THE CELL MEMBRANE AND MATERIAL TRANSPORT

Unit. Molecules and Cells

Problem Area. Cellular Biology

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Describe the biochemistry and functions of animal cell membranes.
2. Define the terms hypertonic, hypotonic, and isotonic.
3. Discuss the permeability of a membrane.
4. Compare and contrast passive and active functions of specialized cells.
5. Explain the importance of endomembrane systems in the life of a cell.

List of Resources. The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. http://www.mycaert.com.
List of Equipment, Tools, Supplies, and Facilities

✔ Writing surface
✔ Overhead projector
✔ Transparencies from attached masters
✔ Copies of student lab sheet
✔ Technical Supplement from attached masters

Terms. The following terms are presented in this lesson (shown in bold italics):

- Active Transport
- Adhesion Proteins
- Bulk-phase endocytosis
- Communication Proteins
- Diffusion
- Endocytosis
- Endomembrane System
- Endoplasmic Reticulum
- Exocytosis
- Fluid Mosaic Model
- Glycolipids
- Golgi Bodies
- Hydrophobic
- Hypertonic
- Hypotonic
- Isotonic
- Lysosomes
- Osmosis
- Passive Transport
- Permeability
- Peroxisomes
- Phagocytosis
- Phospholipids
- Pseudopods
- Receptor Proteins
- Receptor-mediated endocytosis
- Recognition Proteins
- Transport Proteins
- Vesicles
Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

To introduce this lesson, ask your students how they think substances are transported in and out of a cell? For example, how does glucose enter cells to supply energy for walking, running, or even just sitting idle? The discussion should lead towards identifying a barrier (cell membrane) between the exterior environment of a cell and its internal components. The proceeding discussions and questions should be used to lead into the biochemistry of cells, osmosis, and the endomembrane system.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Describe the biochemistry and functions of animal cell membranes.

Anticipated Problem: What is the biochemistry and functions of animal cells?

I. Animal cell membranes are made up of lipids, with the balance being lipid bilayers that are supported by phospholipids. They have a phosphate-laced head and two fatty acid tails attached to a glycerol backbone. The phosphate-laced head is considered *hydrophobic* because it easily dissolves in water. The two fatty acid tails are considered hydrophobic because they do not dissolve in water. When the phospholipids are submerged in water they intermingle among each other and with water molecules to form a film on the surface of water.

A. A two-layer film may form with the fatty acid tails positioned between the phosphate-laced heads. This forms the lipid bilayers of animal cells. The bilayers allow for cells to form vesicles and closing off opening for the control of fluid in and out of a cell.

1. The fluid mosaic model is a crucial part of animal cell membranes. Its unique makeup and various functions control the stability and viability of a cell.
2. Proteins play a role in carrying materials and messages through the cell membranes of animals. Both work hand in hand in cell membranes of animals.

B. The *fluid mosaic model* is a key element of animal cell membranes. The cell membrane is made up of an assortment or mosaic of lipids and proteins. The membrane is impermeable to hydrophilic molecules, but is considered fluid. Lipids found in the fluid mosaic model of the membrane of animal cells include phospholipids, glycolipids, sterols, and proteins. The membrane is considered fluid by the fluid mosaic model in that it allows motions and interactions of its component parts.
1. **Phospholipids** vary in their makeup. Their fatty acids can be saturated or unsaturated. The unsaturated fatty acids of phospholipids have one or more double bonds, while saturated fatty acids do not have any.

2. **Glycolipids** differ from phospholipids in that they have sugars attached to the head of the molecule. The sterols are most common in animal cells. Sterols are found in the form of cholesterol in the membranes of the cells. The proteins of cell membranes facilitate the transport of information and some are able to move freely.

3. The lipids within the membrane are considered fluid, especially phospholipids. The fluid mosaic model allows for the lipids to move up and down and side to side. This motion prevents the lipids from packing tightly into firm layers.

4. The hydrophobic fatty acid tails of phospholipids play a key role in maintaining a fluid status. Their position in the packaging within the phospholid-laced head facilitates fluidity.

C. Proteins transport messages and materials through the cell membrane as well as aid in the specialized function of cells. Proteins found in the membranes of cells are divided into five main categories. They all span the bilayer of cell membranes and perform specific functions.

