1. The description of a membrane as a “fluid mosaic” means—
   a. water molecules make up part of the membrane
   b. the membrane is a mosaic of phospholipids and proteins
   c. the phospholipids that make up the membrane can move
   d. membranes are made of proteins and lipids that can freely move

The correct answer is d—
   A. Answer a is incorrect. Water molecules are not directly involved in the structure of a membrane. The term *fluid* applies to any molecule capable of movement, not just liquid water.

The correct answer is d—
   B. Answer b is incorrect. It is incomplete. This answer describes the mosaic nature of the membrane, but not the concept of fluidity.

The correct answer is d—
   C. Answer c is incorrect. The phospholipid molecules are certainly capable of movement within the plane of the membrane; however, a membrane is composed of more than just phospholipids.

The correct answer is d—membranes are made of proteins and lipids that can freely move
   D. Answer d is correct. It accounts both for the “mosaic” nature of a membrane and the ability of both the proteins and lipids to move within the plane of the membrane.

2. Membrane proteins are distinguished by what chemical property?
   a. They possess regions with hydrophobic amino acids.
   b. They possess regions with hydrophilic amino acids.
   c. They are polar.
   d. They form hydrogen bonds with the fatty acid tails of the lipid molecules.

The correct answer is a—They possess long stretches of hydrophobic amino acids.
   A. Answer a is correct. Membrane proteins must be capable of interacting with the hydrophobic core of the phospholipids bilayer. To do this, these proteins have hydrophobic amino acids in the region of the protein that crosses or sits within the center of the bilayer.

The correct answer is a—
   B. Answer b is incorrect. Hydrophilic amino acids cannot interact with the hydrophobic fatty acid tails of the phospholipids.

The correct answer is a—
   C. Answer c is incorrect. A polar molecule cannot interact with a nonpolar molecule. The fatty acid tails of the phospholipids are nonpolar.

The correct answer is a—
   D. Answer d is incorrect. Hydrogen bond formation can only occur between molecules that possess polar bonds involving hydrogen and an electronegative atom such as oxygen or
nitrogen. The fatty acid tails of the phospholipids molecules do not contain H–O or H–N bonds.

3. What chemical property characterizes the interior of the phospholipid bilayer?
   a. It is hydrophobic.
   b. It is hydrophilic.
   c. It is polar.
   d. It is saturated.

The correct answer is a—It is hydrophobic.
   A. Answer a is correct. The fatty acid tails of the phospholipid molecules that make up a membrane bilayer are long chains of carbon and hydrogen. The H–C bond is nonpolar, therefore the interior is hydrophobic.

The correct answer is a—
   B. Answer b is incorrect. The long chains of carbon and hydrogen that make up the fatty acid tails of the phospholipids molecules are very hydrophobic.

The correct answer is a—
   C. Answer c is incorrect. A polar molecule is a hydrophilic molecule. The fatty acid tails of the phospholipids molecules are hydrophobic.

The correct answer is a—
   D. Answer d is incorrect. Although some phospholipids are made up of saturated fatty acids, this is not true of all phospholipids. Unsaturated fatty acids are “kinked” and contribute to the fluidity of the membrane.

4. How do some bacterial cells adapt to cold temperatures?
   a. By increasing the amount of cholesterol in their membranes
   b. By altering the amount of protein present in the membrane
   c. By increasing the number of carbon–carbon double bonds in the fatty acid portion of their phospholipids
   d. By decreasing the rate of diffusion of the phospholipids

The correct answer is c—
   A. Answer a is incorrect. The amount of cholesterol in a membrane can influence its fluidity in response to temperature; however, bacterial cells have a different adaptation.

The correct answer is c—
   B. Answer b is incorrect. The amount of proteins present in a membrane can influence the fluid behavior of the phospholipids, but this effect would not be an adaptation to temperature changes.

