Lab 1. Osmosis and Diffusion: Why Do Red Blood Cells Appear Bigger After Being Exposed to Distilled Water?

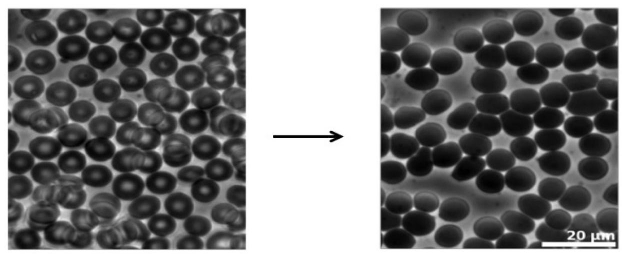
Introduction

All living things are made of cells. Some organisms, such as bacteria, are *unicellular,* which means they consist of a single cell. Other organisms, such as humans, fish, and plants, are *multicellular*, which means they consist of many cells. All cells have some parts in common. One part found in all cells is the *cell membrane.* The cell membrane surrounds the cell, holds the other parts of the cell in place, and protects the cell. Molecules such as oxygen, water, and carbon dioxide can pass in and out of the cell membrane. All cells also contain *cytoplasm.* The cytoplasm is a jelly-like substance inside the cell where most of the cell's activities take place. It's made out of water and other chemicals.

Some cells found in multicellular organisms are highly specialized and carry out very specific functions. An example of a specialized cell found in vertebrates is the erythrocyte, or red blood cell (RBC). RBCs are by far the most abundant cells in the blood. The primary function of RBCs is to transport oxygen from the lungs to the cells of the body. In the capillaries, the oxygen is released so other cells can use it. Ninety-seven percent of the oxygen that is carried by the blood from the lungs is carried by hemoglobin; the other 3% is dissolved in the plasma. Hemoglobin allows the blood to transport 30–100 times more oxygen than could be dissolved in the plasma alone.

As you can see in the figure to the right, RBCs look like little discs when they are viewed under a microscope. They have no nucleus (the nucleus is extruded from the cell as it matures to make room for more hemoglobin). A unique feature of RBCs is that they can change shape; this ability allows them to squeeze through capillaries without breaking. RBCs will also change shape in response to changes in the environment. For example, if you add a few drops of distilled water to blood on a microscope slide, the cells will look bigger after a few seconds (see the figure's right panel).

Red blood cells before and after distilled water is added



Red blood cells ***before*** adding distilled water

Red blood cells ***after*** adding distilled water

Scientists often develop and test explanations for natural phenomena. In this investigation you will have an opportunity to design and carry out an experiment to test two different explanations for why RBCs appear bigger after they are exposed to distilled water. These are the two explanations that you will test:

1. Molecules such as protein and polysaccharides are more concentrated inside the cell than outside the cell when the cell is in distilled water. These molecules therefore begin to move out of the cell because of the process of diffusion but are blocked by the cell membrane. As a result, these molecules push on the cell membrane and make the cell appear bigger.
2. Water molecules move into the cell because the concentration of water is greater outside the cell than it is inside the cell. As a result, water fills the cell and makes it appear bigger.

Your Task

Design and carry out an experiment to determine which of the two explanations about the appearance of RBCs after exposure to distilled water is the most valid or acceptable from a scientific perspective.

The guiding question of this investigation is, **Why do the red blood cells appear bigger after being exposed to distilled water?**

Materials

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

- Starch solution (starch is a polysaccharide)
- Distilled water
- Beakers
- Graduated cylinder
- Balance (electronic or triple beam)
- Dialysis tubing (assume that it behaves just like the membranes of RBCs)
- Safety goggles
- Aprons

Safety Precautions

1. Indirectly vented chemical-splash goggles and aprons are required for this activity.
2. Wash hands with soap and water after completing this lab.
3. Follow all normal lab safety rules.

Getting Started

You will use models of cells rather than real cells during your experiment. You will use cell 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. The cell models will therefore allow you to design a more informative test of the two alternative explanations outlined above.

Tying the dialysis tubing

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 either a starch solution (starch is a common polysaccharide) or distilled water. Once filled, twist the open end several times and tie it tightly as shown in the figure to the right. You can then dry the bag and place it into any type of solution you need.

In designing your experiment, you must determine what type of data you will need to collect, how you will collect it, and how you will analyze it. To determine *what type of data you will need to collect,* think about the following questions:

- What will serve as your dependent variable (e.g., mass of the cell or size of the cell)?
- What type of measurements will you need to make 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 many "cells" will you need to use in each condition?
- 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 the data?

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?
- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

Investigation Proposal Required? ☐ Yes ☐ No

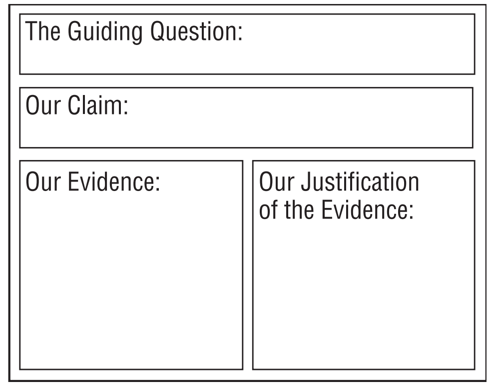
Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

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

- the importance of identifying the underlying cause for observations,
- how models are used to study natural phenomena,
- how matter moves within or through a system,
- the difference between data and evidence in science, and
- the nature and role of experiments in science.

Argumentation Session

Argument presentation on a whiteboard



Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original 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. This 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!