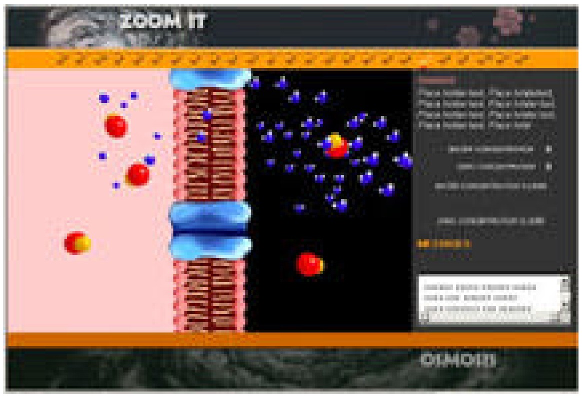


Activity Four

Gradients and Barriers

Activity Overview

Water moves, carrying particles of different sizes in solution. Dissolved particles are always moving about randomly in the water; the flow always goes from a region of high concentration to a region of low concentration.

Using dynamic models, students compare free diffusion with movements of molecules when a solution is separated into two parts by a barrier, a semi-permeable membrane that allows water molecules to pass through it but only some, or none of the other molecules in solution (osmosis). They will explore osmosis and osmotic pressure on the membrane and discuss how the changes in osmostic pressure may affect living cells.

Students will:
1. Consult a computer model to reason about diffusion of dissolved materials moving within a container.
2. Vary concentrations of dissolved materials on either side of the membrane, and describe the role of particle concentration and particle size for the diffusion of the materials.
3. Work with barriers, changing pore sizes and predicting changes in the movement of dissolved materials and its effect on the pressure developed on the cellular membrane.

Learning Objectives

Students will able to:

- Describe the movement of water across a semi-permeable membrane, including the special case of diffusion, which is called osmosis.

- Link the role of osmosis to the maintainance of a cell's shape and to the level of water and many ions.

- Make predictions concerning the concentration of dissolved materials and pressure on the membrane based on the relative size of dissolved particles and the size of the pores in the cell membrane.

Macro to Micro Connection

Changing the concentrations of particles dissolved in water results in changes in the osmotoic pressure on the cellular membrane and turgor* in plant cells.

(* turgor: when the vacuoles within the cell are filled with water to the point that they press against the cell wall. Turgor makes cell walls stiff. It is analogous to the stiffening of a pneumatic tire by air pressure. The wilting of flowers and leaves is caused by a loss of turgor pressure, which results in turn from the loss of water from the plant cells)

Conceptual Prologue

Water molecules and dissolved particle move even in apparently still water, because the individual molecules are in instant motion moving randomly, sliding and colliding by one another. <u>Diffusion of water and particles in solution takes place as molecules move about in this random fashion, and continues until a state of dynamic equilibrium is reached.</u>

<u>Spontaneous movement of water through a semi-permeable membrane is called osmosis.</u> The cell's membrane is an important example of a semi-permeable membrane, controlling the diffusion betweeen the inside and outside of its cellular fluid. The membrane is specially engineered with a variety of openings, or pores, usually designed for specific molecules. Some pores allow particles to diffuse passively, without additional energy, across a membrane; the rates are only limited by how many such pores are available. There are, for example, a large number of pores allowing water to pass back and forth. (Other pores actively push molecules <u>against</u> their gradient, but we will consider that later.)

In this activity, we will change the concentration of salt in the water on one side of a barrier, as we did with the first activity with the erythrocyte. Because particles with charge attract and bind-up water (remember "hydration" is when water builds shells around ions), a gradient is established in which more water from the other side of the membrane diffuses towards the concentrated particles. So, when we add salt to the outside of a cell membrane, water flows out from the cell. (The Haida indians of the Northwest still preserve their salmon catch in this manner.)

Charged particles remove water from a water gradient in two ways: They displace water molecules (so there is now less free water available to reach pores of a membrane and successfully go through them; (more water molecules hit the membrane from the other direction) and they become hydrated with shells of water, thereby binding water molecules, now less likely to cross the membrane).

To restate, we have found it helps to picture the membrane with molecules bouncing against it, and only some getting through. Binding water to ions on one side, which happens after, say, salt is added, reduces the water molecules hitting the membrane. But the same number of water molecules are still hitting the membrane on the other side, so more get through from that side.

Students will discover that <u>changing the size of the pores changes the pressure</u> (osmotic pressure) of molecules hitting against the membrane.

