Lab Topic 3
Diffusion and Osmosis
Lab Topic 3: Diffusion and Osmosis

• Laboratory Objectives
  – After completing this lab topic, you should be able to:
    • 1. Describe the mechanism of diffusion at the molecular level.
    • 2. List several factors that influence the rate of diffusion.
    • 3. Describe a selectively permeable membrane, and explain its role in osmosis.
    • 4. Define hypotonic, hypertonic, and isotonic in terms of relative concentrations of osmotically active substances.
    • 5. Discuss the influence of the cell wall on osmotic behavior in cells.
    • 6. Explain how incubating plant tissues in a series of dilutions of sucrose can give an approximate measurement of osmolarity of tissue cells.
    • 7. Explain why diffusion and osmosis are important to cells.
    • 8. Apply principles of osmotic activity to medical, domestic, and environmental activities.
    • 9. Discuss the scientific progress, propose questions and hypotheses, and make predictions based on experiments to test hypotheses.
    • 10. Practice scientific persuasion and communication by constructing and interpreting graphs.
Introduction

- Maintaining the steady state of a cell is achieved only through regulated movement of materials through the cytoplasm, across organelle membranes, and across the plasma membrane.

- The cytoplasm and extra-cellular environment of the cell are aqueous solutions.
  - Composed of water (solvent) and dissolved organic and organic molecules (solutes).

- Cell membranes are selectively permeable.

- Diffusion is a passive process whereby molecules move down their concentration gradient.
  - Osmosis is the diffusion of water.
Molecules of dye

(a) Passive transport of one type of molecule

(b) Passive transport of two types of molecules
Osmosis

Hypotonic solution  Hypertonic solution  Isotonic solutions

Sugar molecule  Selectively permeable membrane

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Animal cell

H₂O → H₂O

Normal

Plant cell

H₂O → H₂O

Flaccid (wilts)

(a) Isotonic solution

(b) Hypotonic solution

(c) Hypertonic solution

(b) Lysing

H₂O

Turgid

Shriveled

Plasma membrane

H₂O
## MEMBRANE TRANSPORT

<table>
<thead>
<tr>
<th>Passive Transport</th>
<th>Active Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>(requires no energy)</td>
<td>(requires energy)</td>
</tr>
<tr>
<td><strong>Diffusion</strong></td>
<td><strong>Higher solute concentration</strong></td>
</tr>
<tr>
<td>Higher solute concentration</td>
<td></td>
</tr>
<tr>
<td><strong>Facilitated diffusion</strong></td>
<td><strong>Higher water concentration</strong></td>
</tr>
<tr>
<td>Higher water concentration</td>
<td>(lower solute concentration)</td>
</tr>
<tr>
<td><strong>Osmosis</strong></td>
<td><strong>Lower solute concentration</strong></td>
</tr>
<tr>
<td>Higher solute concentration</td>
<td>(higher solute concentration)</td>
</tr>
<tr>
<td>Lower solute concentration</td>
<td>Lower water concentration</td>
</tr>
<tr>
<td>Lower water concentration</td>
<td></td>
</tr>
</tbody>
</table>

Diffusion and Facilitated diffusion involve the movement of solutes from an area of higher concentration to an area of lower concentration. Osmosis involves the movement of water, from an area of lower solute concentration to an area of higher solute concentration, driven by the concentration gradient of solutes. Active transport, on the other hand, requires energy, as indicated by the ATP (adenosine triphosphate) symbol, and moves solutes against their concentration gradient.
Exercise 3.1 – Diffusion of Molecules

- Experiment A. Kinetic Energy of Molecules
  - Materials
    • See page 57
  - Introduction
    • In this exercise you will investigate characteristics of molecules that facilitate diffusion, factors that influence diffusion rates, and diffusion of solutes through a selectively permeable membrane
  - Procedure
    • See page 57
  - Results
    • Answer the questions on pages 57-58
  - Discussion
    • Answer the three questions on page 58
Exercise 3.1 – Diffusion of Molecules