1. **Adhesion proteins** are implanted within the plasma membrane. They provide a variety of functions, including adhering two cells or a cell to a specialized protein. They also relay messages across the membrane. Adhesion proteins can be found in large quantities in the specialized lining of blood vessels of animals, called endothelium.

2. **Communication proteins** form channels that facilitate the transfer of signals and substances between the cytoplasm of two cells. The proteins align with similar proteins in the plasma membrane. They can be found in the heart muscle cells of animals. Their rapid communication ability facilitates the contraction of the heart.

3. **Receptor proteins** bind extracellular substances that activate changes in cell functions. These extracellular substances include hormones that might signal a cell to start manufacturing a particular protein.

4. **Recognition proteins** serve as identifiers of cells to certain tissues or organs. They aid in identifying foreign cells when entering a system, such as bacterial cells that may cause disease or sickness within an animal.

5. **Transport proteins** are divided into two subcategories. They are either passive or active transporters. Passive transporters let solutes cross the cell membrane by allowing the solute to move through the protein without the use of energy. Active transporters use energy to move solutes across the cell membrane through a pumping action.

At the conclusion of this objective a discussion of the fluid mosaic model and roles of transport proteins can be held. This discussion should include the differences in the proteins and lipids of the mosaic model. Transparency masters TM–A and TM–B will assist in the instruction of this objective.
Objective 2: Define the terms hypertonic, hypotonic, and isotonic.

Anticipated Problem: What is the definition of hypertonic, hypotonic, and isotonic?

II. Water and fluids are moved throughout the body of animals by several different means. Blood cells are pumped through the circulatory system by the heart to nourish cells of organs and tissues. These blood cells are concentrated with necessary fluids or water required to maintain life. The concentration of fluids found in the cells is determined by the cell membrane. If the concentration of fluids or water is not equal across an animal cell membrane a response called osmosis typically occurs.

A. Osmosis diffuses water molecules through a selectively permeable membrane of the cell to balance the concentrations. When molecules are concentrated in a small area either inside or outside of a cell, they tend to collide with each other. If moved to a less concentrated area, the molecules will spread out. The movement of water molecules through osmosis is aided by diffusion.

1. **Diffusion** is the movement of molecules from an area of higher concentration to an area of lower concentration. Through osmosis and diffusion molecules are moved along an artificial slope from a higher to a lower concentrated environment. This process occurs through the kinetic energy harnessed from the movement of molecules.

2. When cells are placed in a hypotonic, hypertonic, or isotonic environment, osmosis may be triggered. This allows for the balancing of molecules between the environment and the cell.

B. The selective permeable membrane of a cell only allows certain substances to cross it. In this case we will assume that water is passing across a cellulose membrane of a sac. The sac is representing a cell in its environment. Inside the sac is a 10% starch solution and 90% water. The starch cannot cross the permeable membrane. The sac is placed into a 100% water solution environment and osmosis occurs.

1. Osmosis would cause the water molecules to move into the sac causing the sac to swell. This occurs because of its lower concentration of water molecules inside the sac in comparison to the environment.

2. The water solution is considered **hypotonic** because it contains a lower concentration of dissolved substance, in this case starch, than the solution found in the sac.

3. Cells will eventually burst if placed into a hypotonic solution due to osmotic pressure. Osmotic pressure results from the movement of a fluid during osmosis.

C. The selective membrane not only allows substances to enter a cell, but also allow them to exit. In this case a cellulose membrane sac is again filled with a 10% starch solution and 90% water. Once again, the starch cannot cross the permeable membrane. The sac is placed into a 20% starch solution and 80% water environment.

1. Osmosis would cause the water molecules to move from inside the sac to the environment. This would occur due to the lower concentration of water molecules in the environment. The sac would shrivel as osmosis moved the water out of the sac.
2. The 20% starch solution and 80% water environment is considered **hypertonic** because it contains a higher concentration of dissolved substance than the solution found in the sac. Cells will eventually die if placed in a hypertonic solution, because all the fluids will be moved out through osmosis.

D. Osmosis allows for cells to adjust to a changing environment. Life cannot occur if cells are constantly bursting or shriveling in their environment. In this case the same cellulose membrane sac is again filled with a 10% starch solution and 90% water. Once again, the starch cannot cross the permeable membrane. The sac is placed into a 10% starch solution and 90% water environment.

