

The Fluid Mosaic Membrane

Modeling Membrane Structure and Osmosis

About this lesson

This lesson provides students an opportunity to utilize manipulatives to identify the structure and function of the fluid mosaic model. The students will then use the manipulatives to model different situations involving cells placed in different concentrations (hypertonic, hypotonic, and isotonic). This is an excellent introduction to the concepts of membrane structure and function.

This lesson is included in the Biology Module 6.

Objective

Students will:

- Identify the structure and function of the components of the fluid mosaic model of cell membranes.
- Identify those components on a diagram of the model.
- Use the models to demonstrate hypotonic, hypertonic and isotonic conditions.

Level

Biology

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, *A Framework for K–12 Science Education*, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

Code	Standard	Level of Thinking	Depth of Knowledge
(LITERACY) RST.9-10.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	Apply	II

Connections to AP*

AP Biology: This lesson addresses concepts contained in Big Ideas 2 and 4 in the revised AP Biology curriculum under the following sections: 2.A.2.d.3, 2.A.2.g, 2.A.3.b.2, 2.B.1.a-b, 2.B.2.a, and 4.B.2.a.1.

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Materials

Each lab group will need the following:

bag, zipper-lock, gallon
copy of membrane components
scissors
tape, masking

Assessments

The following types of formative assessments are embedded in this lesson:

- Assessment of prior knowledge
- Assessment of students' understanding of hypertonic, hypotonic, and isotonic during the activity

The following assessments are located on the LTF website:

- Cells Assessment
- 2006, Biology Posttest, Free Response Question 2

Teaching Strategies

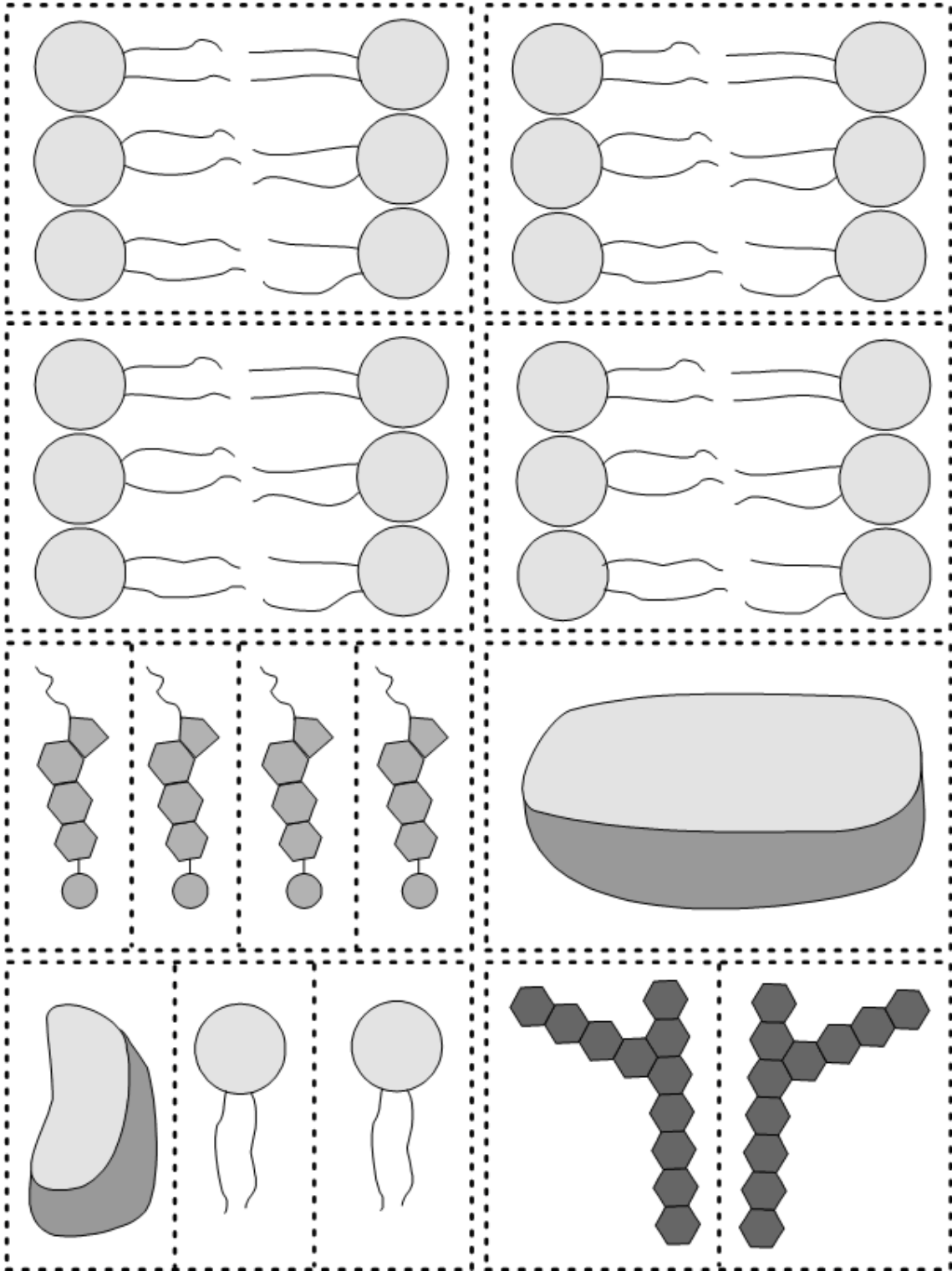
Suggested Teaching procedures:

1. Photocopy and enlarge a set of membrane components to be used on the chalkboard. Magnetic tape or masking tape can be used to adhere the pieces to the board. Color your pieces or photocopy the model pieces on colored paper so they will be visible. Laminate them for added durability.
2. As you check roll and take care of opening procedures, have the students cut out the membrane components and molecules. Provide envelopes, gallon bags or paperclips for the student to use to keep up with their models when the activity is completed. Alternatively, to save time you may want to give students the membrane components and molecules the class period before and have them cut the components out for homework.

