**OSMOSIS**

**Pre-Module Homework Assignment A**

**Background Information and Practice Problems**

**Solutions**

You are made of approximately 68% water. Molecules like salt, amino acids, carbohydrates, enzymes, or any other polar or charged substances, are dissolved in water and make a solution. Water serves as the main ingredient in many solutions, especially biological solutions. A **solution** is a combination of a **solvent**, the main medium, and substances dissolved in the solvent, which are called **solutes**. In our bodies, the water inside and around our cells is the solvent in which various solutes are dissolved. Note even the name of intracellular water, **cytosol**, translates to “cell solvent”.

* + - 1. Which expression below best describes the relationship between solvents, solutes, and solutions?

1. Solvent = Solute + Solution
2. Solute = Solvent + Solution
3. Solution = Solute + Solvent

Solutions can be described based on how much of the solution is solute and how much of the solution is solvent. For example, in humans the plasma of blood is a solution composed of about 92% water as the solvent and 8% solutes like gasses and nutrients (note that the percentages must add up to 100%).

**Solutes vs. non-solutes**

Solutes, like sugars and amino acids, interact with water molecules by forming hydrogen bonds. Formation of hydrogen bonds between water and solutes is what occurs when a substance dissolves in water. Molecules that do not form hydrogen bonds do not dissolve, such as lipids and other non-polar chemicals.