The correct answer is c—By increasing the number of carbon double bonds in the fatty acids
   C. Answer c is correct. The presence of carbon double bonds in the long-chain fatty acids directly affects the ability of lipids to pack together. These lipids increase the fluidity of the membrane phospholipids even in cold temperatures.
The correct answer is c—
D. Answer d is incorrect. Random thermal movements such as diffusion do decrease with temperature; however, this is not an adaptation.

5. The specific function of a membrane within a cell is determined by the—
   a. degree of saturation of the fatty acids within the phospholipids bilayer
   b. location of the membrane within the cell
   c. presence of lipid rafts and cholesterol
   d. type and number of membrane proteins

The correct answer is d—
A. Answer a is incorrect. The degree of saturation of the fatty acids influences the fluid behavior of a membrane but does not directly influence function.

The correct answer is d—
B. Answer b is incorrect. Different membranes within a cell do have different functions, but their location is not the determinant factor.

The correct answer is d—
C. Answer c is incorrect. The presence of lipid rafts and the amount of cholesterol will influence the efficiency of transport or the organization of the membrane, but they do not determine the specific function.

The correct answer is d—type and number of membrane proteins
D. Answer d is correct. The phospholipid bilayer is a common property of all membranes. The type and function of the proteins embedded or associated with the membrane determine its overall function.

6. The transmembrane domain of an integral membrane protein—
   a. is composed of hydrophobic amino acids
   b. often forms an $\alpha$-helical structure
   c. can cross the membrane multiple times
   d. all of the above

The correct answer is d—
A. Answer a is incorrect. The amino acids found within the transmembrane domain are hydrophobic; however, there are other properties associated with this region of the protein.

The correct answer is d—
B. Answer b is incorrect. The region of a protein that crosses a membrane most often is arranged into an $\alpha$-helical structure; however, there are other properties associated with this region of the protein.

The correct answer is d—
C. Answer c is incorrect. Many proteins do fold across the membrane multiple times; however, there are other properties associated with this region of the protein.
The correct answer is d—all of the above
D. Answer d is correct. The transmembrane domain of a membrane protein is typically composed of hydrophobic amino acids that assume an α-helical secondary structure and can cross the membrane multiple times.

7. What variable(s) influences whether a nonpolar molecule can move across a membrane by passive diffusion?
   a. The structure of the phospholipids bilayer
   b. The difference in concentration of the molecule across the membrane
   c. The presence of transport proteins in the membrane
   d. All of the above

The correct answer is b—
A. Answer a is incorrect. The structure of the phospholipids bilayer is not a barrier to the movement of nonpolar molecules. Nonpolar molecules can move through the hydrophobic core of the bilayer.

The correct answer is b—The difference in concentration of the molecule across the membrane
B. Answer b is correct. Passive diffusion of any molecule depends on the concentration gradient of that molecule. Molecules will diffuse from an area of higher concentration to an area of lower concentration. Since the molecule is nonpolar, the hydrophobic core of the bilayer is not a barrier to this movement.

The correct answer is b—
C. Answer c is incorrect. Nonpolar molecules can move through the hydrophobic (nonpolar) core of the bilayer. Channel proteins are not required.

The correct answer is b—
D. Answer d is incorrect. All molecules diffuse in response to their concentration gradient; however, only polar molecules require a channel protein to move across the hydrophobic interior of the bilayer.

8. Which of the following does NOT contribute to the selective permeability of a biological membrane?
   a. Specificity of the carrier proteins in the membrane
   b. Selectivity of channel proteins in the membrane
   c. Hydrophobic barrier of the phospholipids bilayer
   d. Hydrogen bond formation between water and phosphate groups

The correct answer is d—
A. Answer a is incorrect. Different carrier proteins transport different, specific molecules across the membrane. These carrier proteins are selecting for the kinds of molecules that can enter a cell.

The correct answer is d—
B. Answer b is incorrect. Channel proteins only allow certain specific molecules to enter the cell, thereby contributing to the selectivity of the cell membrane.
The correct answer is d—

C. Answer c is incorrect. The hydrophobic core of the bilayer creates a barrier to the transport of large, polar molecules. This property contributes to the selectivity of the membrane.