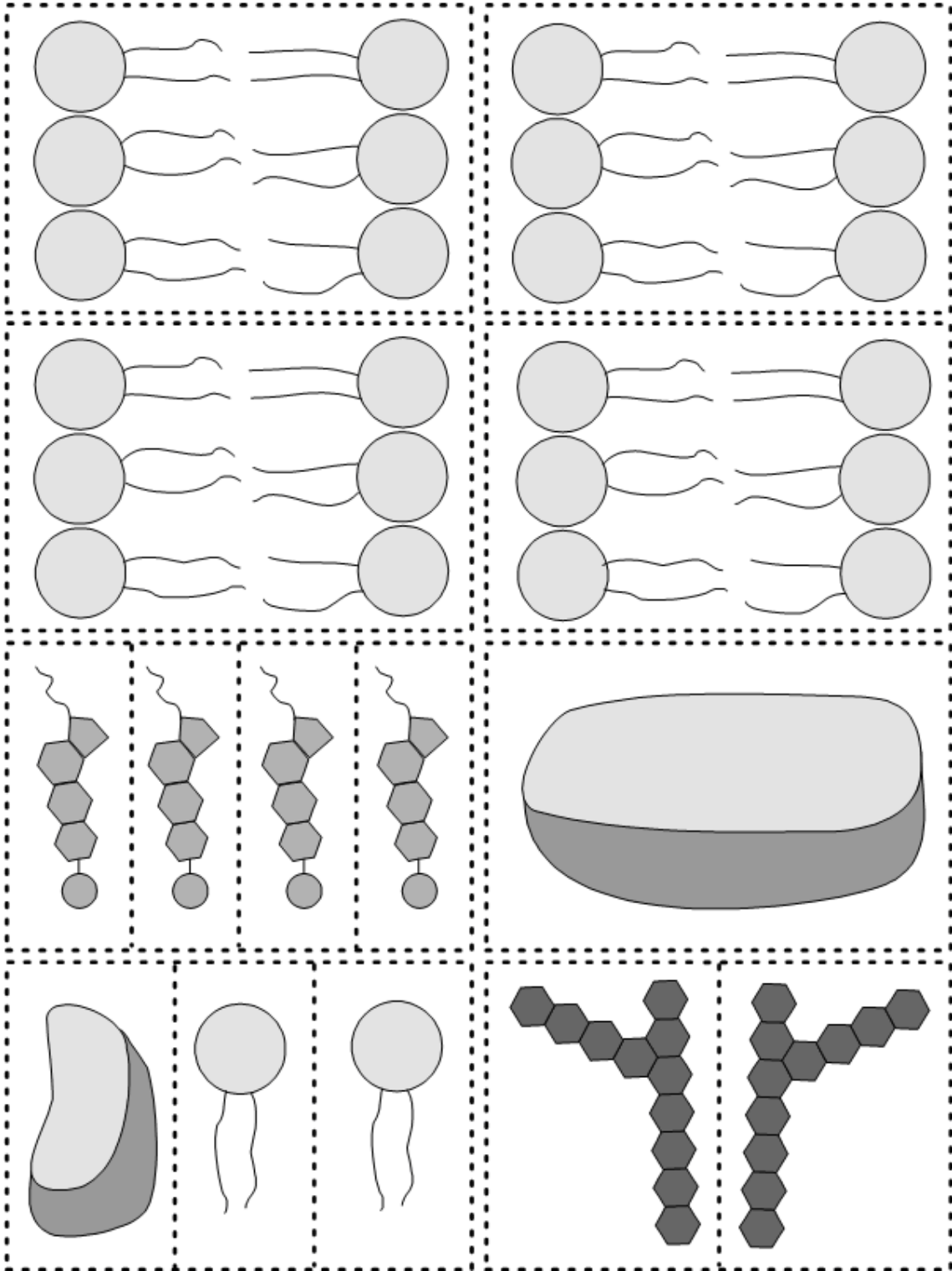
3. Describe the structure and function of the fluid mosaic cell membrane model components. Place the membrane component pieces on the board as you proceed through your descriptions. Students should locate each of the components in their model kits as you present the content. Important points to include are:
 - a. Phospholipids—are arranged in a double layer. These phospholipids are composed of a hydrophilic phosphate head region and a hydrophobic hydrocarbon tail region. The phospholipids are not static but can move laterally within the membrane. This is why the membrane is said to be fluid.
 - b. Membrane proteins—there are two main types of proteins in the membrane, peripheral and integral. Integral proteins span the entire width of the lipid bilayer. Peripheral proteins are not embedded and are loosely attached to the surface of the membrane. Proteins in the membrane may serve as transport proteins, chemical receptors, enzymes, regulators for cell to cell recognition, cell connections, and attachment sites for cytoskeletal structures. These proteins are irregularly distributed throughout the membrane and for this reason the membrane is described as a mosaic.
 - c. Cholesterol—helps keep the phospholipids spaced apart thereby adding to the fluidity of the membrane.
 - d. Surface carbohydrates—the surface carbohydrates function in cell recognition, cell signaling, and cell adhesion.
 - e. Collectively the structure of the membrane allows it to be selectively permeable, allowing small, uncharged particles to move by passive transport through the membrane while preventing the passage of large or charged substances. Large or charged substances must have a special pathway through the membrane.
4. To check student understanding have the student hold up the correct model component in response to each of the following questions. Confirm the correct answer to each question before moving to the next.
 - a. Which membrane component forms the bilayer?
 - b. Which membrane component could serve in cell transport?
 - c. Which structure helps keep the membrane fluid?
 - d. Which structures function in cell adhesion?
 - e. Which structure could serve as an enzyme?
 - f. Which structure can serve as a site for cytoskeletal structure attachment?
 - g. Which structures are spread in a mosaic throughout the membrane?
5. Explain that small, uncharged molecules like water, carbon dioxide, and oxygen can move into the cell by passing between the fluid phospholipid molecules. Larger compounds or charged substances move through the membrane by passing through an integral, transport protein.
6. Have the students assemble their components into a segment of membrane on their desktop and use the water and glucose arrows to indicate where these substances can enter the cell.
7. The students should now label and give the function of each of the structures indicated on the diagram of the fluid mosaic membrane located on your student answer page.
8. Explain that osmosis, the movement of water through the semipermeable membrane, will occur from an area of high water concentration to an area of lower concentration. Use the diagrams of cells to explain the differences between hypertonic, hypotonic and isotonic conditions.

9. Ask the students to use their model to demonstrate each of the situations listed below. Move around the room to observe the students' responses.
 - a. A cell that is hypertonic to its environment.
 - b. A cell that is isotonic to its environment.
 - c. A cell that is hypotonic to its environment.
 - d. A blood cell placed in distilled water.
 - e. A blood cell in 10% saline solution.
10. Explain that when animal cells are placed in hypertonic solutions they will lose water and shrivel or crenate. When animal cells are placed in hypotonic solutions they will gain water and can burst. Plant cells, on the other hand, have a cell wall surrounding the cell membrane so when a plant cell is placed in a hypotonic solution they will gain water until they are full or turgid. When plant cells are placed in hypertonic solutions they will lose water and go through plasmolysis but the cells do not shrivel because the cell wall is in place.
11. Have the students label the osmosis diagrams located on the student answer page. They are to label both sides of the membrane as hypertonic, hypotonic or isotonic and draw an arrow showing the overall pathway of water.
12. Students should now answer the multiple choice questions independently. These questions may also be used as a quiz at the conclusion of the activity.