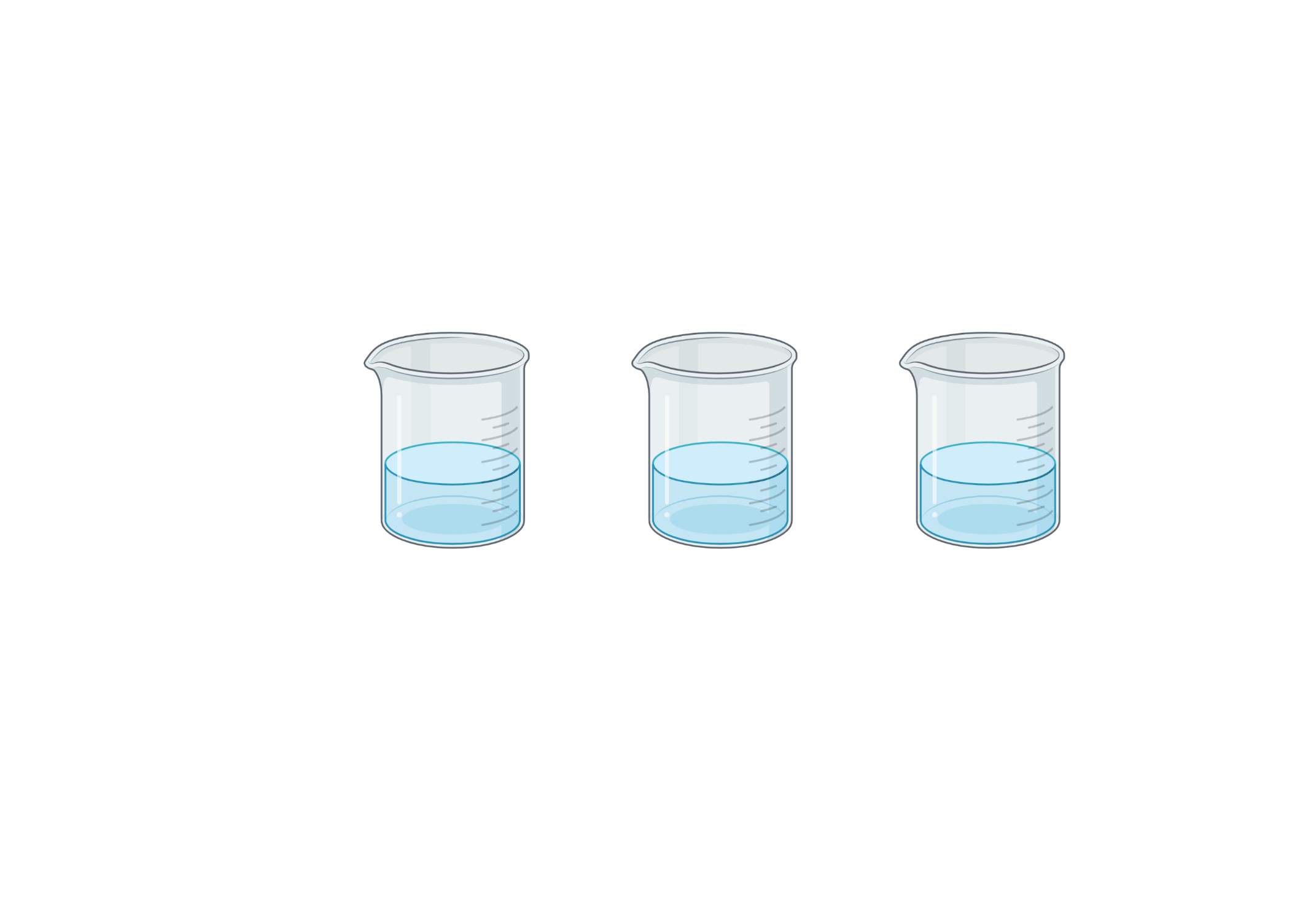
**Semipermeable membranes**

Cells are surrounded by a non-polar phospholipid bilayer. This lipid bilayer prevents most substances from entering or leaving the cell. Water is one of the few substances that can freely cross the membrane, although this movement is slow. The bulk of water molecules diffuse more quickly through water channels called aquaporins that are embedded in the membrane (**facilitated diffusion**). Most polar solutes, like salt, sugar and amino acids, cannot freely cross the membrane and require help from proteins embedded in the membrane.

**Osmosis**

Water moving by **diffusion** across a membrane is called **osmosis**. Remember, diffusion is the movement of molecules from a high concentration to a lower concentration, in order to reach **equilibrium**. Water will move by osmosis from the side with a higher concentration of water to a side with a lower concentration of water. In other words, water will move by osmosis from the side with a lower concentration of solute to the side with a higher concentration of solute. Water is attracted to solutes.

* + - 1. Use the following diagram to answer the questions below. Start by filling in the blanks for the missing % concentrations for beakers B and C.

