Lab 3. Osmosis: How Does the Concentration of Salt in Water Affect the Rate of Osmosis?

Introduction

In both plants and animals, each cell is surrounded by a membrane. This membrane forms a selective barrier between the cell and its environment (see Figure L3.1—the membrane is the wall in the middle of the figure). Large molecules, such as sugars ($C_6H_{12}O_6$) or fats, and charged molecules, such as sodium ions (Na^+) or chlorine ions (Cl^-), cannot pass through the membrane, but small molecules such as oxygen (O_2) can. Without this barrier, the substances necessary to the life of the cell would diffuse uniformly into the cell's surroundings, and toxic materials from the surroundings would enter the cell. The cell membrane is referred to as *semipermeable* because some particles can naturally cross it while others cannot. This ability to regulate the flow of molecules into and out of the cell keeps the cell's internal environment stable, even though parts of that environment are always shifting.

Chemical particles are constantly in motion. How much they move is related to the amount of energy they contain and how concentrated they are. *Diffusion* is the movement of chemical particles (i.e., atoms, molecules, ions) from an area of high concentration to an area of low concentration. Without any barriers to such movement (like a membrane), chemical particles naturally diffuse in this direction. If a membrane is present, then only particles that can cross it naturally will be able to continue to diffuse normally. To make particles move in the opposite direction (low concentration to high concentration), energy must be added to the particles. *Osmosis* refers specifically to the diffusion of water molecules. In cells, water cannot simply diffuse across the membrane. However, special openings in the membrane allow for easy flow of water molecules so cells can take in or get rid of water when needed.

An *isotonic* solution is a solution that has the same concentration of particles and water as the cell. If blood cells (or other cells) are placed in contact with an isotonic solution, they will neither shrink nor swell. If the solution is *hypertonic*—having a higher concentration of solute (and lower concentration of water) than inside the cell membrane—the cells will lose water and shrink. If the solution is *hypotonic*—having a lower concentration of solute and higher concentration of water molecules—the cells will gain water and swell. Saltwater from the ocean is hypertonic to the cells of the human body since it has more salt in it. Cells, as a result, lose water and shrink (see Figure L3.2). That is why we can't drink water from the ocean—it dehydrates body tissues instead of quenching thirst.

FIGURE L3.1

A semipermeable membrane

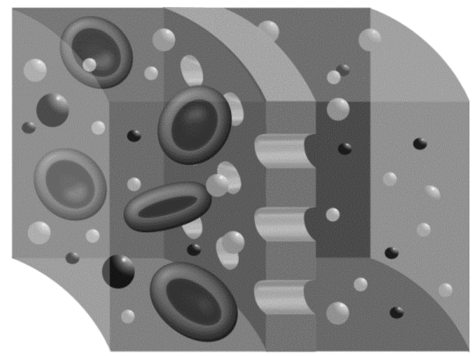
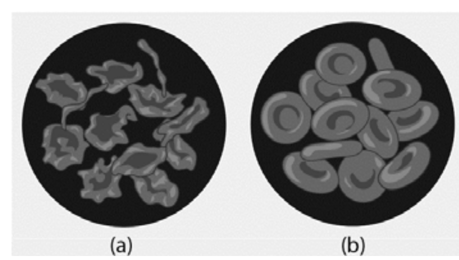


FIGURE L3.2

(a) Red blood cells in saltwater solution and (b) normal red blood cells



Your Task

Design an experiment to determine how the concentration of salt in water affects the rate of osmosis.

The guiding question of this investigation is, **How does the concentration of salt in water affect the rate of osmosis?**

Materials

You may use any of the following materials during your investigation:

Consumables	Equipment
• Salt solutions • Water	• Electronic or triple beam balance • Graduated cylinder and beakers • Dialysis tubing (assume that it behaves just like the membrane of a cell) • Sanitized indirectly vented chemical-splash goggles • Chemical-resistant apron • Gloves

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Put on sanitized indirectly vented chemical-splash goggles and laboratory apron and gloves before starting the lab activity.
2. Immediately wipe up any spilled water to avoid a slip and fall hazard.
3. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

You will use models of cells rather than real cells during your experiment. You will use models for two reasons: (1) a model of a cell is much larger than a real cell, which makes the process of data collection much easier; and (2) you can create your cell models in any way you see fit, which makes it easier to control for a wide range of variables during your experiment.

You can construct a model cell by using the dialysis tubing. Dialysis tubing behaves much like a cell membrane. To create a model of a cell, place the dialysis tubing in water until it is thoroughly soaked. Remove the soaked tubing from the water and tightly twist one end several times and either tie with string or tie a knot in the tubing. You can then fill the model cell with a salt solution or distilled water. Once filled, twist the open end several times and tie it tightly as shown in Figure L3.3. You can then dry the bag and place it into any type of solution you need.

FIGURE L3.3
Tying the dialysis tubing

To answer the guiding question, you will need to design and conduct an experiment. To accomplish this task, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it before you can design your experiment. To determine *what type of data you need to collect*, think about the following questions:

- How will you determine the rate of osmosis?
- What type of measurements or observations will you need to record during your investigation?

To determine *how you will collect your data*, think about the following questions:

- What will serve as a control (or comparison) condition?
- What types of treatment conditions will you need to set up and how will you do it?
- How often will you collect data and when will you do it?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect and how will you organize it?

To determine *how you will analyze your data*, think about the following questions:

- How will you determine if there is a difference between the treatment conditions and the control condition?
- How will you calculate change over time?
- What type of graph could you create to help make sense of your data?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

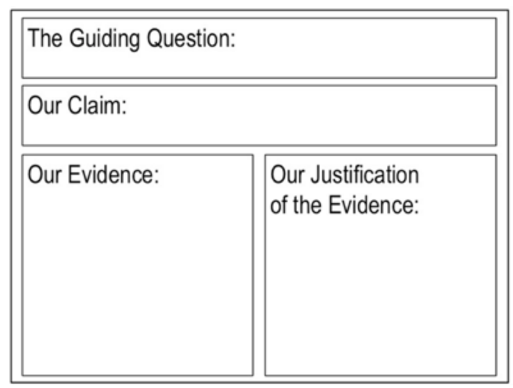
As you work through your investigation, be sure to think about

- why developing and using models is important in science,
- the importance of tracking how matter flows into and out of a system,
- the difference between observations and inferences in science, and
- the nature and role of experiments in science.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L3.4.

FIGURE L3.4
Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

- What did your group do to collect the data? Why do you think that way is the best way to do it?
- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- What did your group do to make sure that these calculations are correct?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those other ideas?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!