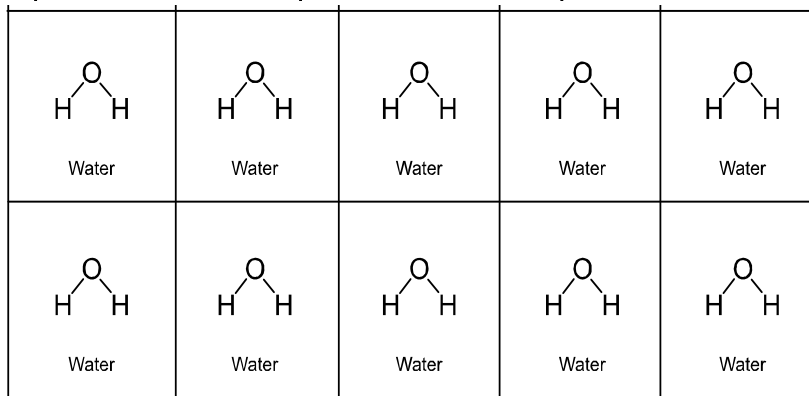
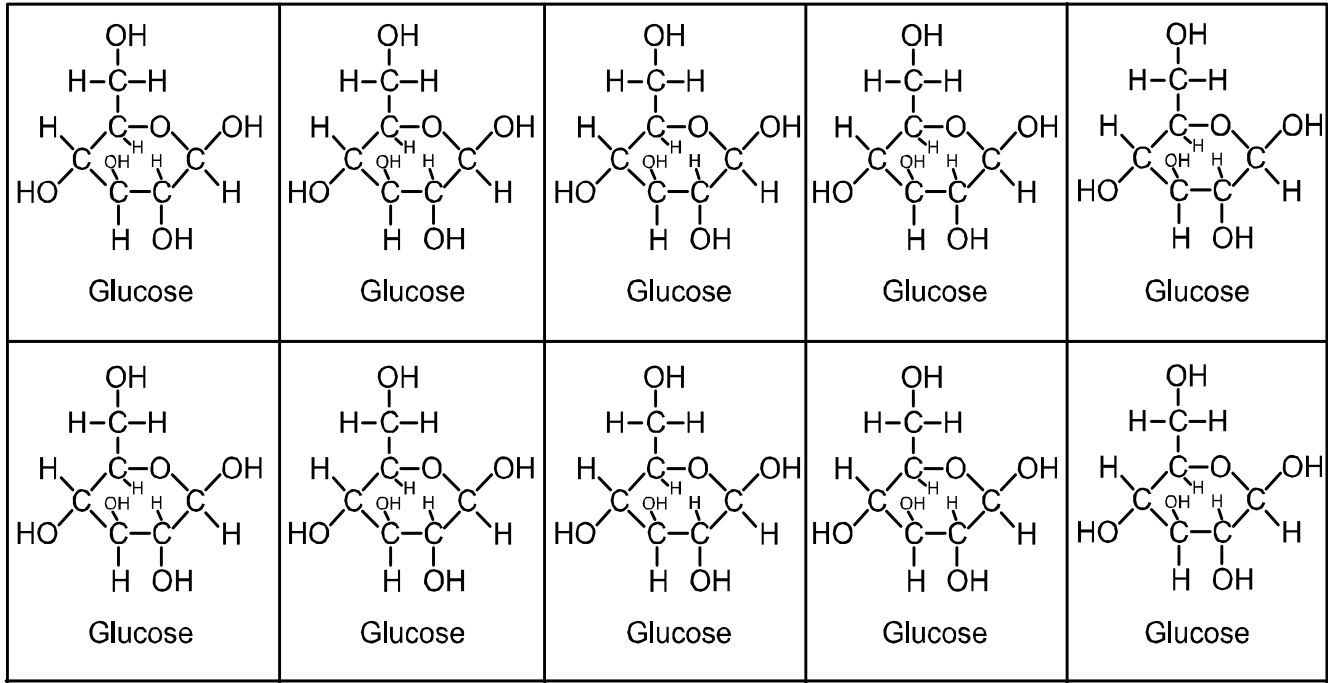
Model pieces – Membrane components



