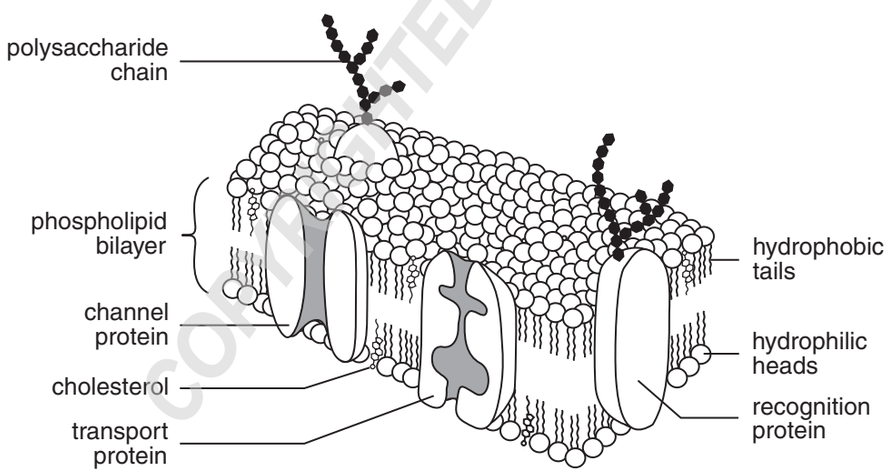
Cells

Review

Structure and Function of the Cell

The **cell** is the basic functional unit of all living things. The **plasma membrane** (**cell membrane**) bounds the cell and encloses the **nucleus** and **cytoplasm**. The **cytoplasm** consists of specialized bodies called **organelles** suspended in a fluid matrix, the **cytosol**, which consists of water and dissolved substances such as proteins and nutrients.

The **plasma membrane** separates internal metabolic events from the external environment and controls the movement of materials into and out of the cell. The plasma membrane is a double phospholipid membrane (**lipid bilayer**) with the polar hydrophilic heads forming the two outer faces and the nonpolar hydrophobic tails pointing toward the inside of the membrane (Figure 2-1).



