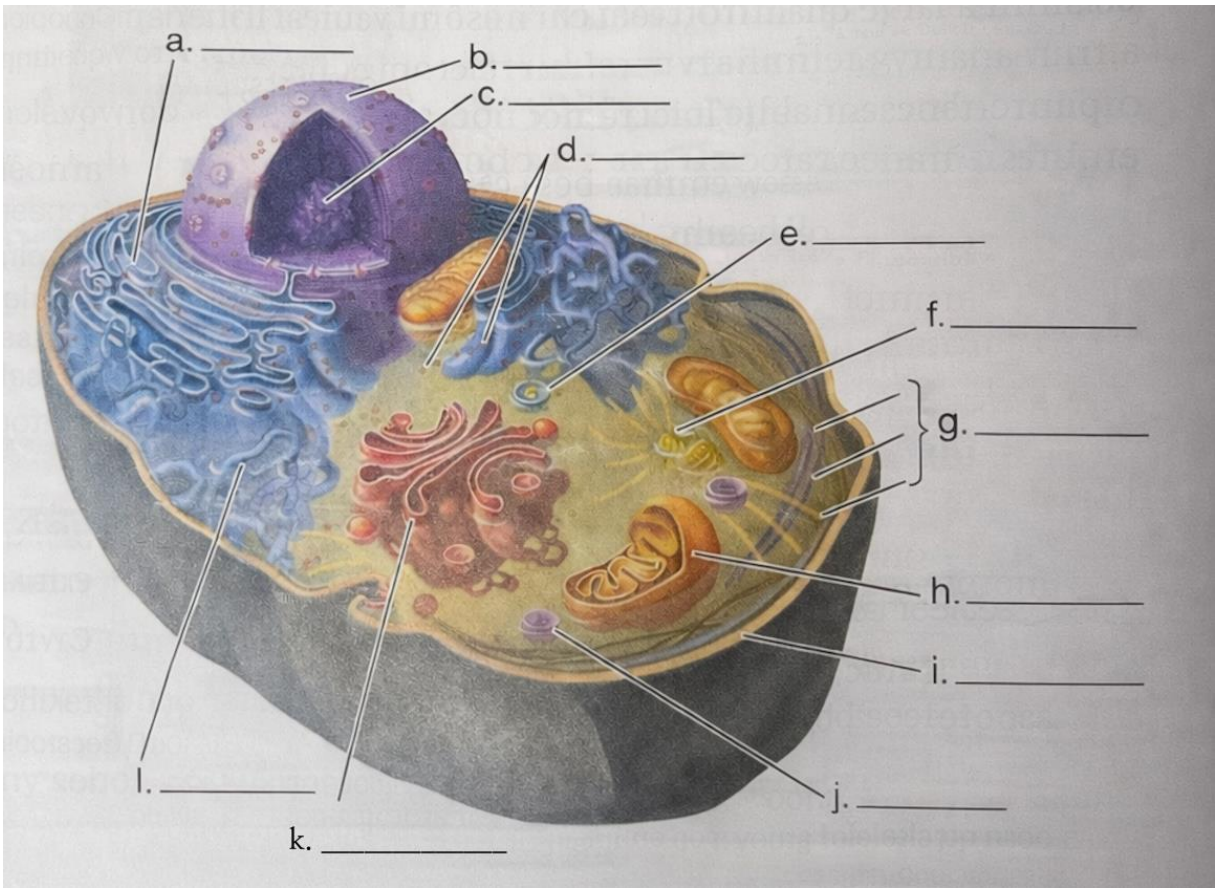
Chapter 4: A Tour of the Cell

Campbell Biology: Concepts & Connections 9E (Taylor et al.)