Model pieces – Membrane components



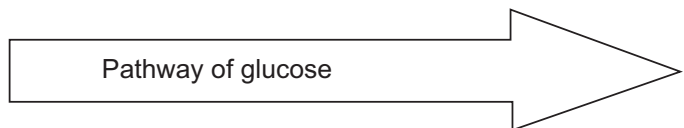
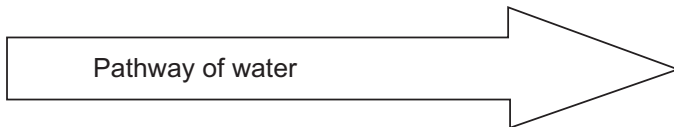
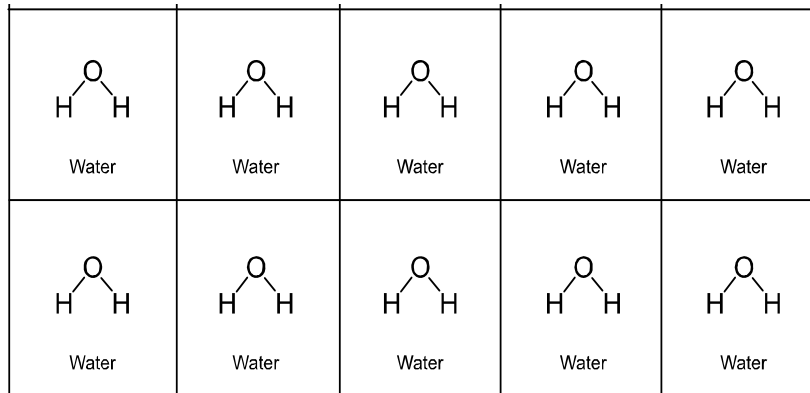
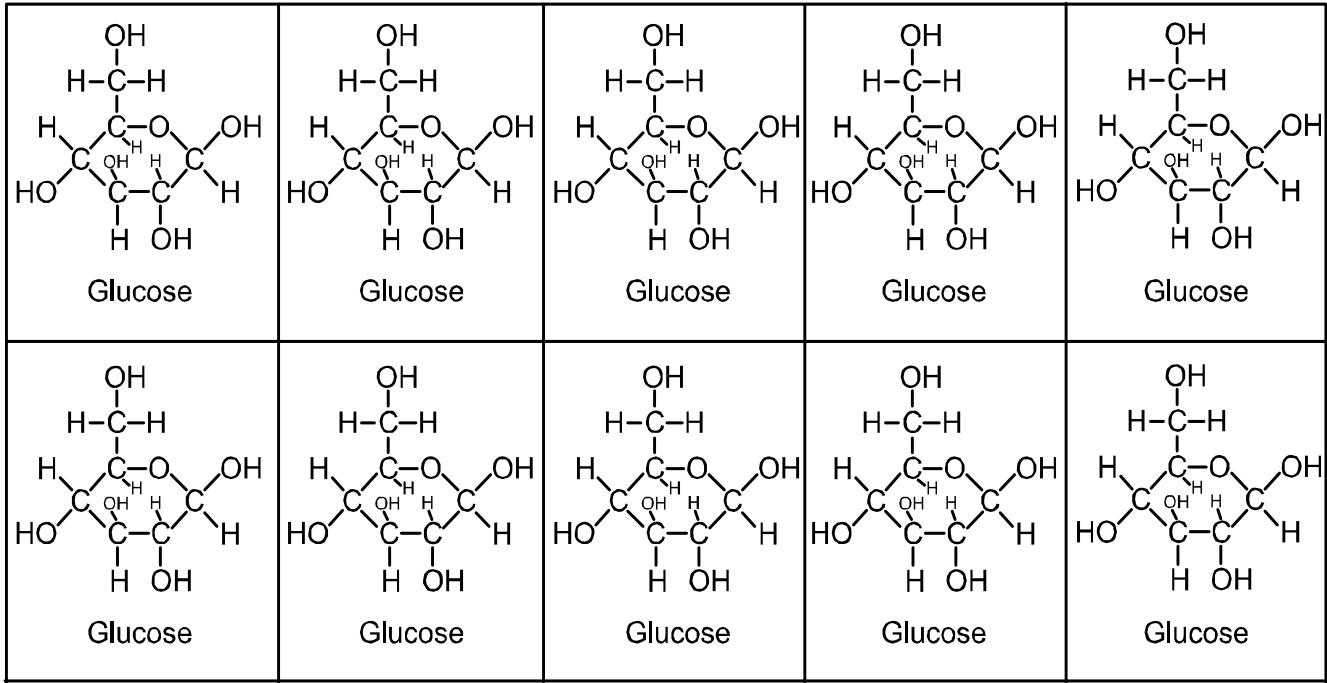
Model pieces – Glucose, water, and pathway arrows