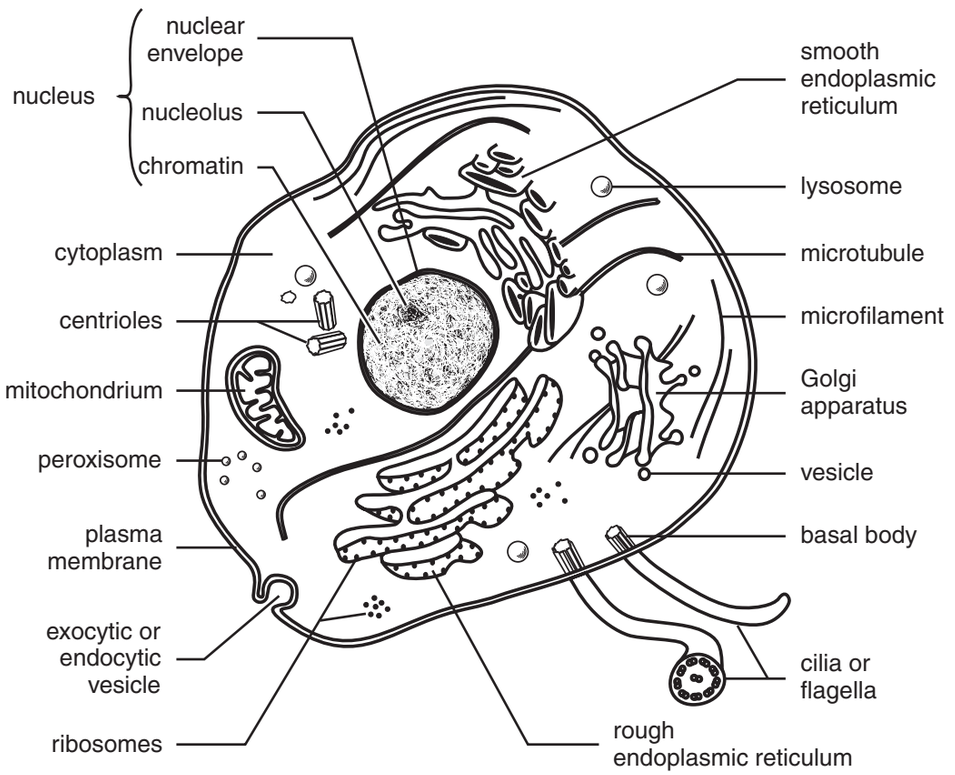
The Plasma Membrane

Figure 2-1

Proteins are scattered throughout the flexible phospholipid membrane. Proteins may attach loosely to the inner or outer surface of the membrane (**peripheral proteins**), or they may extend into the membrane (**integral proteins**). Integral proteins may span across the membrane, appearing at both surfaces (**transmembrane proteins**). Like phospholipids, integral proteins are amphipathic, with the hydrophobic regions embedded in the membrane and the hydrophilic regions exposed to the aqueous solutions bordering the membrane. The mosaic nature of scattered proteins within a flexible matrix of phospholipid molecules describes the **fluid mosaic model** of the cell membrane. Additional features of the plasma membrane follow:

1. The **phospholipid membrane** is selectively permeable. Only small, uncharged, polar molecules (such as H_2O and CO_2) and hydrophobic molecules (nonpolar molecules like O_2 and lipid-soluble molecules such as hydrocarbons) freely pass across the membrane. In contrast, large polar molecules (such as glucose) and all ions are impermeable.
2. **Proteins** in the plasma membrane provide a wide range of functions and include the following:
    - **Channel proteins** provide passageways through the membrane for certain hydrophilic (water-soluble) substances such as polar and charged molecules.
    - **Transport proteins** spend energy (ATP) to transfer materials across the membrane. When energy is used for this purpose, the materials are said to be *actively* transported, and the process is called **active transport**.
    - **Recognition proteins** distinguish the identity of neighboring cells. These proteins are **glycoproteins** because they have short polysaccharide chains (oligosaccharides) attached. The oligosaccharide part of the glycoprotein protrudes from the surface of the membrane like an antenna.
    - **Adhesion proteins** attach cells to neighboring cells or provide anchors for the internal filaments and tubules that give stability to the cell.
    - **Receptor proteins** provide binding sites for hormones or other trigger molecules. In response to the hormone or trigger molecule, a specific cell response is activated.
    - **Electron transfer proteins** are involved in transferring electrons from one molecule to another during chemical reactions.
3. **Cholesterol** molecules distributed throughout the phospholipid bilayer provide some rigidity to the plasma membranes of *animal cells*. In plant cells, related substances (sterols) provide a similar function.
4. The **glycocalyx** is a carbohydrate "coat" covering the outer face of the plasma membrane. It consists of various oligosaccharides that are attached to membrane phospholipids (**glycolipids**) and proteins (such as the **glycoproteins** of recognition proteins). The glycocalyx provides markers for cell-cell recognition.

Organelles are bodies within the cytoplasm that serve to physically separate the various metabolic reactions that occur within cells. A description of these organelles as well as other structures in the cell follows (Figure 2-2).

