Osmosis 1.8

Have you ever gone to the refrigerator to snack on celery, only to find that the stalks were limp? As a stalk of celery loses water, it droops (**Figure 1**). It will become crisp again if water moves back into its cells. Osmosis is the reason why wilted celery becomes crisp after being put in water.

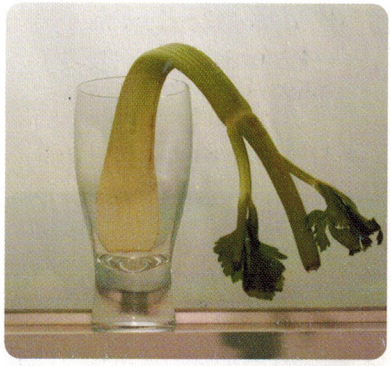

Figure 1
This stalk of celery will become crisp again if put in water.

Water molecules are small, and they move across the cell membranes easily by diffusion. The diffusion of water through a selectively permeable membrane is called **osmosis.** In a normal situation, water molecules are constantly passing through the cell membrane, both into and out of the cell. If there is an imbalance, however, more water moves in one direction than in the other. The direction of the water movement depends on the concentration of water inside the cell compared with the concentration outside the cell.

A Model of Osmosis

Osmosis refers only to the diffusion of water from an area of greater concentration of water to an area of lesser concentration of water. In **Figure 2**, the water molecules (shown in blue) can pass freely through the membrane, but the protein molecules (shown in red) are too large to move through the pores. The membrane is permeable to water, but impermeable to the larger protein molecules; it is a selectively permeable membrane.

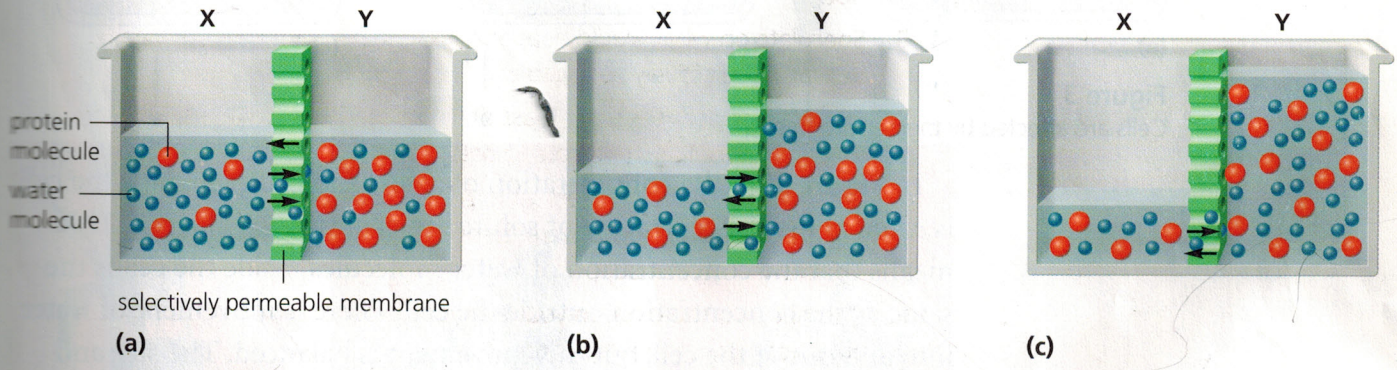

Figure 2
This model of a selectively permeable membrane shows osmosis at work.

In **Figure 2(a)**, the concentration of pure water is 100 %. When materials are dissolved in pure water, the concentration of water is lowered. Which side has the greater concentration of water? There are fewer protein molecules on side X, but many more water molecules. Side X has a greater concentration of water. Water will diffuse from

side X, the area of higher water concentration, to side Y, the area of lower water concentration.

In **Figure 2(b)**, the membrane allows water to move back and forth through it. More water is passing from X to Y, however, than from Y to X.

In **Figure 2(c)**, when the concentration of water on sides X and Y is equal, water molecules still move through the membrane. However, the same number of molecules move in each direction across the membrane.

