Osmosis is most easily defined as the diffusion of water, and diffusion defined is the movement of substances from a high to low concentration. While this sounds simple, osmosis has a profound impact on the processes of the human body. Within the human body, cells live within a fluid environment that can contain a combination of dissolved particles, such as salt and potassium. Cells have a semi-permeable membrane that separates the intracellular fluid (inside the cell) from the extracellular fluid (outside the cell). Diffusion and osmosis between intracellular and extracellular fluids depend on the number and types of dissolved particles inside and outside of the cell.

A cell’s tonicity is dependent on this. If the dissolved particles in the intracellular and extracellular fluids are similar, the same amount of water will diffuse in and out of the cell through the semi-permeable membrane. This would make the extracellular fluid an isotonic solution, and would be found in a healthy individual.

If the dissolved particles in the intracellular fluid are much fewer than that of the extracellular fluid, there would technically be MORE water inside the cell. In this situation, water would move out of the cell through the semi-permeable membrane and cause the cell to shrink, also known as crenation. This would make the extracellular fluid a hypertonic solution.

If the amount of dissolved particles in the intracellular fluid is much higher than that of the extracellular fluid, there would technically be LESS water inside the cell. In this situation, water would move in the cell through the semi-permeable membrane, and may cause the cell to expand so greatly that the cell will burst. This bursting is called lysis, and the bursting of a red blood cell is called hemolysis. This would make the extracellular fluid a hypotonic solution.

Osmosis within the body is crucial to important homeostatic mechanisms. Water is a major component of the human body. Blood pressure and blood volume rely on a balance between water and dissolved particles within the blood vessels. The balance of fluids within the body relies on the input of water through drinking, and output of water through urine and sweating.

A simple example of the importance of osmosis can be observed between the intracellular and
extracellular salt content of red blood cells. Red blood cells maintain their intracellular salt concentration at approximately 0.9%. In a healthy individual, the extracellular fluids would also be maintained at approximately 0.9% salt concentration. If red blood cells are exposed to an extracellular fluid that is less than 0.9% salt, (a hypotonic solution) the red blood cells will undergo hemolysis. If red blood cells are exposed to an extracellular fluid that is greater than 0.9% salt, a hypertonic solution, the red blood cells will undergo crenation.

Some diseases and/or disorders can cause the fluid balance within the body to become unbalanced. Diarrhea may result in a larger than normal amount of water lost from the body. Prolonged diarrhea can cause an imbalance in the amount of water versus sodium, which means that if the lost water is not replaced water will start to cross the cell’s semi-permeable membrane to the extracellular fluid. These dehydrated cells have impaired function, especially within the central nervous system, which can lead to neurological impairment. All of this could result from a case of diarrhea!

Another example of fluid imbalance can be seen when a victim “breathes” in salt water vs. fresh water in a near drowning. Ocean water is a hypertonic solution, and when it enters the alveoli of the lungs it draws more fluid out of the pulmonary arteries into the lungs, causing pulmonary edema. This means that an individual who nearly drowns in the ocean risks the possibility of his or her own lungs drowning themselves, even after that person has been removed from the water.


**Procedure**

**Scenario**

A 58-year-old male patient has been admitted to HASPI Hospital with severe dehydration due to constant vomiting and diarrhea for the past 3 days. The first thing the hospital staff needs to do for this patient is administer fluids intravenously, but the patient is demanding he only be given “pure” water, and is refusing any other IV fluids.

You are responsible for patient education at HASPI Hospital. In order to get the patient to agree to be administered the 0.9% saline IV fluids he needs to rectify his dehydration, you must first educate him on what will happen if he exposes his cells to “pure” water.

You have tried to explain cell tonicity, but the patient has demanded that you “show him, not tell him.” The only items you have found in the break room kitchen that can help you demonstrate this concept is a knife/scalpel, cups/beakers, raw potatoes, water, and salt. You also have weighing boats, a balance scale, and a ruler you can use.
**Directions**

Your job is to create an experiment using only the listed items to MEASURABLY demonstrate what will happen when the potato cells are exposed to an isotonic, hypotonic, and hypertonic solution in order to "show" the patient what will happen to his cells if he is given "pure" water by IV.

**Items You Can Use**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knife/scalpel</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Balance scale</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td></td>
</tr>
<tr>
<td>Ruler</td>
<td></td>
</tr>
<tr>
<td>Cups/beakers (up to 5)</td>
<td></td>
</tr>
<tr>
<td>Weighing boat</td>
<td></td>
</tr>
</tbody>
</table>

**Experiment REQUIREMENTS**

1. You must record the EXPERIMENT STEPS.
2. You must record EXACT AMOUNTS.
3. You must record your results in a DATA TABLE.
4. You must MEASURABLY demonstrate at least one ISOTONIC, HYPOTONIC, and HYPERTONIC solution.
5. You must be able to explain how your results PROVE that giving pure water by IV would be harmful to the patient.

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**Record the following on a separate sheet of paper.**

A. **Experiment Steps:**

List the steps of your experiment. Include exact amounts and measurements.

B. **Data Table:**

Create a data table that will summarize your results.

C. **Measurable Results:**

Explain how your experiment demonstrates each of the following solutions:
- Isotonic Solution
- Hypotonic Solution
- Hypertonic Solution

D. **Patient Explanation:**

Explain how your results prove that pure water by IV could be harmful, and even possibly deadly.
**Review Questions** - on a separate sheet of paper complete the following

1. Define diffusion & osmosis, and give an example of each.
2. What is diffusion/osmosis between intracellular and extracellular fluids dependent upon?
3. How much water composes the average human body? What organ contains the most water?
4. Give two examples of why water is important to the human body?
5. Explain how prolonged diarrhea can result in a water imbalance within the body.
6. Why is it worse for an individual to “breathe” in salt water rather than fresh water?

**Analysis Questions** - on a separate sheet of paper complete the following

1. Two solutions are separated by a semi-permeable membrane. Solution A has a 10% concentration of sugar and solution B has a 40% concentration of sugar. What direction would you expect the water to move, from A to B or from B to A? What is this process called?
2. In the study of human physiology, why is it important to understand osmosis?
3. When the body needs to conserve water, the kidneys excrete a hypertonic urine. What do the terms *isotonic*, *hypotonic*, and *hypertonic* mean? Draw beakers with red blood cells in them to demonstrate isotonic, hypotonic, and hypertonic.
4. The receptors for thirst are located in a part of the brain called the hypothalamus. These receptors, called osmoreceptors, are stimulated by an increase in blood osmolality. Imagine a man who has just landed on a desert island. Trace the course of events leading to his sensation of thirst. Can he satisfy his thirst by drinking seawater? Explain your answer.
5. Before the invention of refrigerators, pioneers preserved meat by salting it. Explain how meat can be preserved by this procedure. (HINT: Think about what salting the meat would do to decomposer organisms, like bacteria and fungi)
6. Research and describe two diseases/disorders related to electrolyte imbalance including information about hypertonic and hypotonic conditions of nitrogen, calcium, sodium, and potassium.
7. **CONCLUSION**: What is cell tonicity?