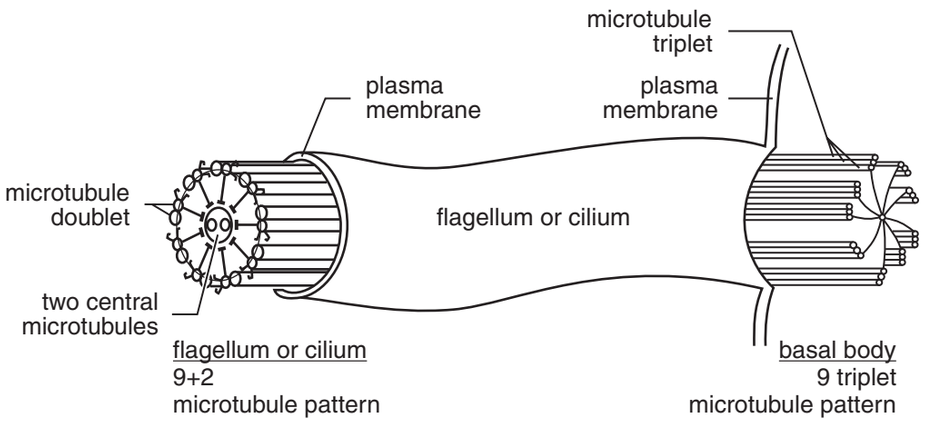


An Animal Cell

Figure 2-2

1. The **nucleus** is bounded by the **nuclear envelope**, a phospholipid bilayer similar to the plasma membrane. The nucleus contains DNA (deoxyribonucleic acid), the hereditary information of the cell. Normally, the DNA is spread out within the nucleus as a threadlike matrix called **chromatin**. When the cell begins to divide, the chromatin condenses into rod-shaped bodies called **chromosomes**, each of which, before dividing, is made up of two long DNA molecules and various histone (protein) molecules. The histones serve to organize the lengthy DNA, coiling it into bundles called **nucleosomes.** Also visible within the nucleus are one or more **nucleoli**, concentrations of DNA in the process of manufacturing the components of **ribosomes.** The nucleus also serves as the site for the separation of chromosomes during cell division.
2. **Ribosome** subunits are manufactured in the nucleus and consist of RNA molecules and proteins. The two subunits, labeled 60S and 40S, move across the nuclear envelope and into the cytoplasm where they are assembled into a single 80S ribosome. (An S value, or Svedberg unit, expresses how readily a product forms a sediment in a centrifuge, with larger values representing larger and heavier products). In the cytoplasm, ribosomes assist in the assembly of amino acids into proteins.

3. The **endoplasmic reticulum,** or **ER,** consists of stacks of flattened sacs involved in the production of various materials. In cross section, they appear as a series of maze-like channels, often closely associated with the nucleus. When ribosomes are present, the ER (called **rough ER)** creates **glycoproteins** by attaching polysaccharide groups to polypeptides as they are assembled by the ribosomes. **Smooth ER,** without ribosomes, is responsible for various activities, including the synthesis of lipids and hormones, especially in cells that produce these substances for export from the cell. In liver cells, smooth ER is involved in the breakdown of toxins, drugs, and toxic by-products from cellular reactions.
4. A **Golgi apparatus** (**Golgi complex** or **Golgi body**) is a group of flattened sacs arranged like a stack of bowls. They function to modify and package proteins and lipids into **vesicles,** small, spherically shaped sacs that bud from the outside surface of the Golgi apparatus. Vesicles often migrate to and merge with the plasma membrane, releasing their contents to the outside of the cell.
5. **Lysosomes** are vesicles from a Golgi apparatus that contain digestive enzymes. They break down food, cellular debris, and foreign invaders such as bacteria. Lysosomes do not occur in plant cells.
6. **Peroxisomes** are organelles that break down various substances. During the breakdown process, O_2 combines with hydrogen to form toxic hydrogen peroxide (H_2O_2), which in turn is converted to H_2O. Peroxisomes are common in liver and kidney cells where they break down toxic substances and in photosynthesizing plant cells.
7. **Mitochondria** carry out aerobic respiration, a process in which energy (in the form of ATP) is obtained from carbohydrates.
8. **Chloroplasts** carry out photosynthesis, the plant process of incorporating energy from sunlight into carbohydrates.
9. **Microtubules, intermediate filaments,** and **microfilaments** are three protein fibers of decreasing diameter, respectively. All are involved in establishing the shape of or in coordinating movements of the **cytoskeleton**, the internal structure of the cytoplasm.
    - **Microtubules** are made of the protein **tubulin** and provide support and motility for cellular activities. They are found in the **spindle apparatus** (which guides the movement of chromosomes during cell division), and in flagella and cilia (described in the following section), structures that project from the plasma membrane to provide motility to the cell.
    - **Intermediate filaments** provide support for maintaining the shape of the cell.
    - **Microfilaments** are made of the protein **actin** and are involved in cell motility. They are found in muscle cells and in cells that move by changing shape, such as phagocytes (white blood cells that wander throughout the body attacking bacteria and other foreign invaders).
10. **Flagella** and **cilia** are structures that protrude from the cell membrane and make wavelike movements. Flagella and cilia are classified by their lengths and by their numbers per cell: flagella are long and few; cilia are short and many. A single flagellum propels sperm, while the numerous cilia that line the respiratory tract sweep away debris. Structurally, both flagella and cilia consist of microtubules arranged in a "9 + 2" array–nine pairs (doublets) of microtubules arranged in a circle surrounding a pair of microtubules (Figure 2-3).