Cells in Solutions of Different Concentrations

The movement of water into and out of cells is vital to living things, and it is driven by imbalances in concentration. Ideally, the solute concentration outside a cell is equal to that inside the cell. A solute is a substance that is dissolved in another substance, the solvent. In cells, salts and sugars are common solutes, and water is the solvent.

Figure 3 shows the three different environments that a cell may find itself in.

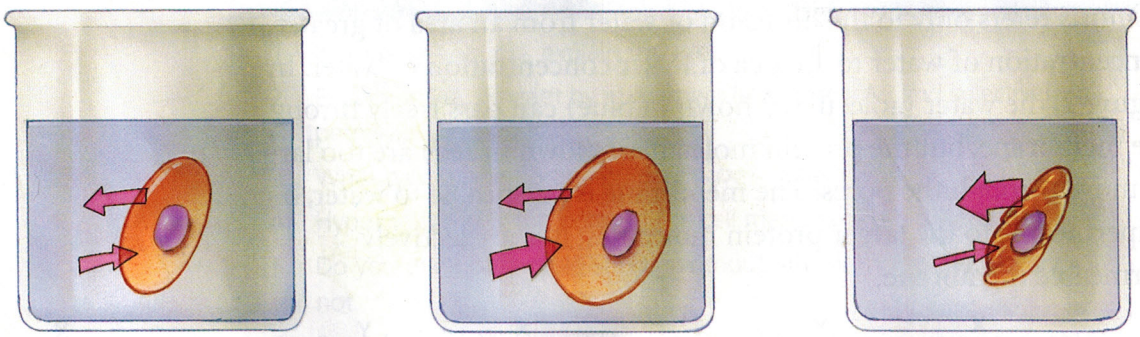

Figure 3
Cells are affected by their environment.

In **Figure 3(a)**, the concentration of solute molecules outside the cell is *equal to* the concentration of solute molecules inside the cell. This means that the concentration of water molecules inside the cell is the same as the concentration outside the cell. There is movement of water into and out of the cell, but this movement is balanced. The size and shape of the cell remain the same.

In **Figure 3(b)**, the concentration of solutes outside the cell is *less than* that found inside the cell. This means that the concentration of water molecules is greater outside the cell than inside the cell. More water molecules move into the cell than out of the cell. The cell increases in size. Cell walls protect plant cells, but animal cells may burst if too much water enters.

In **Figure 3(c)**, the concentration of solutes outside the cell is *greater than* that found inside the cell. This means that the concentration of water is greater inside the cell than outside the cell. More water molecules move out of the cell than into the cell. The cell decreases in size. If enough water leaves, the cell may die.

Turgor Pressure

Have you ever noticed that when salt is used on sidewalks and roads during the winter, the surrounding grass may wilt or die in the spring? Have you also noticed that the vegetable coolers in supermarkets are equipped with sprayers that periodically spray the vegetables (**Figure 4**)?

Figure 4
Markets spray their produce with water. Can you explain why?

If the concentration of water outside a plant cell is higher than the concentration of water inside it, water molecules enter the cell by osmosis. The water fills the vacuoles and cytoplasm, causing them to swell up and push against the cell wall. This outward pressure is called **turgor pressure.** When the cell is full of water, the cell wall resists the turgor pressure, preventing more water from entering the cell. As you can see in **Figure 5**, turgor pressure supports plants, causing their leaves and stems to stay rigid.