1. In this case osmosis would move water in and out of the sac at the same rate. The sac and the surrounding environment are in equilibrium because they contain the same levels of starch and water.

2. The environment and sac are considered **isotonic** due to the similarity of concentrations of a dissolved substance. Cells are able to remain stable when placed in an isotonic environment.

---

**At the conclusion of this objective the lab activity can be started. It will assist the students with better understanding the phenomena of osmosis as well as hypotonic, hypertonic, and isotonic solutions. Transparency masters TM–C and TM–D will assist in the instruction of this objective.**

---

**Objective 3:** Discuss the permeability of a membrane.

**Anticipated Problem:** How does the permeability of a membrane function?

III. The **permeability** of a membrane allows for the transport of materials in and out of a cell. Osmosis allows for fluid to be moved through a selective permeable membrane by harnessing the energy from molecule movement. Transport proteins are only able to move small molecules across the permeable membrane. In order for large molecules or particles to be moved in or out of a cell through the membrane, other methods must be utilized.

A. Vesicles form in the cell to allow for transportation through the membrane. These vesicles form through exocytosis and endocytosis.

1. **Exocytosis** is the process of a vesicle moving to the surface of a cell and the lipid bilayer of its membrane attaches to the plasma membrane of the cell. Once fused to the plasma membrane, the vesicle releases its content out into the environment.

2. **Endocytosis** involves three different pathways of movement. In each pathway a cell ingests substances near the surface of the cell. An indention is made in the plasma membrane and pinches off inside the cell. This forms a vesicle that can be transported inside the cell.
B. The first pathway is called a **receptor-mediated endocytosis**. In this case receptors found on the membrane chemically identify and bind to specific substances. These substances can include a vitamin, mineral, or hormone.

1. Once the receptors bind with the substance they congregate in small pits formed along the plasma membrane. The pits contain protein filaments that link each pit into a pattern.
2. The pits eventually descend into the cytoplasm of the cell and closes up around themselves forming vesicles. Now inside the cell, the vesicle contains the receptor identified substance.

C. The second pathway is called a **bulk-phase endocytosis**. In this case, a vesicle forms around an amount of extracellular fluid. Unlike the receptor-mediated pathway, the bulk-phase pathway does not identify specific substances when forming a vesicle.

1. It is a consistent process of pulling bulk batches of substances into the cytoplasm of a cell.
2. Once pulled inside of the cell, the vesicle’s content is transported to organelles or stored in the cytoplasm for later use.

D. The third pathway is called a **phagocytosis**. It is an active form of endocytosis in which a cell ingests microbes, particles, and cellular waste.

1. Within the body of an animal, bacteria, viruses, and other health threatening bodies are consumed through this process. It is a typical response by white blood cells.
2. Like the receptor-mediated pathway, the phagocytosis pathway is controlled by receptors. A substance binds with a receptor protruding from a cell’s membrane. Once bound, synthesis and cross linking of microfilaments below the plasma membrane is triggered. The microfilaments contract and squeeze part of the cytoplasm towards the borders of the cell.
3. Powered by ATP motors, the squeezing forms lopes called **pseudopods**. The pseudopods coat the substance and bind at their ends. A vesicle then forms and sinks into the cytoplasm of a cell. Once inside the cytoplasm, the vesicle binds with lysosomes and is digested into smaller particles.

Textbook material should be supplied in order for students to master the material covered in this objective. It is important that they conceptualize the permeability of a membrane, understand the three pathways for transport, and identify molecules that are transported. A lecture-discussion fits well to cover the key points of this objective. Transparency master TM–E will assist in presenting the information.
Objective 4: Compare and contrast passive and active functions of specialized cells.

Anticipated Problem: What is the difference between passive and active functions of specialized cells?

IV. Passive and active transporters allow for molecules and ions to enter or exit the interior of cells.

A. Passive transport includes diffusion, osmosis, and facilitated diffusion. They are unassisted diffusion of a specific solute through a transport protein or membrane.
   1. No extra energy is required to perform a passive transport.
   2. It is comparable to pushing a four-wheeled vehicle down a hill, in which the vehicle can coast down the hill without the assistance of a motor.