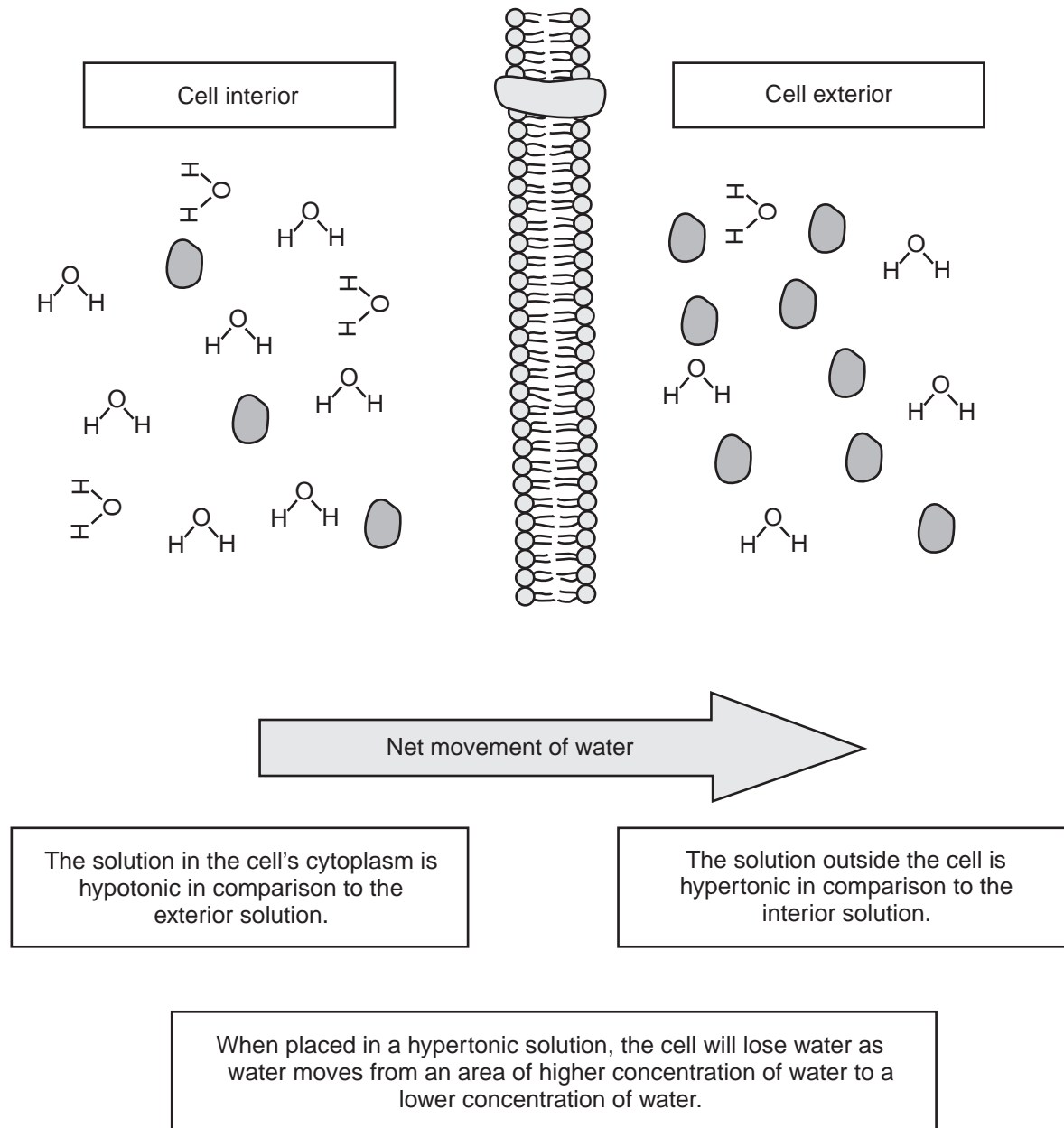
Pathway of water

Pathway of glucose

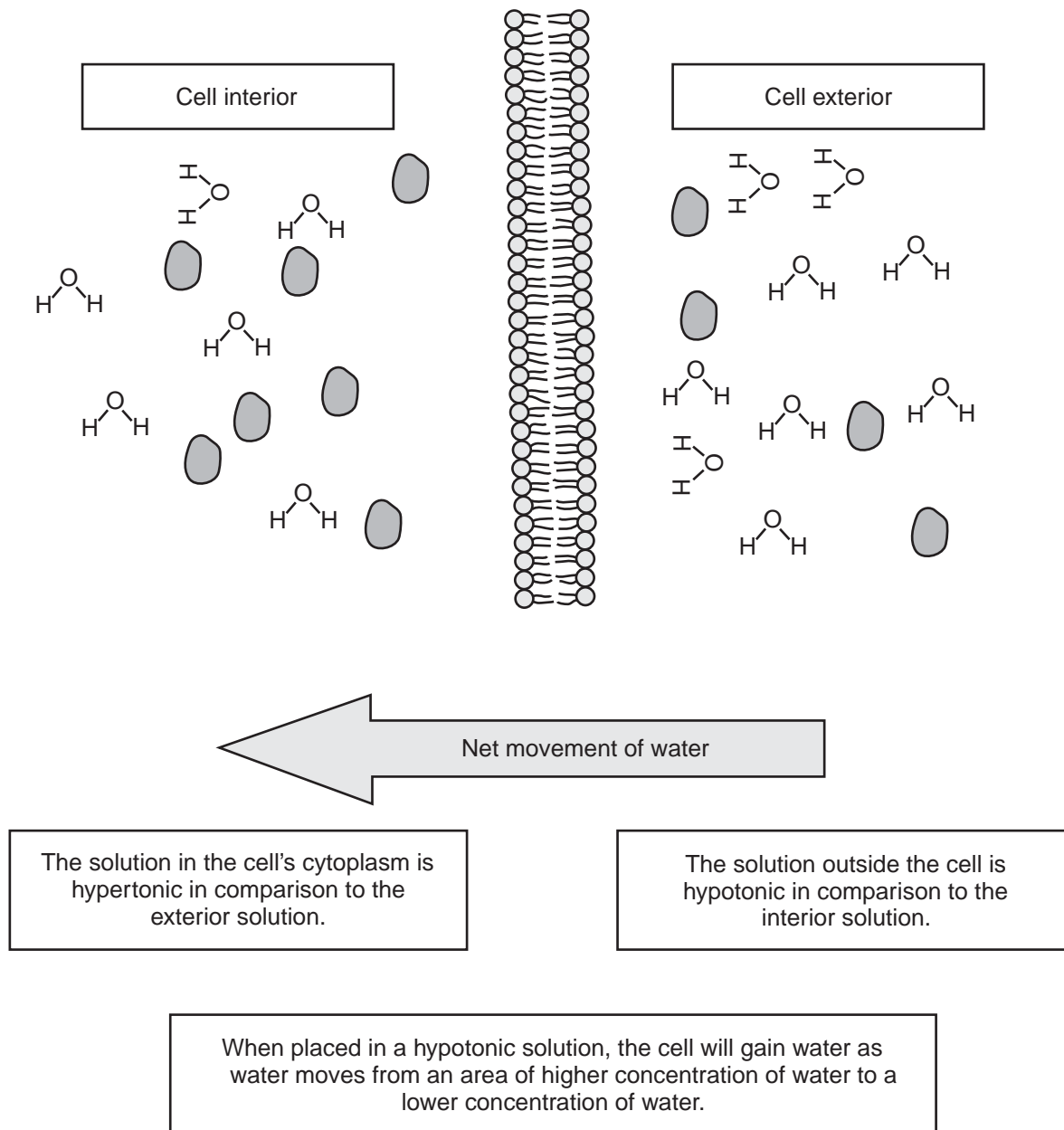
Model pieces – Glucose, water, and pathway arrows