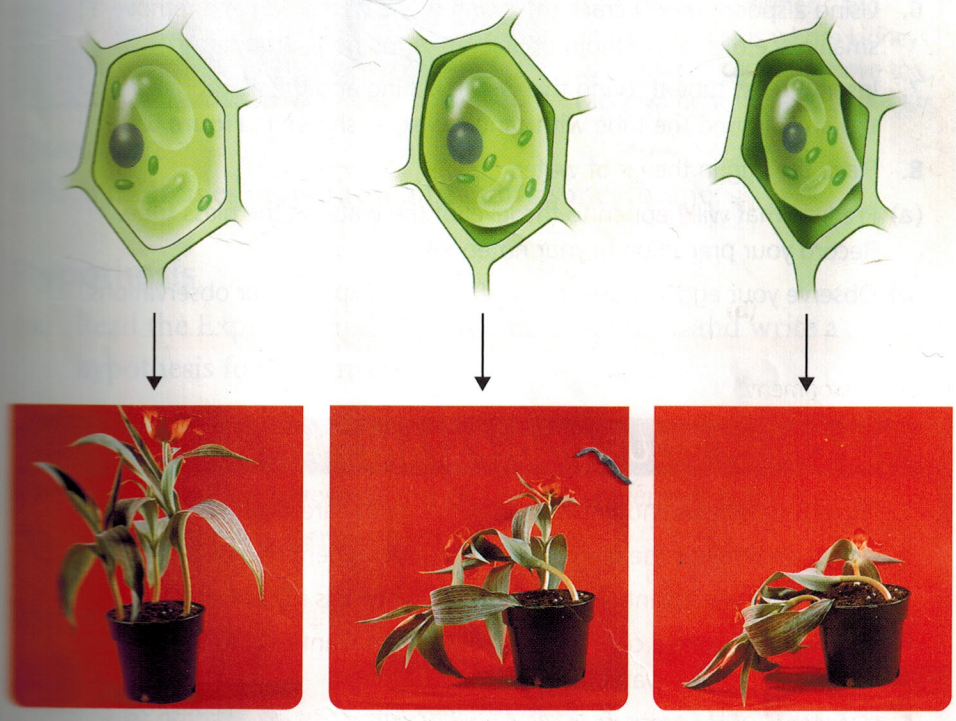

Figure 5
As the plant cells lose turgor pressure, the plant begins to wilt.

In the spring, the salt used on sidewalks and roads during the winter combines with water from the snow to create a solution. The concentration of salt in this solution is much higher than the

concentration of salt in the cells of the grass. Therefore, there is a higher concentration of water inside the cells, so water moves out of the grass cells by osmosis. As water leaves the cells, the cells shrink—their cytoplasm and their cell membranes pull away from the cell walls. Without this support, the grass wilts. If water is not restored to the cells, the grass will die.

Vinegar is an acid. Keep it away from eyes and skin.

Use a hot water bath to carefully melt wax, which can burn easily. Keep hot wax away from skin.

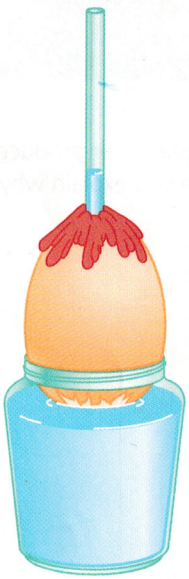

Figure 6
An egg osmosis meter

TRY THIS: An Egg as an Osmosis Meter

Skills Focus: observing, predicting, inferring

In this activity, you will use an egg to study osmosis.

1. Place an uncooked egg, with its round end down, in a small jar that can hold it as shown in **Figure 6**. Note how far down the egg sits.
2. Remove the egg. Fill the jar with vinegar, until the vinegar reaches the level where the egg was.
3. Put the egg back in the jar and allow it to stand with its bottom touching the vinegar for 24 h. (The vinegar will dissolve the bottom of the egg's shell.)
4. Remove the egg, and rinse it with cold water.
5. Dispose of the vinegar. Rinse the jar and refill it with distilled water.
6. Using a spoon, gently crack the pointed end of the egg and remove a small piece of shell, without breaking the membrane underneath.
7. Insert a glass tube through the small opening and the membrane. Seal the area around the tube with candle wax, as shown in **Figure 6**.
8. Place the egg in the jar of water.

(a) Predict what will happen to the level of the water in the glass tube. Record your prediction in your notebook.

(b) Observe your egg osmosis meter after 24 h. Explain your observations.

PERFORMANCE TASK

All cells are subject to osmosis if they are immersed in a pure water solution. How does an understanding of osmosis help you to modify your design? Make a list of problems that must be solved to prevent the cell from shrinking or bursting.

1.8 CHECK YOUR UNDERSTANDING

1. How are osmosis and diffusion different? How are they the same?
2. What determines the direction of water movement into or out of cells?
3. What prevents a plant cell from bursting when it is full of water?
4. Explain why animal cells are more likely than plant cells to burst when placed in distilled water.
5. Describe turgor pressure in your own words.
6. Based on what you have learned about osmosis, explain why grocery stores spray their vegetables with water.