B. Active transport includes exocytosis and pathways of endocytosis like phagocytosis. They require energy to move a specific solute across the cell membrane.
   1. It is comparable to pushing a four-wheeled vehicle up a hill, in which the power of a motor is required.
   2. Cells in the body of an animal utilize both transport functions.

C. Passive transport requires no extra energy to perform the crossing of a gradient, such as a cell membrane. For example, during osmosis the energy from the molecule movement is harnessed to carryout the process.
   1. Osmotic pressure builds to force the movement of a substance. In passive transport the movement moves towards the direction of less concentration.
   2. By moving to a less concentrated area, little to no resistance is met. Passive transport continues until concentrations are equal across the membrane, or become isotonic.

D. Unlike passive transport, active transport uses ATP to carry out functions. It is necessary to transport substances against the gradient or direction of diffusion in order to maintain homeostasis, or stability in cells.
   1. Only particular substances are allowed to enter pathways utilized in active transport. By bonding with ATP the substances are transported into the cell.
   2. Active transporters such as calcium pumps and sodium-potassium pumps are able to keep concentrations and electric gradients stable across membranes. Though it costs energy to run active transporters, they are necessary to perform physical actvates such as muscle contractions and nerve cell functions.

At the conclusion of this objective a discussion should be performed to compare and contrast passive and active transport. The major differences between the two transport systems should be identified and energy requirements of each. Transparency master TM–F will assist in the instruction of this objective.
Objective 5: Explain the importance of endomembrane systems in the life of a cell.

Anticipated Problem: What is the importance of the endomembrane systems in the life of a cell?

V. The endomembrane system is a series of linked organelles inside the cytoplasm of cells of animals. A variety of functions that are crucial to life occur in the endomembrane system.

A. Functions include the production of lipids and modification of polypeptide chains. The system contains the endoplasmic reticulum (ER), Golgi bodies, and vesicles.
   1. By the interconnection of these three main organelles their products are sorted and transported to a variety of destinations within the cell.
   2. Their functions are crucial to the survival of cells, by performing a variety of functions, including the degrading of toxins and the building of proteins.

B. The endoplasmic reticulum (ER) is the beginning point of the endomembrane system. It extends through the cytoplasm of animal cells with rough or smooth membranes.
   1. Rough ER contains many attached ribosomes, while smooth ER does not have ribosomes. Rough ER modifies polypeptide chains by attaching side chains to them and transforming them into final protein form.
   2. Some specialized cells contain large quantities of rough ER. These specialized cells can perform functions such as releasing enzymes used in the digestion of food.
   3. Smooth ER assembles lipids from building blocks. This assembly occurs in a hose like structure of the smooth ER. Toxic waste is degraded in some smooth ER in order to protect the cell from it. Other smooth ER serve in the controlling functions of muscle contractions.

C. The Golgi bodies are considered the packing and shipping center of the endomembrane system. They receive their goods from the endoplasmic reticulum (ER) and place the final touches on proteins and lipids for cells. The sorting that occurs inside the Golgi bodies is determined by how the protein or lipid is earmarked for its final destination.
   1. A chemical change occurs to transform the protein or lipid. By attaching an additional molecule such as a carbohydrate or removal of a water molecule to proteins or lipids denote the direction that it is sent.
   2. The final products move to the end of the Golgi bodies where they are pinched off and ready for delivery.

D. Vesicles serve as the delivery trucks for the shipping center, by taking packaged goods through the cytoplasm. Types of vesicles, such as lysosomes carry enzymes for intracellular digestion.
   1. The enzymes digest proteins, carbohydrates, nucleic acids, and some lipids. Special types of lysosomes can digest cells and cell parts. This digestion is a planned part of growth and development for some organisms.
   2. Peroxisomes are another type of vesicles that perform a specialized function. They are commonly found in the liver and kidney. They degrade specific toxins that can damage cells and organs within the body.
At the conclusion of this objective have the students perform a visual demonstration. Utilizing an example from the Internet (students can conduct an image search for any one of this lesson’s terms), have the students draw and identify the parts of the endomembrane system. Assign each student a particular part of the system and have him or her recite the function(s) of his or her assigned part. Transparency masters TM–G through TM–H will assist in the instruction of this objective.

**Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle.

**Application.** Use the following transparencies, lab sheet, and technical supplement to apply the information.

- TM–A: Lipids Found in the Fluid Mosaic Model
- TM–B: Membrane Proteins
- TM–C: Osmosis
- TM–D: Diffusion
- TM–E: Pathways of Endocytosis
- TM–G: Parts of the Endomembrane System
- TM–H: Location of Endomembrane in the Animal Cell
- LS–A: Osmosis and Diffusion in a Chicken Egg
- TS–A: Technical Supplement

**Evaluation.** Focus the evaluation of student achievement on mastery of the objectives stated in the lesson. Measure student performance based on classroom participation and the sample written test.

**Answers to Sample Test:**

**Part One: Matching**

1. b.
2. a.
3. d.
4. c.

**Part Two: Fill-in-the-Blank**

1. Permeability
2. Fluid Mosaic Model
3. Exocytosis
4. Peroxisomes

**Part Three: Multiple Choice**

1. c.
2. b.
3. a.
4. c.

**Part Four: Short Answer**

1. Endocytosis involves three different pathways of movement. In each pathway a cell ingests substances near the surface of the cell. An indentation is made in the plasma membrane and pinches off inside the cell. This forms a vesicle that can be transported inside the cell. The first pathway is called a receptor-mediated endocytosis. In this case receptors found on the membrane chemically identify and bind to specific substances. These substances can include a vitamin, mineral, or hormone. Once the receptors bind with the substance they congregate in small pits formed along the plasma membrane. The pits contain protein filaments that link each pit into a pattern. The pits eventually descend into the cytoplasm of the cell and closes up around themselves forming vesicles. Now inside the cell, the vesicle contains the receptor identified substance. The second pathway is called a bulk-phase endocytosis. In this case a vesicle forms around an amount of extracellular fluid. Unlike the receptor-mediated pathway, the bulk-phase pathway does not identify specific substances when forming a vesicle. It is a consistent process of pulling bulk batches of substances into the cytoplasm of a cell. Once pulled inside of the cell the vesicle’s content is transported to organelles of the cell or stored in the cytoplasm for later use. The third pathway is called a phagocytosis. It is an active form of endocytosis in which a cell ingests microbes, particles, and cellular waste. Within the body of an animal, bacteria, viruses, and other health threatening bodies are consumed through this process. It is a typical response by white blood cells. Like the receptor-mediated pathway, the phagocytosis pathway is controlled by receptors. A substance binds with a receptor protruding from a cell’s membrane. Once bound, synthesis and cross linking of microfilaments below the plasma membrane is triggered. The microfilaments contract and squeeze part of the cytoplasm towards the borders of the cell. Powered by ATP motors, the squeezing forms lopes called pseudopods. The pseudopods coat the substance and bind at their ends. A vesicle then forms and sinks into the cytoplasm of a cell. Once inside the cytoplasm, the vesicle binds with lysosomes and is digested into smaller particles.
THE CELL MEMBRANE AND MATERIAL TRANSPORT

Part One: Matching

Instructions: Match the word with the correct definition.

a. Passive Transport  
b. Active Transport  
c. Receptor Proteins  
d. Recognition Proteins

1. This uses ATP to carry out functions.
2. This requires no extra energy to perform the crossing of a gradient, such as a cell membrane.
3. These types of proteins serve as identifiers of cells to certain tissues or organs.
4. These types of proteins bind extra-cellular substances that activate changes in cell functions.

Part Two: Fill-in-the-Blank

Instructions: Complete the following statements.

1. The _________ of a membrane allow for the transport of materials in and out of a cell.
2. Lipids found in the _________ of the membrane of animal cells include phospholipids, glycolipids, sterols, and proteins.
3. The process of a vesicle moving to the surface of a cell and the lipid bilayer of its membrane attaches to the plasma membrane of the cell is called ________________.
4. These vesicles, known as ________, are commonly found in the liver and kidney.
Part Three: Multiple Choice

Instructions: Circle the letter of the correct answer.