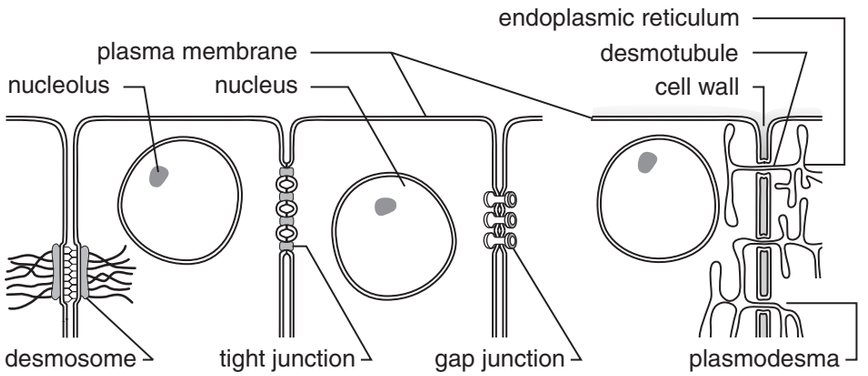


Flagella, Cilia, and Basal Bodies

Figure 2-3

11. **Centrioles** and **basal bodies** act as **microtubule organizing centers** (**MTOCs**). A pair of centrioles (enclosed in a **centrosome**) located outside the nuclear envelope gives rise to the microtubules that make up the spindle apparatus used during cell division. Basal bodies are at the base of each flagellum and cilium and appear to organize their development. Both centrioles and basal bodies are made up of nine triplets arranged in a circle (Figure 2-3). Plant cells lack centrioles and only "lower" plants (such as mosses and ferns) with motile sperm have flagella and basal bodies.
12. **Cell walls** are found in plants, fungi, protists, and bacteria. They develop outside the plasma membrane and provide support for the cell. In plants, the cell wall consists mainly of **cellulose,** a polysaccharide made from β-glucose. The cell walls of fungi are usually made of cellulose or chitin. **Chitin** is a modified polysaccharide differing from cellulose in that one of the hydroxyl groups is replaced by a group containing nitrogen.
13. **Vacuoles and vesicles** are fluid-filled, membrane-bound bodies.
    - **Transport vesicles** move materials between organelles or between organelles and the plasma membrane.
    - **Food vacuoles** are temporary receptacles of nutrients. Food vacuoles often merge with lysosomes, whose digestive enzymes break down the food.
    - **Storage vacuoles** in plants store starch, pigments, and toxic substances (nicotine, for example).
    - **Central vacuoles** are large bodies occupying most of the interior of certain plant cells. When fully filled, they exert **turgor,** or pressure, on the cell walls, thus maintaining rigidity in the cell. They also store nutrients and carry out functions otherwise assumed by lysosomes in animal cells.
    - **Contractile vacuoles** are specialized organelles in single-celled organisms that collect and pump excess water out of the cell.

14. Cell junctions serve to *anchor* cells to one another or to provide a passageway for cellular *exchange*. They include the following (Figure 2-4):



Cell Junctions

Figure 2-4

- **Desmosomes** are protein attachments between adjacent *animal* cells. Inside the plasma membrane, a desmosome bears a disk-shaped structure from which protein fibers extend into the cytoplasm. Desmosomes act like spot welds to hold together tissues that undergo considerable stress (such as skin or heart muscle).
- **Tight junctions** are tightly stitched seams between *animal* cells. The junction completely encircles each cell, preventing the movement of material between the cells. Tight junctions are characteristic of cells lining the digestive tract where materials are required to pass through cells (rather than intercellular spaces) to penetrate the blood stream.
- **Gap junctions** are narrow tunnels between *animal* cells that consist of proteins called **connexons**. The proteins prevent the cytoplasms of each cell from mixing, but allow the passage of ions and small molecules. In this manner, gap junctions allow communication between cells through the exchange of materials or through the transmission of electrical impulses.
- **Plasmodesmata** (singular, plasmodesma) are narrow channels between *plant* cells. A narrow tube of endoplasmic reticulum, called a **desmotubule**, surrounded by cytoplasm and the plasma membrane, passes through the channel. Material exchange through a plasmodesma apparently occurs through the cytoplasm surrounding the desmotubule.

Note that plant cells can *generally* be distinguished from animal cells by:

1. the *presence* of cell walls, chloroplasts, and central vacuoles in *plants* and their absence in animals, and
2. the *presence* of lysosomes and centrioles in *animals* and their absence in plants.