The correct answer is d—Hydrogen bond formation between water and the phosphate groups

D. The hydrogen bond formation between water and the phosphate groups helps stabilize the bilayer structure of the membrane; however, on its own it does not influence selective transport of molecules across the membrane.

9. Which of the following membrane proteins does NOT rely on diffusion to function?
   a. An ion channel protein
   b. A carrier protein
   c. Aquaporin
   d. Na\(^+\)/K\(^+\) pump

The correct answer is d—

A. Answer a is incorrect. A channel protein functions like a tunnel through the membrane. The movement of molecules through the channel is driven by diffusion.

The correct answer is d—

B. Answer b is incorrect. A carrier protein undergoes a conformational (shape) change as it binds to and moves a molecule from one side of the membrane to the other. This shape change requires energy. The potential energy used to drive diffusion is the source of this energy.

The correct answer is d—

C. Answer c is incorrect. Aquaporin is a type of carrier protein specific for the transport of water molecules. The carrier protein facilitates the process of osmosis, that is, the diffusion of water molecules.

The correct answer is d— Na\(^+\)/K\(^+\) pump

D. Answer d is correct. The Na\(^+\)/K\(^+\) pump requires chemical energy in the form of ATP to move Na\(^+\) out of the cell and K\(^+\) into the cell. ATP energy is required because the pump is moving ions against their concentration gradients, opposite to the direction of diffusion.

10. The movement of water across a membrane is dependent on—
   a. the solvent concentration
   b. the solute concentration
   c. the presence of carrier proteins
   d. membrane potential

The correct answer is b—

A. Answer a is incorrect. A solvent is the material that a solute molecule is dissolved into. Water is a solvent.

The correct answer is b—the solute concentration
B. Answer b is correct. Solute molecules are the molecules dissolved in the water. The concentration gradient of the solutes creates the concentration gradient for the water. The movement of water (osmosis) occurs in response to this gradient.

The correct answer is b—

C. Answer c is incorrect. Although carrier proteins can facilitate the transport of water across a membrane, the actual movement of water molecules is driven by diffusion.

The correct answer is b—

D. Answer d is incorrect. A membrane potential refers to a difference in charge across the membrane. Concentration gradients of different ions plus the sum of all the charged molecules (DNA and proteins) within the cell contribute to this property.

11. If a cell is in an isotonic environment, then which of the following is true?
   a. The cell will gain water and burst.
   b. No water will move across the membrane. There will be no effect.
   c. The cell will lose water and shrink.
   d. Osmosis still occurs, but there is no net gain or loss of cell volume.

The correct answer is d—

A. Answer a is incorrect. The net movement of water into a cell occurs when the interior of the cell is more concentrated than the surrounding environment—that is, when the environment is hypotonic.

The correct answer is d—

B. Answer b is incorrect. In an isotonic environment there is no net movement of water into or out of a cell; however, diffusion will still occur.

The correct answer is d—

C. Answer c is incorrect. The loss of water from a cell occurs when the environment surrounding the cell is more concentrated (hypertonic) relative to the inside of the cell.

The correct answer is d—Osmosis still occurs, but there is no net gain or loss of cell volume.

D. Answer d is correct. In an isotonic environment there is not net movement of water into or out of the cell; however, even at equilibrium there is passive diffusion of molecules across the membrane.

12. How are active transport and coupled transport related?
   a. They both use ATP to move molecules.
   b. Active transport establishes a concentration gradient, but coupled transport doesn’t.
   c. Coupled transport uses the concentration gradient established by active transport.
   d. Active transport moves one molecule, but coupled transport moves two.

The correct answer is c—

A. Answer a is incorrect. The pump proteins used in active transport use ATP energy; however, the proteins used in coupled transport do not.

The correct answer is c—
B. Answer b is incorrect. Both active and coupled transport move molecules from lower to higher concentration, thereby creating a concentration gradient.