Connecting the Concepts

1. Label the structures in this diagram of an animal cell. Review the functions of each of these organelles.



Testing Your Knowledge

Level 1: Knowledge / Comprehension

1. Fluorescent antibody stains are used to enhance microscopy by
    a. selectively binding to specific cellular components
    b. colorizing black and white election microscopy images
    c. making cells more visible in low-light conditions
    d. keeping cells alive for use in electron microscopy

2. The cells of an ant and an elephant are, on average, the same small size; an elephant just has more of them. What is the main advantage of small cell size? (*Explain your reasoning*)
    a. A small cell has a larger plasma membrane surface area than does a large cell.
    b. Small cells can better take up sufficient nutrients and oxygen to service their cell volume.
    c. It takes less energy to make an organism out of small cells.
    d. Small cells require less oxygen than do large cells.

3. Which pair of organelles is present in animal cells but not in plant cells?
    a. lysosome and peroxisome
    b. lysosome and centrosome
    c. plasmodesma and centrosome
    d. plasmodesma and peroxisome

4. Which component of a cell's cytoskeleton can be disassembled, moved, and reused elsewhere?
    a. microfilaments
    b. intermediate filaments
    c. motor proteins
    d. microtubules

5. What four cellular components are shared by prokaryotic and eukaryotic cells?

6. Which type of cell junction facilitates communication between neighboring cells?

Level 2: Application / Analysis

Choose from the following cells for questions 7-10:

    a. pancreatic cell that secretes digestive enzymes
    b. ovarian cell that produces estrogen (a steroid hormone)
    c. muscle cell in the thigh of a long-distance runner
    d. white blood cell that engulfs bacteria

7. In which cell would you find the most lysosomes?

8. In which cell would you find the most smooth ER?

9. In which cell would you find the most rough ER?

10. In which cell would you find the most mitochondria?

11. Explain why it is important that the inner membrane in mitochondria be highly folded.

12. Is this statement true or false? "Animal cells have mitochondria; plant cells have chloroplasts." Explain your answer, and describe the functions of these organelles.

13. Describe the structure of a plant cell wall.

14. Imagine a spherical cell with a radius of 10 μm. What is the cell's surface area in μm^2? Its volume, in μm^3? (*Note:* For a sphere or radius *r*, surface area = $4\pi r^2$ and volume = $\frac{4}{3}\pi r^3$. Remember that the value of π is 3.14.) What is the ratio of surface area to volume for this cell? Now do the same calculations for a second cell, this one with a radius of 20 μm. Compare the surface-to-volume ratios of the two cells. How is this comparison significant to the functioning of cells?

15. Compare and contrast the intermediate filaments and the microfilaments of a cell's cytoskeleton

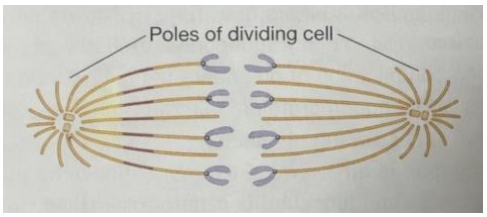
Level 3: Synthesis / Evaluation

16. Multicellular organisms would not be possible without the extracellular matrix (ECM). Explain.

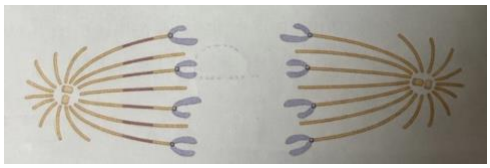
17. Cilia are found on cells in almost every organ of the human body, and the malfunction of cilia is involved in several human disorders. During embryological development, for example, cilia generate a leftward flow of fluid that initiates the left-right organization of the body organs. Some individuals with primary ciliary dyskinesia (see Module 4.18 checkpoint question) exhibit a condition (*situs inversus*) in which internal organs such as the heart are on the wrong side of the body. Explain why this reversed arrangement may be a symptom of PCD.

18. Microtubules often produce movement through their interaction with motor proteins. But in some cases, microtubules move cell components when the length of the microtubule changes. Through a series of experiments, researchers determined that microtubules grow and shorten as tubulin proteins are added or removed from their ends. Other experiments showed that microtubules make up the spindle apparatus that "pulls" chromosomes toward opposite ends (poles) of a dividing cell/ The figures below describe a clever experiment done in 1987 to determine whether a spindle microtubule shortens (depolymerizes) at the end holding a chromosome or at the pole end of a dividing cell.