Prokaryotes and Eukaryotes

The cells described so far are those of **eukaryotic** organisms. Eukaryotic organisms include all living things except for bacteria and cyanobacteria. Bacteria and cyanobacteria are **prokaryotes** and lack all the organelles described above. They generally consist of only a plasma membrane, a DNA molecule, ribosomes, cytoplasm, and often a cell wall. In addition, they differ in the following respects:

1. Prokaryotes do not have a nucleus.
2. The hereditary material in prokaryotes exists as a single "naked" DNA molecule without the proteins that are associated with the DNA in eukaryotic chromosomes.
3. Prokaryotic ribosomes are smaller (70S, with 50S and 30S subunits) than those of eukaryotes (80S, with 60S and 40S subunits).
4. The cell walls of bacteria, when present, are constructed from peptidoglycans, a polysaccharide-protein molecule.
5. Flagella, when present in prokaryotes, are not constructed of microtubules.

Movement of Substances

Various terms are used to describe the movement of substances between cells and into and out of a cell. These terms differ in the following respects.

1. The movement of substances may occur across a **selectively permeable membrane** (such as the plasma membrane). A selectively permeable membrane allows only specific substances to pass.
2. The substance whose movement is being described may be *water* (the *solvent*) or it may be the substance dissolved in the water (the *solute*).
3. Movement of substances may occur from higher to lower concentrations (*down* the concentration gradient) or the reverse (*up* or *against* the gradient).
4. Solute concentrations between two areas may be compared. A solute may be **hypertonic** (a higher concentration of *solutes*), **hypotonic** (a lower concentration of *solutes*), or **isotonic** (an equal concentration of *solutes*) relative to another region.
5. The movement of substances may be *passive* or *active*. Active movement requires the expenditure of energy and usually occurs up a gradient.

Bulk flow is the collective movement of substances in the same direction in response to a force or pressure. Blood moving through a blood vessel is bulk flow.

Passive transport processes describe the movement of substances from regions of higher to lower concentrations (*down* a concentration gradient) and do not require expenditure of energy.

1. **Simple diffusion**, or **diffusion**, is the *net* movement of substances from an area of higher concentration to an area of lower concentration. This movement occurs as a result of the random and constant motion characteristic of all molecules (atoms or ions), motion that is independent from the motion of other molecules. Since, at any one time, some molecules may be moving against the gradient and some molecules may be moving down the gradient (remember, the motion is random), the word "net" is used to indicate the overall, eventual result of the movement. Eventually, a state of **equilibrium** is attained where molecules are uniformly distributed but continue to move randomly.
2. **Osmosis** is the diffusion of *water* molecules across a selectively permeable membrane. When water moves into a body by osmosis, hydrostatic pressure (**osmotic pressure)** may build up inside the body. **Turgor pressure** is the osmotic pressure that develops when water enters the cells of plants and microorganisms.
3. **Dialysis** is the diffusion of *solutes* across a selectively permeable membrane. The term dialysis is usually used when different solutes are separated by a selectively permeable membrane.
4. **Plasmolysis** is the movement of water out of a *cell* (osmosis) that results in the collapse of the cell (especially plant cells with central vacuoles).
5. **Facilitated diffusion** is the diffusion of *solutes* through channel proteins in the plasma membrane. Note that *water* can pass through the plasma membrane without the aid of specialized proteins.
6. **Countercurrent exchange** describes the diffusion of substances between two regions in which substances are moving by bulk flow in opposite directions. For example, the direction of water flow through the gills of a fish is opposite to the flow of blood in the blood vessels. Diffusion of oxygen from water to blood is maximized because the relative motion of the molecules between the two regions is increased and because the concentration gradients between the two regions remain constant along their area of contact.

Active transport is the movement of *solutes against* a gradient and requires the expenditure of *energy* (usually ATP). Transport proteins in the plasma membrane transfer solutes such as small ions (Na^+, K^+, Cl^-, H^+), amino acids, and monosaccharides across the membrane.

Vesicular transport uses vesicles or other bodies in the cytoplasm to move macromolecules or large particles across the plasma membrane. Types of vesicular transport are described below.

- **Exocytosis** describes the process of vesicles fusing with the plasma membrane and releasing their contents to the outside of the cell. This is common when a cell produces substances for export.

- **Endocytosis** describes the capture of a substance outside the cell when the plasma membrane merges to engulf it. The substance subsequently enters the cytoplasm enclosed in a vesicle. There are three kinds of endocytosis.

