Applications of Diffusion and Osmosis
Instructor's Guide

Time to Complete

This activity will take approximately 75 minutes but can be shortened depending on how much time the instructor takes to review questions while moving through the activity.

Prior Knowledge

- Process of Diffusion.
- Process of Osmosis.

Content Objectives/Learning Goals

Students will be able to:

- Apply the concept of diffusion to explain the benefit of forming glycogen to store glucose in hepatocytes.
- Apply the concept of osmosis to explain possible complications associated with intake of saltwater and the condition of hyperglycemia.

Process Objectives

- **Information Processing**: Students will interpret graphical information related to osmolarity of body fluids.
- **Information Processing**: Students will apply their understanding of osmolarity to ….

Roles

Manager – keeps the team on task
Reader – reads the questions to the group.
Recorder – records "official" team answers
Reporter – reports team answers when requested by the instructor

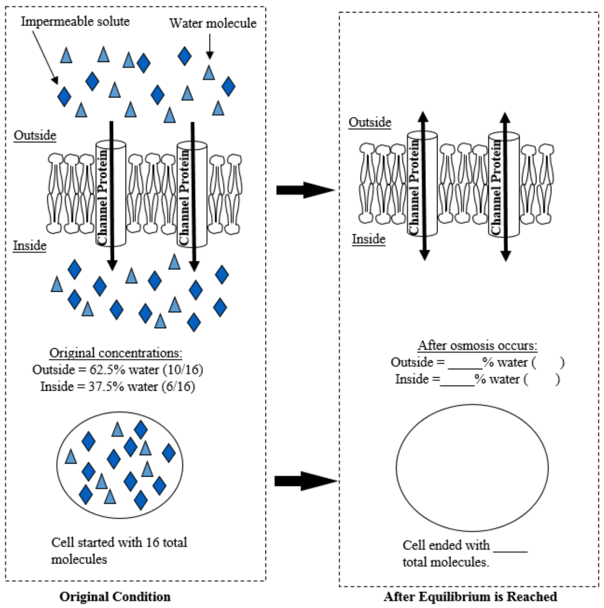
Implementation Notes for Instructors:

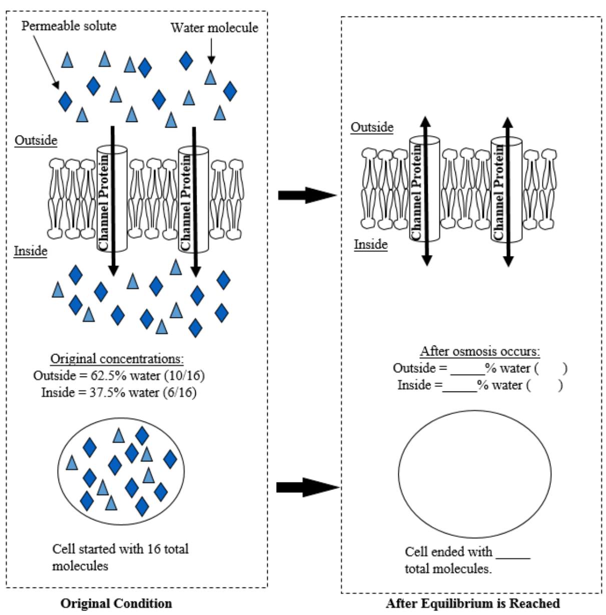
Instructors are encouraged to read through the entire activity and make adjustments based on their particular needs before making copies for their students.

Application of Diffusion and Osmosis

Model 1: Movement of Molecules across a Membrane

Models 1A and 1B show two different conditions. In Model 1A, the membrane is only permeable to water. In model 1B, the membrane is permeable to both water and solute.





Model 1A: Movement of water, but not solute. **Model 1B: Movement of water and solute.**

REVIEW QUESTIONS:

1. What is the difference between models 1A and 1B?

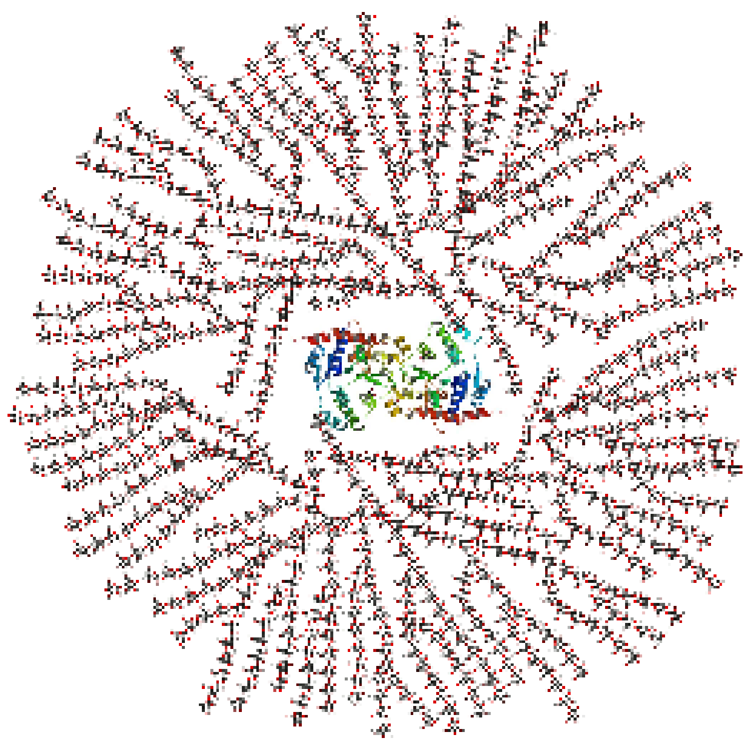
2. On model 1A, indicate the numbers and concentrations of water and solutes in both the extracellular and intracellular fluid after equilibrium is reached. Also indicate the total number of molecules within the cell after equilibrium. Assume no hydrostatic pressure influence from the interior of the cell.