_____ 1. This is when there are similarities of concentrations of a dissolved substance in the environment and sac?
   a. Hypotonic
   b. Hypertonic
   c. Isotonic
   d. None of the Above

_____ 2. The 20% starch solution and 80% water environment in this type of water solution is called?
   a. Hypotonic
   b. Hypertonic
   c. Isotonic
   d. None of the Above

_____ 3. When placed in this type of water solution, cells will eventually burst due to osmotic pressure?
   a. Hypotonic
   b. Hypertonic
   c. Isotonic
   d. None of the Above

_____ 4. This is a series of linked organelles inside the cytoplasm of cells of animals?
   a. Gogli Body
   b. Isotonic System
   c. Endomembrane System
   d. Endoplasmic System

Part Four: Short Answer

Instructions: Answer the following statement.

1. Explain the purpose and functions of the Endocytosis and list its three pathways.
LIPIDS FOUND IN THE FLUID MOSAIC MODEL

♦ Phospholipids
♦ Glycolipids
♦ Sterols
♦ Proteins
MEMBRANE PROTEINS

♦ Adhesion Proteins
♦ Communication Proteins
♦ Receptor Proteins
♦ Recognition Proteins
♦ Transport Proteins
OSMOSIS

Animal Cell

Membrane

Osmosis

Water Molecules
Diffusion

Cell

Diffusion

Membrane

Low Concentration

High Concentration
PATHWAYS OF ENDOCYTOSIS

◆ Receptor-mediated Endocytosis
◆ Bulk-phase Endocytosis
◆ Phagocytosis
## PASSIVE VS. ACTIVE TRANSPORT

<table>
<thead>
<tr>
<th>Passive</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Extra Energy</td>
<td>Requires Energy</td>
</tr>
<tr>
<td>Moves with gradient</td>
<td>Moves against gradient</td>
</tr>
<tr>
<td>Rely on other processes</td>
<td>Works independently</td>
</tr>
</tbody>
</table>
PARTS OF THE ENDOMEMBRANE SYSTEM

♦ Endoplasmic Reticulum (ER)
♦ Golgi bodies
♦ Vesicles
LOCATION OF ENDOOMEMBRANE IN THE ANIMAL CELL

Cell membrane
Endoplasmic reticulum
Ribosomes
Nucleus
Mitochondrion
Lysosome

Cytoplasm
Nuclear membrane
Nucleolus
Golgi body
Agricultural Applications and Practices

Cells found in the body of animals contain semi permeable membranes that facilitate or prevent the transfer of materials in and out of the cell. This is done through the process of diffusion and osmosis. Diffusion occurs to keep both the animal and its cells in homeostasis. This is a state in which all is in balance and functioning properly. Diffusion allows materials such as water molecules to move in or out of the cell depending were the higher concentration is located. It is important to understand this process to conceptualize how a cell and eventually the entire animal becomes dehydrated or re-hydrates itself after extensive work or exercise. Osmosis is the transfer of molecules across the semi permeable membrane that surrounds a cell. This selective membrane only permits certain items to enter or exit a cell. For example, small molecules of proteins and other substances may be allowed to enter a cell through osmosis to distribute a message of function of supply energy to the cell in the form of ATP. Through a visual demonstration of osmosis, diffusion, and exposure of a cell membrane to hypotonic or hypertonic solution will aid in better understanding how cells perform specialized functions. Through advanced research scientist can determine how a virus, bacteria, or disorder is attaching cells or invading the cellular environment.

Science Connections—Questions for Investigation

1. What is the process of osmosis?
2. What is the process of diffusion?
3. How does passive and active transport affect a cell membrane?
4. How do hypotonic and hypertonic solutions affect a cell membrane?

Research Problem

How do the processes of osmosis and diffusion occur with an egg’s cell membrane?
Purpose of Lab and Student Performance Objectives

The purpose of this experiment is to investigate the effects of osmosis and diffusion on cell membranes of a fresh hen’s eggs. Through this lab exercise and related discussions, students will be able to:

1. Identify examples of passive and active transport.
2. Demonstrate the processes of osmosis and diffusion on cell membranes.
3. Predict permeability of a cell membrane based upon exposure to hypotonic and hypertonic solutions surrounding a cell membrane.