    - **Phagocytosis** ("cellular eating") occurs when *undissolved* material enters the cell. The plasma membrane wraps around the solid material and engulfs it, forming a phagocytic vesicle. Phagocytic cells (such as certain white blood cells) attack and engulf bacteria in this manner.

- **Pinocytosis** ("cellular drinking") occurs when *dissolved* substances enter the cell. The plasma membrane folds inward to form a channel allowing the liquid to enter. Subsequently, the plasma membrane closes off the channel, encircling the liquid inside a vesicle.
- **Receptor-mediated endocytosis** occurs when *specific molecules* in the fluid surrounding the cell bind to specialized receptors that concentrate in coated pits in the plasma membrane. The membrane pits, the receptors, and their specific molecules (called **ligands**) fold inward and the formation of a vesicle follows. Proteins that transport cholesterol in blood (low-density lipoproteins, or LDLs) and certain hormones target specific cells by receptor-mediated endocytosis.

Sample Questions and Answers

Multiple-Choice Questions

Directions: Each of the following questions or statements is followed by five possible answers or sentence completions. Choose the one best answer or sentence completion.

1. The cellular structure that is involved in producing ATP during aerobic respiration is the

A. nucleus
B. nucleolus
C. chloroplast
D. mitochondrion
E. endoplasmic reticulum

2. Which of the following cellular structures are common to both prokaryotes and eukaryotes?

A. Ribosomes
B. Nucleoli
C. Chloroplasts
D. Mitochondria
E. Golgi bodies

3. The plasma membrane consists principally of

A. proteins embedded in a carbohydrate bilayer
B. phospholipids embedded in a protein bilayer
C. proteins embedded in a phospholipid bilayer
D. proteins embedded in a nucleic acid bilayer
E. proteins embedded in a polymer of glucose molecules

4. When the concentration of solutes differs on the two sides of a membrane permeable only to water,

A. water will move across the membrane by osmosis
B. water will move across the membrane by active transport
C. water will move across the membrane by plasmolysis
D. water will move across the membrane by facilitated diffusion
E. solutes will move across the membrane from the region of higher concentration to the region of lower concentration

5. All of the following characterize microtubules EXCEPT:

A. They are made of the protein tubulin.
B. They are involved in providing motility.
C. They are organized by basal bodies or centrioles.
D. They develop from the plasma membrane.
E. They make up the spindle apparatus observed during cell division.

6. Lysosomes are

- **A.** involved in the production of fats
- **B.** involved in the production of proteins
- **C.** involved in the production of polysaccharides
- **D.** often found near areas requiring a great deal of energy (ATP)
- **E.** involved in the degradation of cellular substances

7. Mitochondria

- **A.** are found only in animal cells
- **B.** produce energy (ATP) with the aid of sunlight
- **C.** are often more numerous near areas of major cellular activity
- **D.** originate from centrioles
- **E.** are microtubule organizing centers

Questions 8–12

Use the following key for the next five questions. Each answer in the key may be used once, more than once, or not at all.

- **A.** Active transport
- **B.** Bulk flow
- **C.** Osmosis
- **D.** Facilitated diffusion
- **E.** Plasmolysis

8. Movement of solutes across a plasma membrane from a region of higher solute concentration to a region of lower solute concentration with the aid of proteins.

9. Movement of water across a membrane from a region of higher concentration of water to a region of lower concentration of water.

10. Movement of water out of a cell resulting in the collapse of the plasma membrane.

11. Movement of urine through the urinary tract.

12. Movement of solutes across a plasma membrane requiring the addition of energy.

13. The movement of molecules during diffusion can be described by all of the following EXCEPT:

- **A.** Molecular movements are random.
- **B.** Net movement of solute molecules is from a region of higher concentration to a region of lower concentration.
- **C.** Each molecule moves independently of other molecules.
- **D.** Solute molecules always move down the concentration gradient.
- **E.** Net movement of gas molecules is from a region of higher concentration to a region of lower concentration.

