and explain three examples of movements that involve microfilaments.

48. What are the motor proteins that move the microfilaments?

49. *Intermediate filaments* are bigger than microfilaments but smaller than microtubules. They are more permanent fixtures of cells. Give two functions of intermediate filaments.

Concept 6.7 Extracellular components and connections between cells help coordinate cellular activities

LO 6.7: Compare and contrast (1) the extracellular components of plant and animal cells and (2) the cell junctions of plant and animal cells.

50. What are three functions of the *cell wall*?

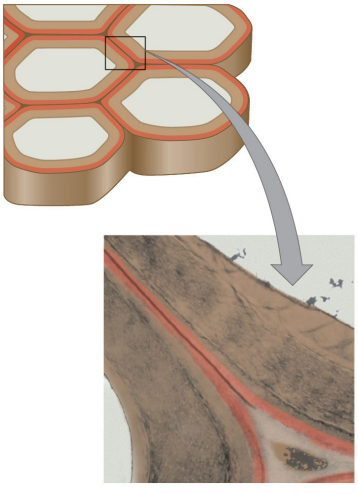
51. What is the composition of the cell wall?

52. What is the relatively thin and flexible wall secreted first by a plant cell?

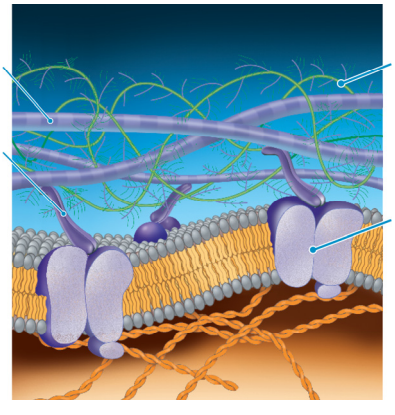
53. What is the *middle lamella*? Where is it found? What material is it made of?

54. Describe the deposition of a *secondary cell wall*.

55. On the sketch, label the *primary cell wall*, *secondary cell wall*, *middle lamella*, *cytosol*, *plasma membrane*, *central vacuole*, and *plasmodesmata*.

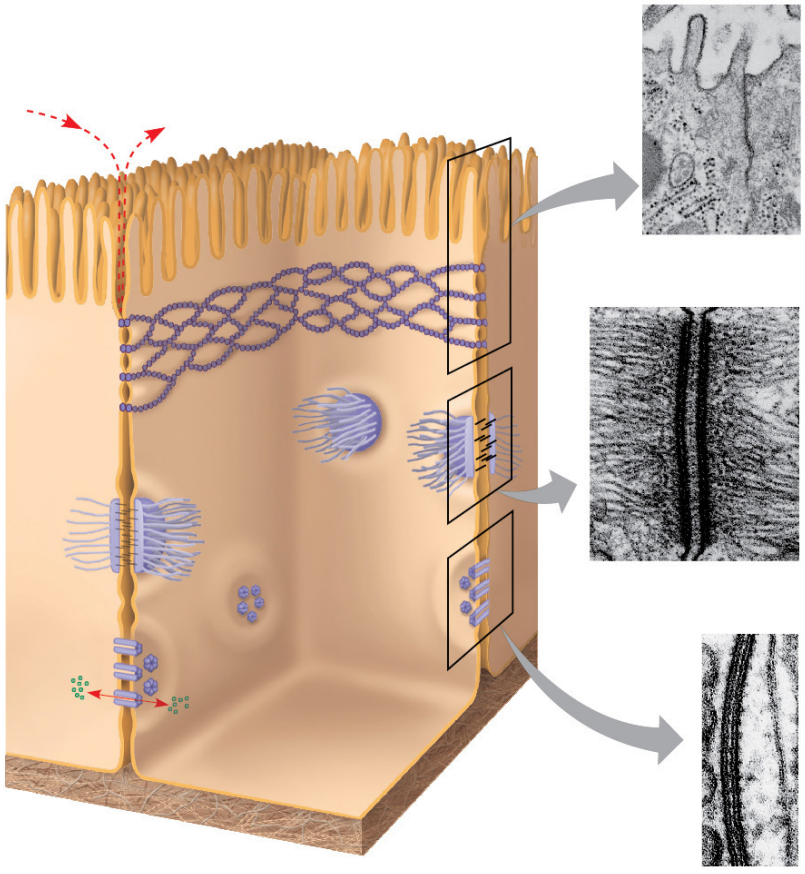


56. Animal cells do not have cell walls, but they do have an extracellular matrix (ECM). On this figure, label the elements indicated, and give the role of each. Also label the extracellular fluid and cytoplasm.



57. What are the intercellular junctions between plant cells? What can pass through them?

58. Animal cells do not have *plasmodesmata*. This figure shows the three types of intercellular junctions seen in animal cells. Label each type and summarize its role.



There is a fascinating figure on pp. 122–123 of your text that will help you visualize the molecular machinery in a cell. Notice that a number of details reference other chapters. You will want to come back to this important diagram through the cell biology part of your course. Study Figure 6.32 carefully and then answer the three questions on p. 123 at the end of the figure. Place your answers here.

1.

2.

3.

This chapter ends like it started with diagrams, drawings, and visualization. These are the things that allow an understanding of the material beyond memorization.

Test Your Understanding, p. 125

Now you should be ready to test your knowledge. Place your answers here:

1. ____ 2. ____ 3. ____ 4. ____ 5. ____

Solution to question 10:

Cell A: SA = (125 × 1) × 4 + (1 × 1) × 2 = 502 units^2; Volume = 125 × 1 × 1 = 125 units^3; S-to-V = 502/125 = 4.02

Cell B: SA = 5 × 5 × 6 = 150 units^2; Volume = 5 × 5 × 5 =125 units^3; S-to-V = 150/125 = 1.2

Note that both cells have the same volume, but the elongated cell A has a higher S-to-V ratio and therefore is better able to exchange materials with the environment.