> a. If the pore size is big enough for all molecules to move freely from one side to the other, i.e. a totally permeable membrane, the model will show that there is no osmotic pressure.
>
> b. If the pore size is moderate, such that the membrane is semi-permeable, then there will be osmotic pressure.The osmotic pressure results in a small net displacement of the "membrane" from its original position.
>
> c. If the pore size is so small that molecules of both sides cannot go through the membrane, then the original pressure, whatever it was, will be maintained.

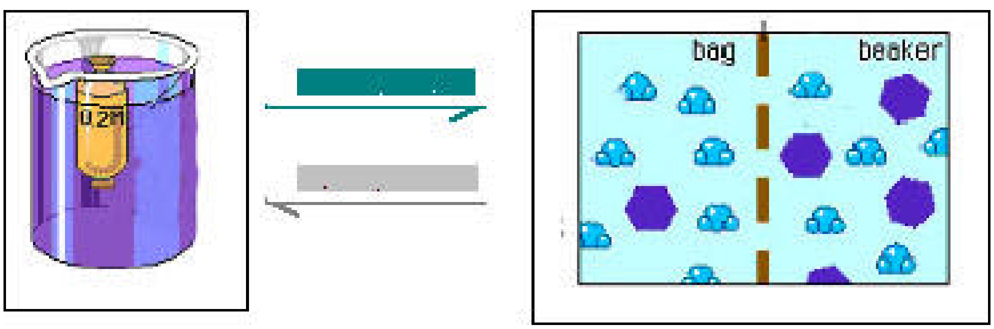
Activity Design and Execution

Major Science Concepts	diffusion, membrane, gradient, osmosis
Assumed Previous Knowledge:	solution
Time:	1-2 50 minute classes
Materials:	
Advanced preparation (if any)	

[OPTIONAL 1. *Students are reminded:* **What does a cell have to regulate?** (They should, by this point, go rather quickly through the this exercise.) What would happen if it were completely sealed off from its neighbors? (In order to live, a cell has to bring amino acids, nutrients and nucleotides in across its membrane, and get rid of wastes. Without regulation, there would be more water outside than water in, and more solutes inside the cell than outside. Water would tend to come into the cell and rupture it.)]

2. *Students consider:* **What is a good model of this membrane-bounded cell?**

2A. **What are the key components** - draw them in position. The model at left shows a beginning: a membrane and 2 different molecules.



on either side of the barrier. (Different concentrations of ions on two sides of a membrane.)
2C. **What qualifies as the model's 'working'?** (If there is a net migration of water toward the concentrated side.)

3.  **Open the Solutions: Osmosis Simulation.** Students can vary the type and size of particles, their density, and the ambient temperature.

4.  Have several students stand making an arch, and others make a wall. Then have an equal number of students on either side move about randomly, changing course when they collide with another "atom". Each time a student makes it through the doorway because its trajectory takes it directly through, a student acting as counter should make a sound. (and indeed count the numbers from left to right and from right to left. They should be about equal.) Then "tie up" half the students on one side of the wall in shells of 6, and see how this changes the numbers getting through the doorway. More should get through from the side in which there are fewer or no shells. IF THERE ISTROUBLE SEEING THIS, explain to your students that it is hard to model some ideas, and ask for their suggestions.

5. Students should revise their erythrocyte model if necessary.

Extensions and Connections:

Research: Extremophiles: Extremophile bacteria live in places that are too challenging for most living beings. How do **halophile** (salt-loving) bacteria maintain their **osmotic pressure** while living in very salty environments? Read even more about **halophiles**, bacteria that can survive in extremely salty environments. Salts hold onto water. Lots of salt outside a cell can dry it out by changing osmosic pressure in the less desirable direction. So survival strategies include either making small molecules to hold on to water, or increasing salts inside cell, the strategy of archaea.

Research: Desalinization: Research some good ways to remove salt from water, so people living in areas with low rainfall can have more water. [Search word: desalinization, reverse osmosis]

Research: Plant Turgot. Read about **Plant Turgor**

Research: Ion gradients and cell death: Different types of cells have their own "normal" concentration of ions. A normal neuron cell has, for example, 10 times as many potassium (K) pores as Sodium (Na) pores.
(http://www.biology.washington.edu/bsa/IonTransport/cellpotentialsmanyion.html)
When a person gets older and less healthy, cell gradients can weaken and the cells become less efficient.