Material and Equipment

- 2 fresh eggs in the shell per lab group
- overhead marker
- 400 milliliters of water
- Graduated cylinder
- 1 large beaker per group
- 2 medium beakers per group
- 1 small beaker per group
- White Vinegar
- Sugar syrup (Karo)
- Distilled water
- Pencil
- Paper
- Eye goggles
- Saran Wrap
- Masking tape
- Plastic tray
- Tongs
- Electronic Balance
- Paper Towel
Procedures

Give each student or group of students a copy of the worksheet to perform the activity.

Helpful Hints

♦ The laboratory experiment is designed to begin after teaching objective two.

♦ This lab will take 4 to 5 days to complete. The first part of the lab will take 15–20 minutes. The second part of the lab will take 20–25 minutes. The third part of the lab will take 20–25 minutes. The fourth part of the lab and final observations will take 25–30 minutes to complete the lab activity and lab report.

♦ This lab activity requires the students to demonstrate osmosis and diffusion processes in two eggs. Students can work individually or in groups of two to three so that data or observations can be compared.

♦ It is recommended that the teacher guide students in specific types of observations that should be recorded. For example, students should identify the size, weight, color, texture and structure of the egg (with or without shell). Also, be sure to point out specific functions that are occurring in the egg and solutions.

♦ Be sure to supply a waste container for the students to discard the syrup. It should not be poured down the drain, as it will cause blockage.

♦ It is also recommended that the summary table of the laboratory data be pre-formatted so students can insert data or observations and be totaled at the conclusion of the lab.
OSMOSIS AND DIFFUSION IN A CHICKEN EGG

Material and Equipment

♦ 2 fresh eggs in the shell per lab group
♦ overhead marker
♦ 400 milliliters of water
♦ Graduated cylinder
♦ 1 large beaker per group
♦ 2 medium beakers per group
♦ 1 small beaker per group
♦ White Vinegar
♦ Sugar syrup (Karo)
♦ Distilled water
♦ Pencil
♦ Paper
♦ Eye goggles
♦ Saran Wrap
♦ Masking tape
♦ Plastic tray
♦ Tongs
♦ Electronic Balance
♦ Paper Towel
Procedures

1. Read through the procedures of this lab activity and make a prediction of any changes in appearance of the eggs between various solutions. Record your hypothesis in your lab report.

2. Each lab group should assemble supplies needed to complete this lab activity. First, measure the weight of both the eggs in the shell. Using the overhead marker label the large beaker “vinegar, lab group.”

3. Measure 400 mL of white vinegar and pour into the labeled beaker. Place both eggs in the solution. To insure that eggs remain submerged, place a small beaker on top of the solution. This will hold the eggs down into the vinegar. Cover beakers with saran wrap. Let eggs stand for 24 hours or more to remove shell.

4. After waiting 24 hours, record observations of the eggs in vinegar solution in the data table of your lab sheet. Be sure to include the size and appearance of the eggs in observations. Carefully, use tongs to take the eggs out of the solution. Gently, rinse off the eggs with water. Gently pat the eggs dry with a paper towel. You do not want to break your eggs’ membrane. Weigh the eggs on the electronic balance and record data. Clean the two beakers used with the vinegar solution.

5. Using the overhead marker label the two medium beakers, “Syrup, lab group.” Place an egg in each beaker. Pour enough syrup to completely cover the circumference of the eggs. Adhere saran wrap to the top of each beaker loosely. Let eggs stand for 24 hours.

6. After letting the solution sit for 24 hours, record observation of the eggs in the sugar syrup solution in the data table sheet. Be sure to include the size and appearance of the eggs in observations. Carefully, use tongs to take the eggs out of the solution. Gently, rinse off the eggs with water. Gently pat the eggs dry with a paper towel. Weigh the eggs on the electronic balance and record data.

7. Pour the remaining sugar syrup solution from the beakers into a container provided by the teacher. Clean the two beakers labeled syrup. Re-label the beakers “distilled water, lab group.” Pour 200 mL of distilled water in each beaker. Place the eggs in the distilled water solution. Cover the beakers with saran wrap and let stand for 24 hours.

8. After allowing the solution to sit for 24 hours, record observations of the eggs in the distilled water solution in the data table sheet. Be sure to include the size and appearance of the eggs in observations. Carefully, use tongs to take the eggs out of the solution. After the teacher observes the eggs, discard the eggs in the proper place. Clean all materials used in lab and return to proper storage places.
9. Take the complete data table and enter your results on the table provided by your teacher for each solution. After discussion regarding averages of the solutions, record those solutions in your data table.