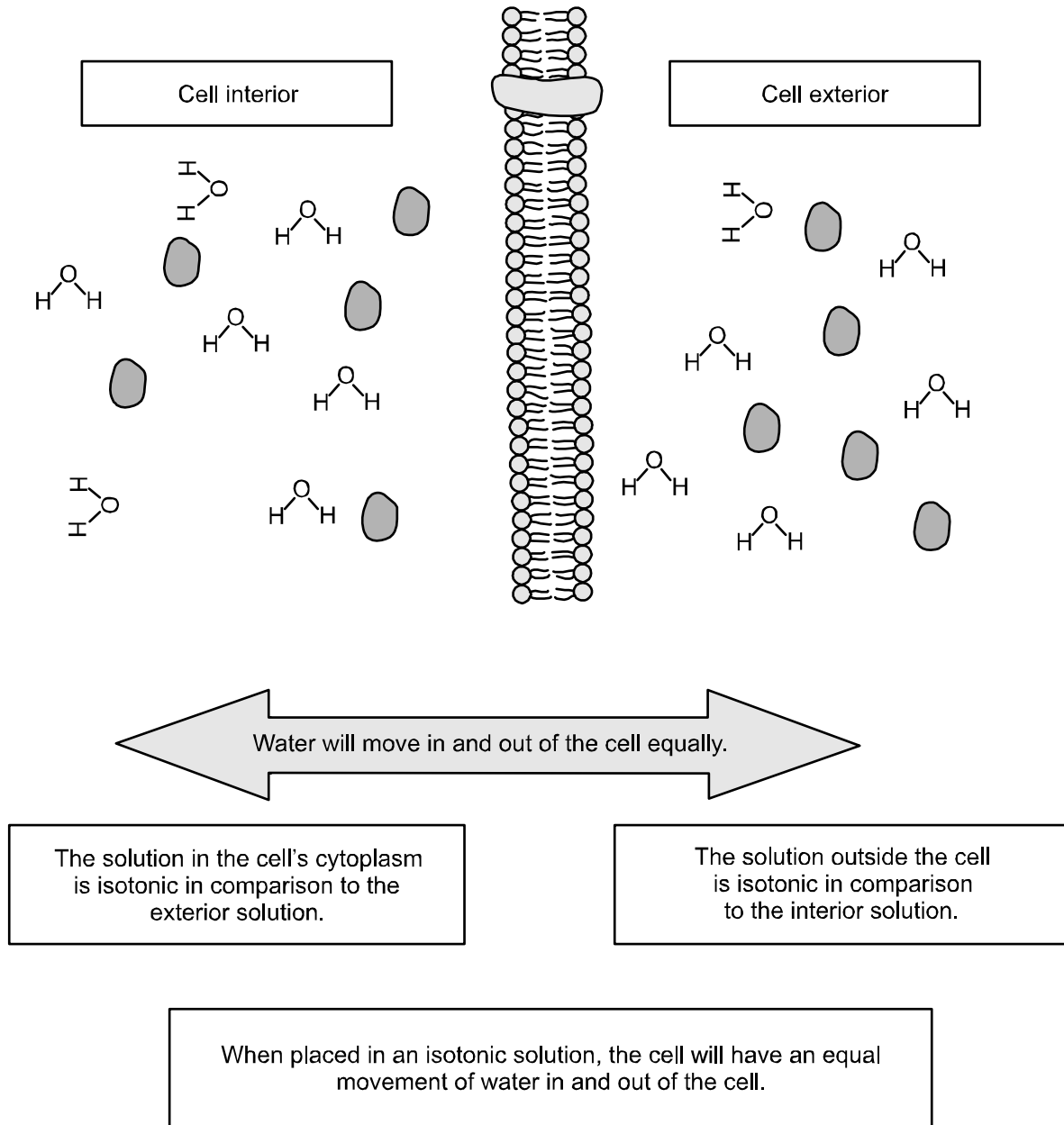
CELL IN A HYPERTONIC ENVIRONMENT



CELL IN A HYPOTONIC ENVIRONMENT



CELL IN AN ISOTONIC ENVIRONMENT



POSSIBLE ANSWERS TO THE CONCLUSION QUESTIONS AND SAMPLE DATA

PART I

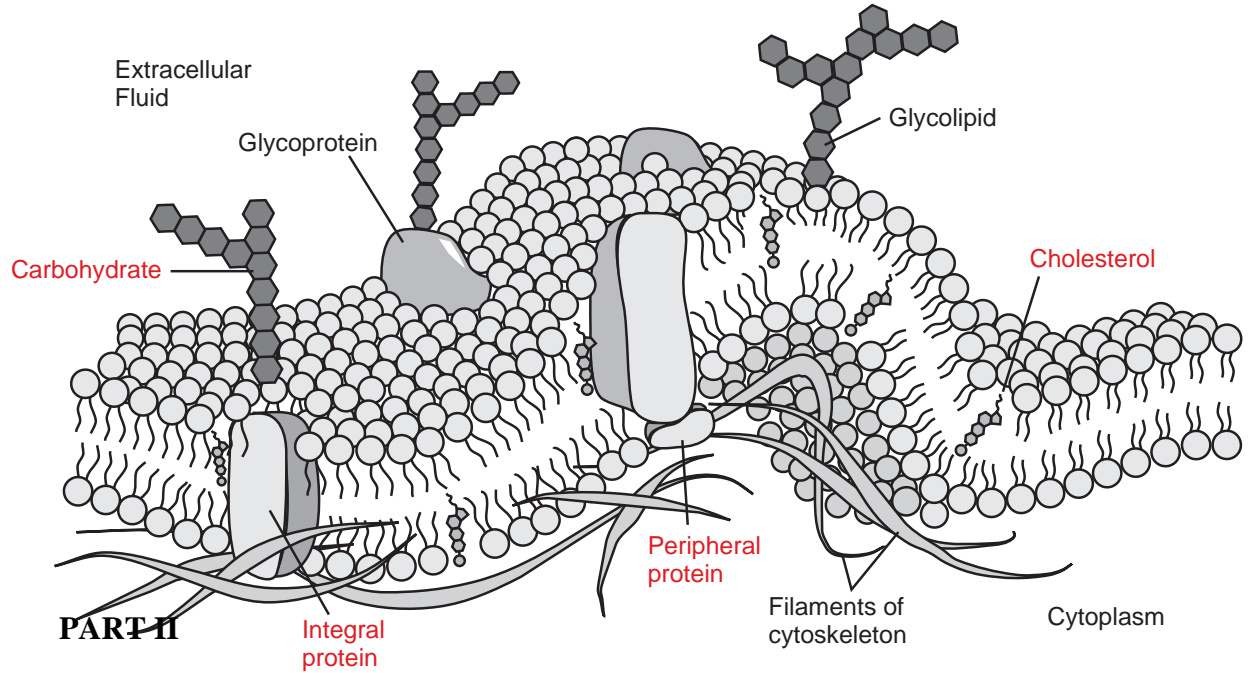
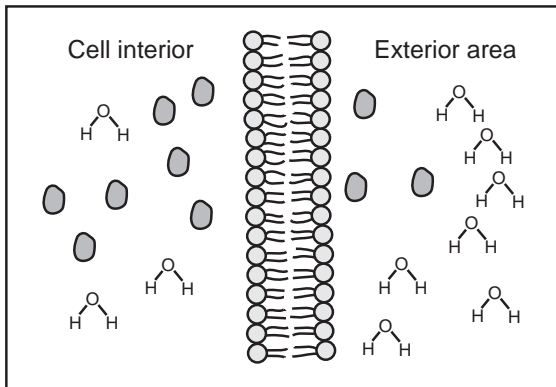


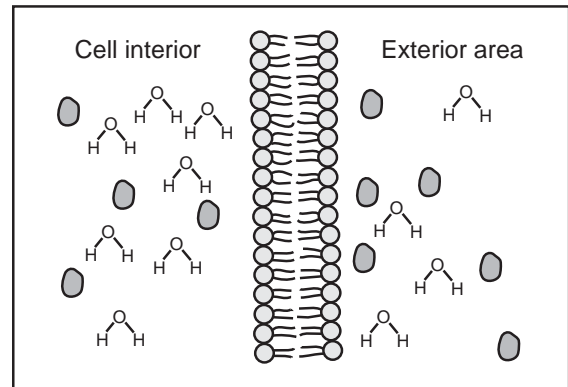
Fig. 2



hypertonic

hypotonic

Fig. 3



hypotonic

hypertonic

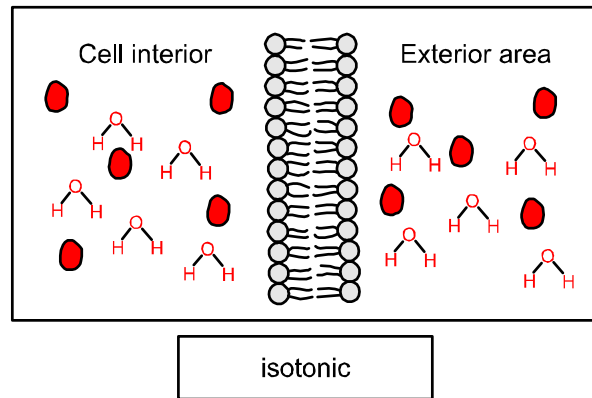


Figure 4

ANALYSIS

PART I: MEMBRANE STRUCTURE CHART

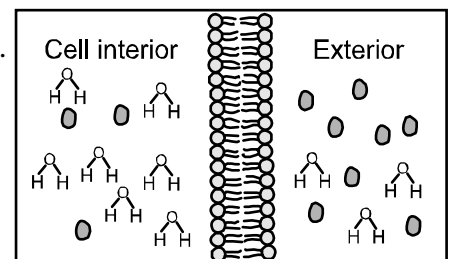
Functional Cellular Event	Membrane Structural Component Involved
Hydrogen ions (H ⁺) are being pumped to the inside of the membrane	Integral transport protein
Glucose is entering the cell	Integral transport protein
Water is entering the cell	Aquaporins
Carbon dioxide is diffusing out of the cell	Phospholipids
The cell is recognized as belonging to a specific tissue	Carbohydrate tags
Intermediate filaments of the cytoskeleton are anchored in place	Peripheral protein

