**OSMOSIS**

**Pre-module Homework Assignment B**

**Application of Osmosis in Real Life: Opening and closing of stomata of leaves**

Plants, and other autotrophs, perform **photosynthesis**, providing organic molecules and oxygen for use by most other organisms. This process requires sunlight as a source of energy, water as a source of electrons, and carbon dioxide as a source of carbon. Plants absorb carbon dioxide from the air, through pores on their leaves called stomata. Through the same stomata, they release oxygen to the air. Each stoma is formed by two guard cells. **The opening and closing of stomata are regulated by osmosis in guard cells as illustrated below**. Various signals, such as lowering of carbon dioxide levels, trigger uptake of water by guard cells and opening of stomata. Other signals, such as drought, trigger loss of water by guard cells and closing of stomata.



<https://upload.wikimedia.org/wikipedia/commons/2/20/Guard_cells_signals.png>

June Kwak, Pascal Mäser, Public domain, via Wikimedia Commons

**Background Information and Practice Problems**

**Solutions**

Most organisms are made mostly of water. Molecules like salt, amino acids, carbohydrates, enzymes, or any other polar or charged substances, are dissolved in water and make a solution. A **solution** is a homogeneous mixture of a solvent and a solute. Water, in this case, is the **solvent**, as it is the main ingredient in this mixture. Different solvents are possible, but in biological systems, water is typically the main medium, and therefore acts as the solvent. Salt, amino acids, or carbohydrates, are examples of **solutes**.

The **concentration** of a solution is the **ratio** of the amount of solute over the amount of solvent or solution. There are many ways to describe concentration. Commonly it is described in terms of **percentage** (volume of solute over volume of solution or mass of solute over volume of solution) or **molarity** (moles of solute over volume of solution).

**Solubility**

Solutes, which are polar or charged, are soluble in water because they interact with water molecules by forming **hydrogen bonds**. Molecules that do not form hydrogen bonds do not dissolve, for example, oil, or other nonpolar or hydrophobic substances.

**Semipermeable membrane**

Cells are surrounded by a **phospholipid bilayer**. The lipid core of the membrane prevents most substances from simply diffusing through it. Polar and charged solutes, like salt, sugar and many amino acids, cannot freely cross the membrane and require help from a protein embedded in the membrane. The diagram below shows a schematic of the cell membrane.



[https://commons.wikimedia.org/wiki/File:Cell\_membrane\_detailed\_diagram\_en.svg](https://commons.wikimedia.org/wiki/File%3ACell_membrane_detailed_diagram_en.svg)

LadyofHats [Public domain]

**Osmosis**

Diffusion of water across a semipermeable membrane is called **osmosis**. Diffusion is the movement of molecules from a high concentration to a lower concentration (**passive transport**), in order to reach equilibrium. Due to the polarity of water, the bulk of water molecules do not simply diffuse through the lipid bilayer. Instead, they diffuse through water channels called aquaporins (**facilitated diffusion**). Water will move by osmosis from the side with a higher concentration of water to a side with a lower concentration of water. Another way to think about it is that water will move to the side of higher solute concentration, in order to dilute that concentration and achieve equilibrium. **Tonicity** is the ability of a solution to cause osmosis. A solution that is **hypertonic** has a higher concentration of solute than the cell. A solution that is **hypotonic** has a lower concentration of solute than the cell. An **isotonic** solution has an equal concentration of solute as the cell.

1. Use the diagram of a cell submerged in a solution, shown below. The cell membrane is permeable to water but not to sugar.



Modified from: <https://upload.wikimedia.org/wikipedia/commons/5/50/202208_beaker-2.svg>

DataBase Center for Life Science (DBCLS), CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons

1. Complete the percent concentrations of solute and solvent in the diagram. What is the tonicity of the *solution* in the beaker compared to the cell in this example? Explain.
2. What *process* is going to take place and why?
3. Predict the type of change that will occur in the cell. Explain your answer.
4. Flasks X, Y, and Z contain solutions with different concentrations of glucose. Flask X has 0.3 M glucose, flask Y has 0.8 M glucose, and flask Z has 0.1 M glucose. Red blood cells (0.3 M glucose) are placed in each flask.
5. Predict what will happen to the red blood cells in flask X.
6. Predict what will happen to the red blood cells in flask Y.
7. Predict what will happen to the red blood cells in flask Z.
8. What keeps plant cells from bursting when placed in a hypotonic solution?
9. What happens to plant cells placed in a hypertonic solution?

**Visualizing changes in solute concentrations: Graphing the data**

Variables that change continuously can be visually represented in line graphs. An electrocardiogram of blood pressure as the heart beats and blood insulin levels during a glucose tolerance test are two common examples. Solute concentrations across membranes also change continuously over time due to osmosis and other factors, so line graphs are useful ways to visualize the changes.

Remember that line graphs need to have some basic components to them:

* **Data.** Usually data are collected at discrete points, and the individual points are plotted and then connected by a line.
* **Legend.** If more than one line is represented on a graph, a legend is needed to define the different lines.
* **X-Axis.** Horizontal axis usually (with some exceptions) represents the **independent variable**, the factor being tested according to the hypothesis.
* **Y-Axis.** Vertical axis represents the **dependent variable**, which is measured, as is expected to change due to the independent variable.

One classic lab exercise performed in general biology classes is to take regular chicken eggs and dissolve their shells by placing the eggs in an acidic solution overnight (usually in vinegar; you could do this at home!). The egg makes for a nice model of a cell that’s visible to the naked eye. This cell model can be used to observe osmosis and the effects of different solute concentrations on osmosis firsthand. Usually three eggs are used, and one each placed in hypotonic, isotonic, and hypertonic salt (NaCl) solutions.

1. Below is data collected from this experiment. Use the data and create an excel line graph of percent change in mass (y) versus time (x).

|  |  |
| --- | --- |
|  | **% Mass Change** |
| **Time (min)** | **0 M salt** | **0.8 M salt** | **2 M salt** |
| 0 | 0 | 0 | 0 |
| 15 | 0.2 | 0.01 | -0.65 |
| 30 | 0.45 | 0.02 | -1.4 |
| 45 | 0.75 | -0.01 | -1.95 |
| 60 | 1.1 | 0.01 | -2.55 |

<http://www.khaydock.com/articles/SSR%20June%202014%20027-036%20Haydock.pdf>

Insert your graph below and answer the following questions.

1. What are the dependent and independent variables for this experiment?
2. Which line represents the hypotonic, isotonic, and hypertonic environments? Explain how this is evident from the graph.
3. How long did it take the egg placed in the 0 M solution to increase its mass by about 1% due to osmosis? How long did it take for the egg to decrease its mass by 1% in the 2 M solution?