14. Plant and animal cells differ mostly in that

A. only animal cells have mitochondria.

B. only animal cells have flagella and cilia with a "9 + 2" microtubule arrangement.

C. only plant cells have plasma membranes with cholesterol.

D. only plant cells have cell walls.

E. only plant cells have ribosomes attached to the endoplasmic reticulum.

15. A smooth endoplasmic reticulum exhibits all of the following activities EXCEPT:

A. assembling amino acids to make proteins

B. manufacturing lipids

C. manufacturing hormones

D. breaking down toxins

E. breaking down toxic cellular by-products

16. All of the following are known to be components of cell walls EXCEPT:

A. actin

B. chitin

C. polysaccharides

D. cellulose

E. peptidoglycans

17. A saturated suspension of starch is enclosed in a bag formed from dialysis tubing, a material through which water can pass, but starch cannot. The bag with the starch is placed into a beaker of distilled water. All of the following are expected to occur EXCEPT:

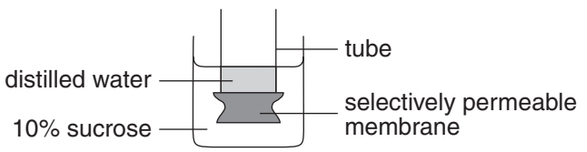
A. There will be a net movement of water from a hypotonic region to a hypertonic region.

B. There will be a net movement of solute from a hypertonic region to a hypotonic region.

C. There will be a net movement of water from a region of higher concentration of water to a region of lower concentration of water.

D. The dialysis bag with its contents will gain weight.

E. No starch will be detected outside the dialysis bag.



18. As shown above, a tube covered on one end by a membrane impermeable to sucrose is inverted and half filled with distilled water. It is then placed into a beaker of 10% sucrose to a depth equal to the midpoint of the tube. Which of the following statements is true?

A. The water level in the tube will rise to a level above the water in the beaker.

B. The water level in the tube will drop to a level below the water in the beaker.

C. There will be no change in the water level of the tube, and the water in the tube will remain pure.

D. There will be no change in the water level of the tube, but sucrose will enter and mix with the water in the tube.

E. The concentration of the sucrose solution will increase.

Answers to Multiple-Choice Questions

1. **D.** Respiration takes place in the mitochondrion. ATP is also produced in the chloroplast, but that is from photosynthesis.
2. **A.** Prokaryotes lack nucleoli, chloroplasts, mitochondria, and Golgi bodies.
3. **C.** The plasma membrane consists principally of proteins embedded a phospholipid bilayer.
4. **A.** When there is a concentration gradient, water will move across a membrane unassisted by ATP or channel proteins. In contrast, solutes (the dissolved substances) cannot cross the membrane unassisted.
5. **D.** Microtubules originate from basal bodies or centrioles (microtubule organizing centers, or MTOCs), not from the plasma membrane.
6. **E.** Fats usually originate from smooth ER; proteins originate from ribosomes or rough ER; polysaccharides have various origins; answer **D** would be appropriate for mitochondria.
7. **C.** Since mitochondria produce ATP, they are often found near areas of major cellular activity, areas that require large amounts of energy.
8. **D.** Note that this question asks about *solutes* moving *down* a concentration gradient across a plasma membrane and without ATP.
9. **C.** Note that this question asks about *water* moving down a gradient.
10. **E.** If the solute concentration is higher outside than inside the cell, water moves out of the cell (by osmosis), resulting in the collapse of the cell.
11. **B.** The movement of urine through the urinary tract is by bulk flow, a collective movement of all substances moving in the same general direction. This is in contrast to diffusion, osmosis, and other molecular motions, in which the motion of particular molecules with respect to other molecules is being described.
12. **A.** The energy requirement indicates active transport.
13. **D.** Since the motion of the molecules is random, at any particular moment there are sure to be some molecules moving against the concentration gradient. It is only the *net* movement of molecules that moves down the gradient.
14. **D.** Animal cells, not plant cells, have plasma membranes that contain cholesterol. Both animals and plants have cells with mitochondria and have ribosomes attached to ER. The flagella of all eukaryotic cells (including plants such as ferms and mosses) contain microtubules with the 9+2 arrangement.
15. **A.** Ribosomes assemble amino acids into proteins.
16. **A.** Microfilaments are made up of the protein actin; chitin is often found in the cell walls of fungi; cellulose is the main constituent of plant cell walls; peptidoglycans are found in the cell walls of bacteria.

17. B. The solute, starch, cannot pass through the dialysis tubing. The dialysis bag will gain weight because water will diffuse into it. Note that **A** refers to the movement of water and **B** refers to the movement of the solute and that both describe the gradient relative to the solute (hypotonic and hypertonic refer to *solute* concentrations).