PART II: OSMOTIC PREDICTIONS

Cell Type	If Placed in this Solution	Predicted Results
Liver cell	Hypotonic	Gain water and the cell will burst
Onion cell	Hypertonic	Lose water and plasmolysis will occur
Cheek cell	Isotonic	Neither
Red blood cell	Hypertonic	Lose water and the cell will shrink
Potato cell	Hypotonic	Gain water and cell will become turgid

CONCLUSION QUESTIONS

- D 1. Which of the following statements is supported by the fluid-mosaic model of membrane structure?
- The cell membrane is a phospholipid layer divided by carbohydrates.
 - The cell membrane is a protein layer in which large lipids are found.
 - The cell membrane is composed of carbohydrates floating in a sea of lipids.
 - The cell membrane is a phospholipid bilayer in which proteins float.
- B 2. A red blood cell placed in distilled water will swell and burst due to the movement of
- salt from the distilled water diffusing into the red blood cell.
 - water molecules moving by osmosis into the red blood cell.
 - water from the red blood cell moving into the distilled water.
 - salt from the red blood cell moving into the distilled water.
- C 3. The pathway taken by water molecules into the cell is
- through the cholesterol molecules.
 - between the globular proteins.
 - between the aquaporins.
 - through the peripheral proteins.
- A 4. If excess fertilizer is placed around the root of a tomato plant, the leaves of the plant will shrivel and turn brown. All of the statements help explain why EXCEPT
- The fertilizer makes the soil solution hypotonic to the root cells.
 - The water moves out of the root cells by osmosis into the soil.
 - The plant's roots are in a hypertonic solution.
 - Water is moving from an area of high water concentration to low water concentration.
- C 5. Which of the following terms is most closely associated with the selective permeability of the cell membrane?
- hydrolysis
 - hypothesis
 - homeostasis
 - homologous
- D 6. A cell that has deformity or irregularities in transport proteins may not be able to
- allow water to enter the cell.
 - prevent carbon dioxide from entering the cell.
 - move small particles out of the cell.
 - move large particles into the cell.
- B 7. Which of the following is a true statement regarding the following situation?
- The exterior is hypotonic.
 - There will be a net movement of water out of the cell.
 - This diagram could be of an animal cell in distilled water.
 - The cell's internal solution is hypertonic.



The Fluid Mosaic Membrane

Modeling Membrane Structure and Osmosis

Living cells are surrounded by a cell membrane. The structure of the membrane allows it to function as a selectively permeable barrier separating the cell's internal cytoplasmic solution from the external environment. The currently accepted model of structure for this membrane is referred to as the fluid-mosaic model. The major components of the cell membrane are described below.

- a. Phospholipids—are arranged in a double layer. These phospholipids are composed of a hydrophilic phosphate head region, which face the watery environment inside and outside the cell. The hydrophobic hydrocarbon tails of each layer face one another away from the watery environment. The phospholipids are not static but can move laterally within the membrane. This is why the membrane is said to be fluid.
- b. Membrane proteins—there are two main types of proteins in the membrane, peripheral and integral. Integral proteins span the distance of the lipid bilayer. Peripheral proteins are not embedded and are loosely attached to the surface of the membrane. Proteins in the membrane may serve as transport proteins, chemical receptors, enzymes, and regulators of cell-to-cell recognition, cell connections, and attachment sites for cytoskeletal structures. These proteins are irregularly distributed throughout the membrane and for this reason the membrane is described as a mosaic.
- c. Cholesterol—helps keep the phospholipids spaced apart which adds to the fluidity of the membrane.
- d. Surface carbohydrates—the surface carbohydrates function in cell recognition, cell signaling, and cell adhesion.

This selectively permeable membrane is important in the cell's ability to maintain homeostasis or the condition of equilibrium. Collectively, the components of the cell membrane allow it to be selectively permeable, allowing small, uncharged particles to move by passive transport through the membrane while preventing the passage of large or charged substances. Large or charged substances must have a special pathway through the membrane.

Water will move through the membrane with relative ease from an area of high water concentration to an area of low water concentration. In comparing two solutions, a solution is said to be hypertonic if it contains a higher concentration of solutes than another. The solution with the smaller number of dissolved substances (or solutes) is called hypotonic. When comparing two solutions that are of equal solute concentration, they are referred to as isotonic. Hypertonic solutions have lower water concentrations and will gain water from hypotonic solutions. Cells placed in distilled water, for example, will gain water as water moves through the selectively permeable membrane from an area of high water concentration to an area of lower water concentration. Under these conditions, animal cells will burst, but plant cells do not because of the presence of a cell wall. Cells placed in a solution of syrup for example, will lose water as water moves through the selectively permeable membrane from an area of high water concentration to an area of lower water concentration. Animal cells will shrink, and the membrane of a plant cell will pull away from the cell wall or undergo plasmolysis. An understanding of this phenomenon will allow us to explain why cells will gain or lose water in various settings.

PURPOSE

In this activity, you will model and demonstrate your understanding of the structure of the fluid-mosaic membrane and the effects of the membrane's permeability to water.

MATERIALS

Each lab group will need the following:

bag, zipper-lock, gallon
copy of membrane components
scissors
tape, masking

PROCEDURE

PART I

1. Cut out all of the components on the membrane model by cutting along the dotted lines. Your teacher will provide an envelope or plastic baggie for storage of your cut out pieces.
2. Listen as your teacher describes the fluid mosaic membrane components. Use your membrane component pieces to respond as your teacher asks you to identify various membrane structures.
3. Assemble your components into a simulated membrane on your desk top. Place the pathway of water arrow so that it passes through the phospholipids. Place the pathway of glucose arrow so that it passes through an integral protein.
4. Label the diagram of the fluid mosaic membrane found in Figure 1 on your student answer page.
5. Locate the Membrane Structure Chart on your student answer page. Using the information you have learned during this segment of the activity, identify the membrane component involved for each of the cell functions listed.