 **Created with BioRender.com**

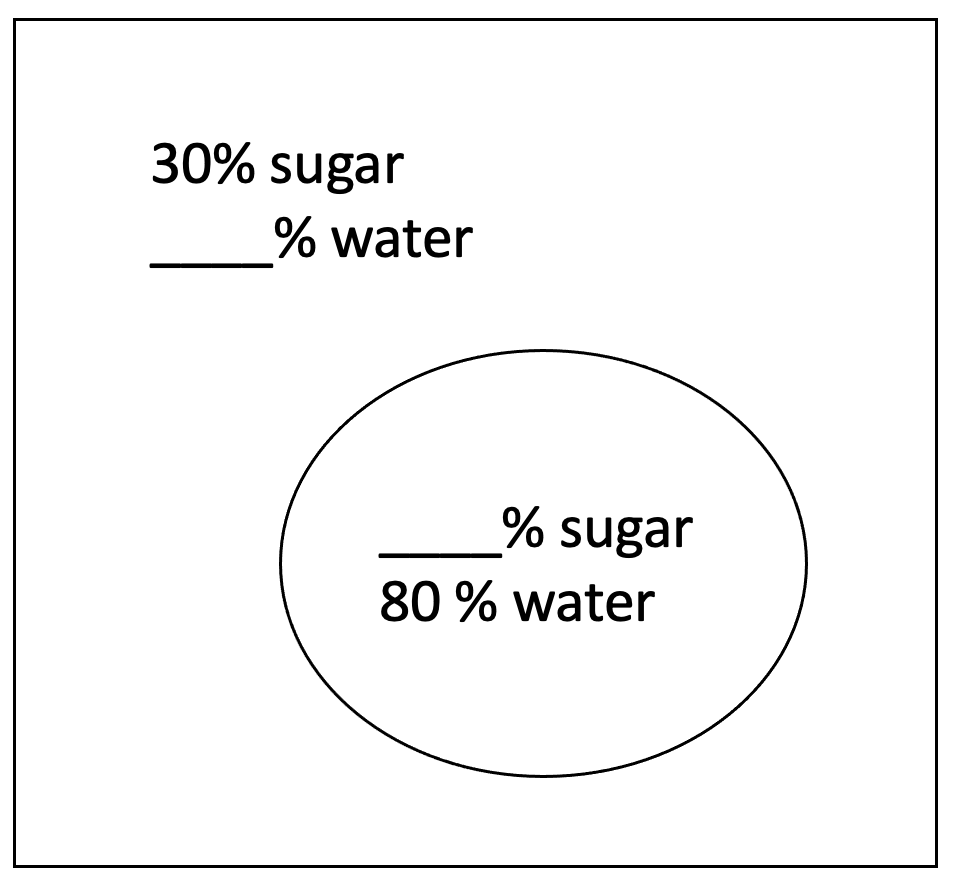
**Beaker A Beaker B Beaker C**

0 % Sugar % Sugar 40 % Sugar

100 % Water 90 % Water % Water

1. What is the *solute* concentration of:
   * Beaker A?
   * Beaker B?
2. What is the *solvent* concentration of Beaker C?

When we think about solutions in human biology, we mostly think about the intracellular cytosol compared to extracellular solutions like plasma and interstitial fluid. (Remember, we are about 68% water.) To describe the relative amounts of solutes on either side of a membrane, we use the terms **hypertonic**, **hypotonic** and **isotonic**. If the solutions have equal concentrations of solute, we say that they are isotonic. If the concentration of solute is not equal, hypotonic describes the side with a lower concentration of solute and hypertonic describes the solution with a higher concentration of solute. Use the questions below to practice using these terms.

* + - 1. The diagram to the right depicts a cell (the circle) submerged in a solution. The cell membrane is permeable to water but not to sugar. Start by completing the % concentrations of the intracellular and extracellular fluids.
  1. What is the *cytosol* in this example? (circle the correct term below)

*hypotonic* hypertonic isotonic

* 1. How do you know?
  2. Because the solutions are not isotonic, osmosis is going to occur. In what direction is water going to move?
  3. Predict: What is going to happen to the size(mass) of the cell?
  4. Predict: What is going to happen to the *extracellular* solute concentration?

**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, or 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 (flat) axis representing the independent variable, the factor being tested according to the hypothesis.
* **Y-Axis.** Vertical (up and down) axis representing the **dependent variable**, which is measured, as is expected to change due to the independent variable.

One classic experiment performed in general biology classes is to take regular chicken eggs and dissolve their shells by placing the eggs in an acidic solution (usually vinegar; you could do this at home!) overnight. The remaining soft membrane and white and yolk inside the egg make 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 3 eggs are used, and each placed in salt solutions that are hypotonic, isotonic, and hypertonic.

Below are data collected from this experiment. Use the data and the graph to answer the following questions.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **% Mass Change** | | |
| **Time (min)** | **0% salt** | **0.8% salt** | **2% 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>

A picture containing text, line, plot, screenshot

Description automatically generated

* + - 1. Notice that the graph does not have a key to match the solutions to the shapes. Based on your examining of the data table and graph, what solution (% salt) is represented by the yellow, triangle points, the orange, square points, and the blue, circular points?
      2. How long did it take the egg placed in the 0 % salt solution to increase its mass by about 1% due to osmosis?
      3. How long did it take the egg placed in the 2 % salt solution to decrease its mass by about 1% due to osmosis?
      4. Which line represents the hypotonic, isotonic, and hypertonic environments? Explain how this is evident from the graph.