18. B. Since sucrose cannot pass through the membrane, no sucrose will enter the tube. However, since there is a concentration gradient, water will diffuse down the gradient. The beginning concentrations of water in the tube and in the beaker are 100% and 90%, respectively. Therefore, water will move from the tube and into the beaker. The water level in the tube will drop (and the beaker level will rise), and the concentration of sugar in the beaker will decrease.

Free-Response Questions

Free-response questions on the AP exam may require you to provide information from a narrow area of biology, or they may consist of parts that require you to assemble information from diverse areas of biology. The questions that follow are typical of either an entire AP exam question or merely that part of a question that is related to this section.

Directions: Answer the questions below as completely and as thoroughly as possible. Answer the question in essay form (NOT outline form), using complete sentences. You may use diagrams to supplement your answers, but a diagram ALONE without appropriate discussion is inadequate.

1. Describe the structure of the plasma membrane and the various ways in which the plasma membrane permits interactions with the outside environment.

2. Compare and contrast the cellular characteristics of prokaryotes and eukaryotes.

3. Describe the various activities that occur within cells and the methods which cells use to separate these activities from one another.

Some Typical Answers to Free-Response Questions

Question 1

(a.) Structure of the plasma membrane:

The plasma membrane is composed of a bilayer of phospholipids. A molecule of phospholipid consists of two fatty acids and a phosphate group attached to a glycerol component. The fatty acid tails represent a hydrophobic region of the molecule, while the glycerol-phosphate head is hydrophilic. The phospholipids are arranged into a bilayer formation with the hydrophilic heads pointing to the outside and the hydrophobic tails pointing toward the inside. As a result, the plasma membrane is a barrier to most molecules. In plants, fungi, and bacteria, the membrane deposits cellulose or other polysaccharides on the outside of the membrane to create a cell wall. The cell wall provides support to the cell.

Embedded in the phospholipid bilayer are cholesterol molecules and various proteins. This mixture of molecules accounts for the fluid mosaic model of the plasma membrane, that is, a highly flexible lipid boundary impregnated with various other molecules.

(b.) Interactions of plasma membrane with the outside environment:

The plasma membrane is a selectively permeable membrane. Small molecules, like H_2, O_2, and CO_2, readily diffuse through the membrane. The movement of larger molecules is regulated by proteins in the plasma membrane. There are several kinds of these proteins. Channel proteins provide passage for certain dissolved substances. Transport proteins actively transport substances against a concentration gradient. The glycocalyx, consisting of the oligosaccharides from glycolipids, recognition proteins, and other glycoproteins, participates in cell-to-cell interactions. Receptor proteins recognize hormones and transmit their signals to the interior of the cell.

Various substances can be exported into the external environment by exocytosis. In exocytosis, substances are packaged in vesicles that merge with the plasma membrane. Once they merge with the membrane, their contents are released to the outside. In an opposite kind of procedure, food and other substances can be imported by endocytosis. In endocytosis, the plasma membrane encircles the substance and encloses it in a vesicle.

When a question has two or more parts, you should separate your answers and identify the parts.

Question 2

You should separate your answer into two distinct parts. The first part should compare prokaryotes and eukaryotes that is, describe characteristics they have in common For example, they both have a plasma membrane, ribosomes, and DNA. Also, many prokaryotes have a cell wall, a structure they have in common with the eukaryotic cells of plants and fungi.

In the second part of your answer, contrast prokaryotes and eukaryotes that is, describe how they are different. Indicate that the DNA is packaged differently (naked DNA molecules in prokaryotes compared to DNA associated with proteins in eukaryotes), that prokaryotic

ribosomes are smaller than those of eukaryotes, that the prokaryotic flagella do not contain microtubules, and that prokaryotic cells lack a nuclear membrane and the various eukaryotic organelles. Also, the cell walls of bacteria contain peptidoglycans, unlike the cellulose and chitin of plants and fungi.

Question 3

This is a two-part question. In the first part, describe each cell organelle and its function. In the second part, explain that partitioning metabolic functions into organelles serves primarily to separate the biochemical activities. In addition, describe how the channels among layers of endoplasmic reticulum serve to create compartments as well. Last, describe the packaging relationship between the ER and Golgi bodies.