- **Experiment B. Diffusion of Molecules through a Selectively Permeable Membrane**
  - **Materials**
    - See page 58
  - **Introduction**
    - Working in teams of four, we will investigate the selective permeability of dialysis tubing
  - **Question**
    - Review the experimental design and formulate a question about the permeability of dialysis tubing
  - **Hypothesis**
    - Hypothesize about the selective permeability of dialysis tubing to the substances being tested
  - **Prediction**
    - Predict the results of the I2KI and Benedict’s test based on your hypothesis (if/then)
  - **Procedure**
    - Follow the procedures on pages 60-61
  - **Results**
    - Complete Table 3.1 on page 60
  - **Discussion**
    - Answer questions 1-4 on page 61
Dialysis tubing in beaker
Exercise 3.2 – Osmotic Activity in Cells

- In this exercise we will investigate the osmotic behavior of plant and animal cells placed in different molar solutions
- Experiment A. Osmotic Behavior of Animal Cells
  - Materials
    • See page 62
  - Introduction
    • In this experiment we will investigate the behavior of red blood cells when the osmolarity of the environment changes from isotonic to hypertonic or hypotonic
  - Hypothesis
    • Hypothesize about the behavior of red blood cells when they are placed in hypertonic or hypotonic environments
  - Prediction
    • Predict the results of the experiment based upon your hypothesis (if/then)
  - Procedure
    • Follow the procedures on page 63
  - Results
    • Record your observations in Tables 3.2 and 3.3 on pages 63-64
  - Discussion
    • Answer questions 1-3 on page 64
Exercise 3.2 – Osmotic Activity in Cells

• Experiment B. Osmotic Behavior of in Cells with a Cell Wall
  – Materials
    • See page 65
  – Introduction
    • Cells of freshwater plants and algae are typically bathed in water containing only dilute concentrations of solvents
  – Question
    • Propose a question about the movement of water in *Elodea* leaves placed in different molar solutions
  – Hypothesis
    • Hypothesize about the movement of water in cells with a cell wall when they are placed in hypertonic or hypotonic environments
  – Prediction
    • Predict the appearance of Elodea cells in the two solutions
  – Procedure
    • Follow the procedures on page 66
  – Results
    • Complete Table 3.4 on page 66
  – Discussion
    • Answer the 4 questions on page 67
Plasmolysis in *Elodea* plant cells
Exercise 3.3 – Investigating Osmolarity of Plant Cells

- In the following experiments, we will estimate the osmolarity (solute concentration) of potato tuber cells using two methods (change in weight and volume)

- **Experiment A. Estimating Osmolarity by Change in Weight**
  - **Materials**
    - See page 68
  - **Introduction**
    - In this experiment, we will determine the weight of several potato tuber cylinders and incubate them in a series of sucrose solutions to determine weight gain or loss
  - **Question**
    - What question is being investigated in this experiment?
  - **Hypothesis**
    - Hypothesize about the osmolarity of potato tuber tissue in relation to the sucrose solutions
  - **Prediction**
    - Predict the results of the experiment based on your hypothesis (if/then)
  - **Procedure**
    - Follow the procedures on pages 68-70 in your lab manual
  - **Results**
    - Complete Table 3.5 and Figure 3.5
  - **Discussion**
    - Answer questions 1-4 on page 71
Exercise 3.3 – Investigating Osmolarity of Plant Cells

• Experiment B. Estimating Osmolarity by Change in Volume
  – Materials
    • See page 72
  – Introduction
    • In this experiment, we will determine the volume of several potato tuber cylinders by measuring the length and diameter of each. We will then incubate them in a series of sucrose solutions to determine changes in dimensions so we can determine the osmolarity of the potato tuber tissue
  – Question
    • What question is being investigated in this experiment?
  – Hypothesis
    • Hypothesize about the osmolarity of potato tuber tissue
  – Prediction
    • Predict the results of the experiment based on your hypothesis (if/then)
  – Procedure
    • Follow the procedures on pages 72-74 in your lab manual
  – Results
    • Complete Table 3.6 and Figure 3.7
  – Discussion
    • Answer questions 1-4 on page 76
Lab Topic 3: Diffusion and Osmosis

- **Reviewing Your Knowledge**
  - Answer questions 1 and 2 on page 76 in your lab manual

- **Applying Your Knowledge**
  - Answer questions 1-4 on pages 76-77 in your lab manual