10. Complete a lab report for the lab activity you concluded. Be sure to include: materials used, procedures, purpose, data, and answers to the following questions regarding your lab.

   a. How did your hypothesis compare to the results you found in your experiment?
   b. Why do you think you had these results?
   c. When the egg was placed in the water in which direction did the water molecules move? Why do you think this happened?
   d. How do you explain the amount of liquid remaining when the egg was removed from the syrup?
   e. When the egg was placed in the water after being removed from the syrup in which direction did the water move?
   f. Why did the water molecules travel more easily across the membrane than the syrup molecules?
   g. What was the purpose of placing the egg in vinegar?

### Data Table

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Egg weight before added into the solution (g)</th>
<th>Egg weight after added into the solution (g)</th>
<th>Record of Observations</th>
<th>Average for Classroom Data for Each Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syrup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distilled Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. **What is the process of osmosis?**

Water and fluids are moved throughout the body of animals by several different means. Blood cells are pumped through the circulatory system by the heart to nourish cells of organs and tissues. These blood cells are concentrated with necessary fluids or water required to maintain life. The concentration of fluids found in the cells is determined by the cell membrane. If the concentration of fluids or water is not equal across an animal cell membrane a response called osmosis typically occurs. Osmosis diffuses water molecules through a selectively permeable membrane of the cell to balance the concentrations. When molecules are concentrated in a small area either inside or outside of a cell, they tend to collide with each other. If moved to a less concentrated area, the molecules will spread out.

2. **What is the process of diffusion?**

The movement of water molecules through osmosis is aided by diffusion. Diffusion is the movement of molecules from an area of higher concentration to an area of lower concentration through osmosis and diffusion molecules are moved along an artificial slope from a higher to a lower concentrated environment. This process occurs through the kinetic energy harnessed from the movement of molecules. When cells are placed in a hypotonic, hypertonic, or isotonic environment, osmosis may be triggered. This allows for the balancing of molecules between the environment and the cell.
3. How does passive and active transport affect a cell membrane?

Passive and active transporters allow for molecules and ions to enter or exit the interior of cells. Passive transport includes diffusion, osmosis, and facilitated diffusion. They are unassisted diffusion of a specific solute through a transport protein or membrane. No extra energy is required to perform a passive transport. It is comparable to pushing a four-wheeled vehicle down a hill, in which the vehicle can coast down the hill without the assistance of a motor. Active transport includes exocytosis and pathways of endocytosis like phagocytosis. They require energy to move a specific solute across the cell membrane. It is comparable to pushing a four-wheeled vehicle up a hill, in which the power of a motor is required. Cells in the body of an animal utilize both transport functions.

4. How do hypotonic and hypertonic solutions affect a cell membrane?

The selective permeable membrane of a cell only allows certain substances to cross it. In this case, we will assume that water is passing across a cellulose membrane of a sac. The sac is representing a cell in its environment. Inside the sac is a 10% starch solution and 90% water. The starch cannot cross the permeable membrane. The sac is placed into a 100% water solution environment and osmosis occurs. Osmosis would cause the water molecules to move into the sac causing the sac to swell. This occurs because of its lower concentration of water molecules inside the sac in comparison to the environment. The water solution is considered hypotonic because it contains a lower concentration of dissolved substance, in this case starch, than the solution found in the sac. Cells will eventually burst if placed into a hypotonic solution due to osmotic pressure. Osmotic pressure results from the movement of a fluid during osmosis. The selective membrane not only allows substances to enter a cell, but also allow them to exit. In this case a cellulose membrane sac is again filled with a 10% starch solution and 90% water. Once again, the starch cannot cross the permeable membrane. The sac is placed into a 20% starch solution and 80% water environment. Osmosis would cause the water molecules to move from inside the sac to the environment. This would occur due to the lower concentration of water molecules in the environment. The sac would shrink as osmosis moved the water out of the sac. The 20% starch solution and 80% water environment is considered hypertonic because it contains a higher concentration of dissolved substance than the solution found in the sac. Cells will eventually die if placed in a hypertonic solution, because all the fluids will be moved out through osmosis.