3. On model 1B, indicate the numbers and concentrations of water and solutes in both the extracellular and intracellular fluid after equilibrium is reached. Also indicate the total number of molecules within the cell after equilibrium. Assume no hydrostatic pressure influence from the interior of the cell.

4. What process is illustrated in model 1A? What process is illustrated in model 1B?

<u>Model 2:</u>

The hepatocytes of the liver can be modeled as a single container with volume of 1,200 mL. Under normal conditions, the liver stores approximately 100 g of glycogen, a storage form of glucose in which glucose molecules are complexed together (Model 2A). Glucose enters these cells passively (facilitated diffusion). Blood (plasma) glucose levels are close to 100 mg/dl, which corresponds to an osmolarity of 6 mOsm/L, as indicated in the Model 2B.



Model 2A: **Glycogen structure**. Image from Häggström, Mikael. "Medical gallery of Mikael Häggström 2014". Wikiversity Journal of Medicine 1 (2). DOI:10.15347/wjm/2014.008. ISSN 20018762.

Model 2B: Table of Select Osmotically Active Substances in Plasma

Select osmotically active substance in plasma	**Plasma Concentration**	**Plasma Osmolarity**
Sodium (Na^+)	142 mEq/L	142 mOsm/L
Potassium (K^+)	4.2 mEq/L	4.0 mOsm/L
Chloride (Cl^-)	108 mEq/L	108 mOsm/L
Bicarbonate (HCO_3^-)	24 mEq/L	28 mOsm/L
Glucose	100 mg/dl	6 mOsm/L
Others	Varies	Varies
Total		300 mOsm/L

QUESTIONS:

5. What is the total plasma osmolarity? What percentage of the total is due to sodium and chloride? What percentage of the total osmolarity is due to glucose?

6. Predict the intracellular osmolarity (total) of hepatocytes by *considering how it should compare to extracellular osmolarity*. Justify your answer.

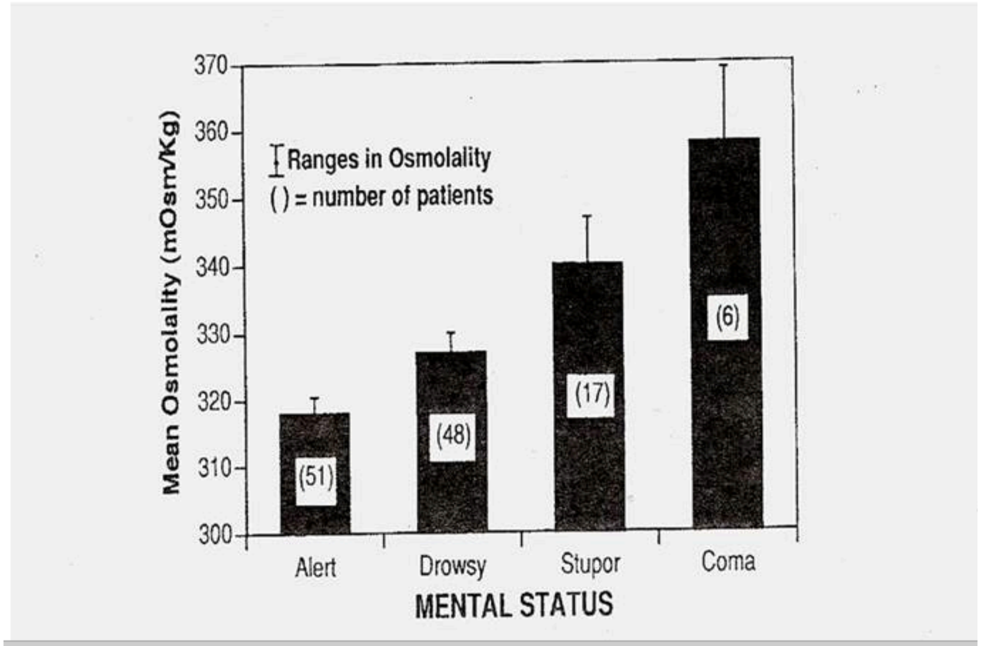
7. What is the concentration of glucose in a liter of plasma (reminder: there is 10 dL in a L and 1000 mg in a gram)? Assuming 100 g of glycogen is equivalent to 100 g of glucose, what would be the concentration of "glucose" in the liver hepatocytes when modeling the liver as a single compartment? Answer on a per liter basis.

8. If the hepatocytes could not convert glucose to glycogen, how much glucose could enter (be stored) in the liver if the extracellular plasma concentration is 1.2 g/L? What would limit the amount of glucose that could enter?

9. If the hepatocytes could actively pump glucose into the intracellular space, such that they could amass 100 g worth of glucose but could not convert it to glycogen, what would happen to the intracellular osmolarity of the hepatocytes? What would happen as a result of this? Consider how the increased glucose would impact the osmolarity.

Extension Questions

Model 3: Relationship between Plasma Osmolarity and Mental Status:
The relationship between plasma osmolarity and mental status is shown in model 4.



10. Using the information in models 2 and 3, determine the approximate plasma glucose concentration that would be necessary to put a typical person into a state of stupor.

11. A person eats a large meal high in carbohydrates such that they consume 100 grams of glucose. Assuming no cellular uptake after absorption, how much would their plasma glucose concentration increase, assuming the glucose is just distributed in plasma? Re-calculate assuming the glucose distributes in plasma and interstitial fluid.