PART II

1. Listen as your teacher explains the meaning of hypertonic, hypotonic, and isotonic conditions.
2. Observe Figure 2 and label the cell interior and exterior as hypertonic, hypotonic or isotonic. Also, draw an arrow to indicate the direction water will move.
3. Repeat step 2 for Figure 3.
4. Sketch in solute and water molecules in Figure 4 to represent an isotonic condition.
5. Locate the Osmotic Predictions Chart on your student answer page. Using the information you have gained from this activity, predict what will occur for each cell and condition listed.
6. Upon your teacher's instruction, read and answer each multiple choice question in the conclusion section of your student answer page.

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Modeling Membrane Structure and Osmosis

PART I

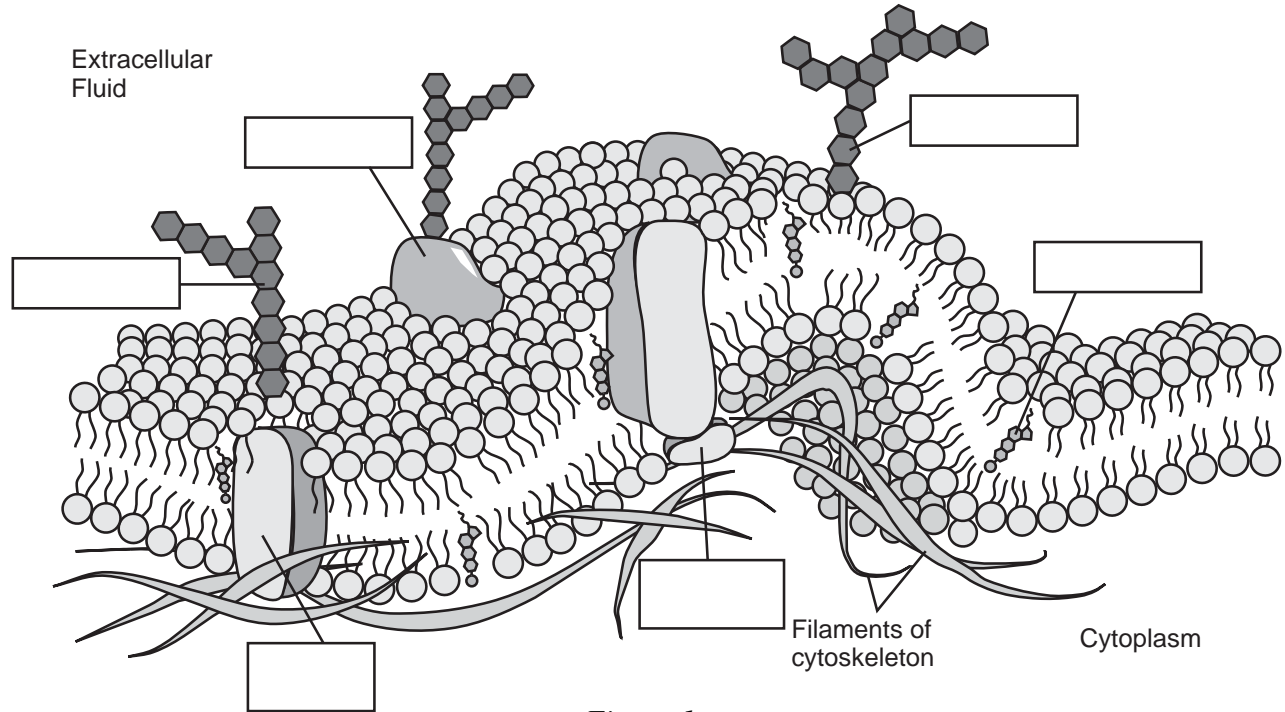


Figure 1

PART II

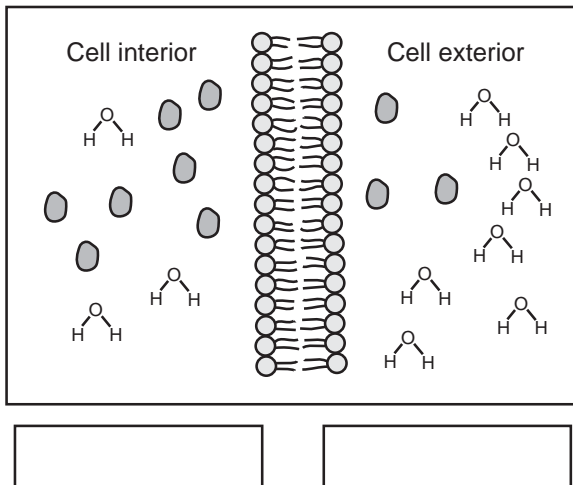


Figure 2

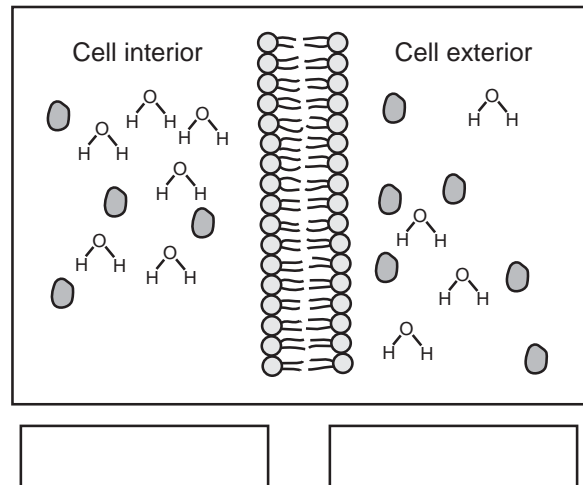


Figure 3

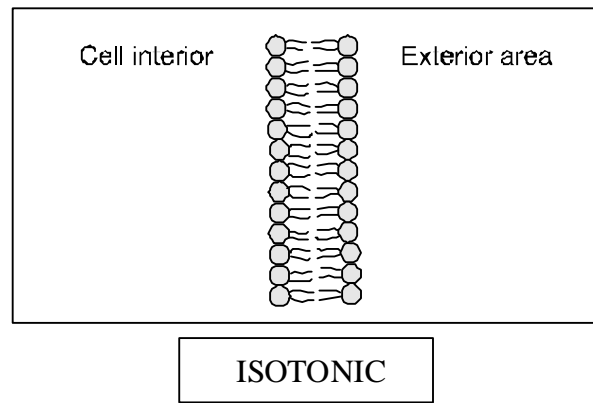


Figure 4

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The cell is recognized as belonging to a specific tissue	
Intermediate filaments of the cytoskeleton are anchored in place	

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Onion cell	Hypertonic	
Cheek cell	Isotonic	
Red blood cell	Hypertonic	
Potato cell	Hypotonic	

CONCLUSION QUESTIONS

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