Experimenters labeled the microtubules of a dividing cell from a pig kidney with a yellow fluorescent dye. As shown on the left half of the diagram below, they then marked a region halfway along the microtubules by using a laser to eliminate the fluorescence from that region. They did not mark the other side of the spindle (right side of the figure).



The figure below illustrates the results they observed as the chromosomes moved toward the opposite poles of the cell.



Describe these results. What would you conclude about where the microtubules depolymerize from comparing the length of the microtubules on either side of the mark? How could the experimenters determine whether this is the mechanism of chromosome movement in all cells?

Source: G. J. Gorbsky et al. Chromosomes move poleward in anaphase along stationary microtubules that coordinately disassemble from their kinetochore ends, *Journal of Cell Biology* 104:9-18 (1987).

<Answer Key>

1. a. rough ER; b. nucleus; c. nucleolus; d. ribosomes; e. peroxisome; f. centrosome; g. cytoskeleton; h. mitochondrion; i. plasma membrane; j. lysosome; k. Golgi apparatus; l. smooth ER. For functions, see Table 4.2. A centrosome is a microtubule-organizing center.

1. a. 2. b (Small cells have a greater ratio of surface area to volume.) 3. b 4 . d

5. DNA as genetic material, ribosomes, plasma membrane, and cytosol

6. Gap junctions facilitate communication between neighboring cells by allowing the transfer of small molecules between them.

7. d 8 .b 9. a 10. c

11. Cristae or the folds of the inner membrane of mitochondria increases the surface area of the membrane, thereby boosting mitochondrion's ability to produce ATP.

12. Part true, part false. All animal and plant cells have mitochondria; plant cells do have chloroplasts, but animal cells do not. Both organelles process energy. A mitochondrion converts chemical energy (such as in sugar molecules) to another form of chemical energy (ATP). This process provides eukaryotic cells with ATP needed for cellular work. A chloroplast converts light energy to chemical energy (sugar molecules). These sugar molecules may then provide a plant cell's mitochondria with a source of energy. Or they may be stored in the plant body and passed to animals that eat plants or each other.

13. Plant cell walls comprise cellulose fibers embedded in a matrix of other polysaccharides and proteins, providing a strong, protective cover for the cell. Plant cell walls do not fully enclose cells: Plasmodesmata are pores in plant cell walls that allow communication and molecular exchange to take place between neighboring cells.

14. Cell 1: S = 1,256 μm^2; V = 4,187 μm^3; S/V = 0.3. Cell 2: S = 5,024 μm^2; V = 33,493 μm^3; S/V = 0.15. The smaller cell has a larger surface area relative to volume, facilitating the uptake of sufficient nutrients and oxygen and the excretion of waste.

15. Intermediate filaments are made of fibrous proteins, while microfilaments are solid rods made of the protein actin. While intermediate filaments primarily function to maintain cell shape and anchor specific organelles, microfilaments are primarily involved in cell motility and contraction. They also act as tracks along which organelles can move.

16. The ECM is required for many key processes. These include cell-cell communication, structural rigidity, directed growth, and genetic control. All of these combined processes are essential for cells to undergo coordinated growth, development, and division. The ECM allows cells to sense and react to changes and signals coming from the external environment and other cells. Without this, it would be impossible to form a functioning multicellular organism.

17. Individuals with PCD have nonfunctional cilia and flagella because of a lack of dynein motor proteins. This defect would also mean that the cilia involved in left-right pattern formation in the embryo would not be able to set up the fluid flow that initiates the normal arrangement of organs.

18. As the chromosomes moved poleward, the microtubule segments on the chromosome side of the mark shortened, while those on the pole side stayed the same length. Thus chromosome movement toward the poles of this dividing cell is correlated with the shortening (depolymerizing) of the microtubules at the end where the chromosome is attached. The experiment would have to be repeated on different types of cells from different organisms to determine whether the location where a spindle fiber depolymerizes is always the same. Indeed, other experiments have shown that in some cells, the microtubules depolymerize from the pole end of the spindle fibers.