The correct answer is c—Coupled transport uses the concentration gradient established by active transport.

C. Answer c is correct. The potential energy of a concentration gradient (generated through active transport) is used by the coupled transport proteins to move molecules against their concentration gradient in the absence of ATP.

The correct answer is c—

D. Answer d is not correct. Pump proteins like the Na\(^+\)/K\(^+\) ATPase can carry more than one molecule.

13. In the process of receptor-mediated endocytosis, the receptor is a _________ protein, but the clathrin is an example of a _________ membrane protein.
   a. carrier; channel
   b. transmembrane; peripheral
   c. pump; uniporter
   d. phagocytosis; pinocytosis

The correct answer is b—

A. Answer a is incorrect. Carrier and channel proteins are involved in the transport of molecules across the phospholipids bilayer. Receptor-mediated endocytosis involves capturing material on the surface of the cell and internalizing it inside of a vesicle.

The correct answer is b—transmembrane; peripheral

B. Answer b is correct. Receptors are transmembrane proteins, allowing them to interact both with the ligands on the surface of the cell and with the peripheral membrane protein, clathrin, on the interior of the cell.

The correct answer is b—

C. Answer c is incorrect. Both a pump and a uniporter are carrier proteins that transport molecules inside the cell by moving them directly across the bilayer. Receptor-mediated endocytosis brings material into the cell inside of a vesicle created from the plasma membrane.

The correct answer is b—

D. Answer d is incorrect. Phagocytosis and pinocytosis are two different cellular mechanisms that bring material into the cell. They are distinct processes from receptor-mediated endocytosis.

14. Which of the following is NOT a mechanism for bringing material into a cell?
   a. Exocytosis
   b. Endocytosis
   c. Pinocytosis
   d. Phagocytosis

The correct answer is a—Exocytosis
A. Answer a is correct. Exocytosis is the movement of materials from the inside of the cell to the outside environment.

The correct answer is a—

B. Answer b is incorrect. The term endo means inner, therefore endocytosis is the movement of material into the cell.

The correct answer is a—

C. Answer c is incorrect. Pinocytosis is “cell drinking.” It is the movement of solute molecules into the cell.

The correct answer is a—

D. Answer d is incorrect. Phagocytosis is “cell eating.” It is the movement of large materials into the cell by engulfing them by an extension of the plasma membrane.

Challenge Questions

1. Figure 5.4 describes a classic experiment demonstrating the ability of proteins to move within the plane of the cell’s plasma membrane. The following table outlines three different experiments using the fusion of labeled mouse and human cells.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Conditions</th>
<th>Temperature (°C)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuse human and mouse cells</td>
<td>37</td>
<td>Intermixed membrane proteins</td>
</tr>
<tr>
<td>2</td>
<td>Fuse human and mouse cells in presence of ATP inhibitors</td>
<td>37</td>
<td>Intermixed membrane proteins</td>
</tr>
<tr>
<td>3</td>
<td>Fuse human and mouse cells</td>
<td>4</td>
<td>No intermixing of membrane proteins</td>
</tr>
</tbody>
</table>

What conclusions can you reach about the movement of these proteins?

**Answer**—Since the membrane proteins become intermixed in the absence of the energy molecule, ATP, one can conclude that chemical energy is not required for their movement. Since the proteins do not move and intermix when the temperature is cold, one can also conclude that the movement is temperature-sensitive. The passive diffusion of molecules also depends on temperature and does not require chemical energy; therefore, it is possible to conclude that membrane fluidity occurs as a consequence of passive diffusion.

2. Each compartment of the endomembrane system of a cell is connected to the plasma membrane. Create a simple diagram of a cell including the RER, Golgi apparatus, vesicle, and the plasma membrane. Starting with the RER, use two different colors to represent the inner and outer halves of the bilayer for each of these membranes. What do you observe?

**Answer**—The inner half of the bilayer of the various endomembranes becomes the outer half of the bilayer of the plasma membrane.