Looking into Eggs

Overview

In this demonstration exercise, students will observe the process of osmosis in eggs that have had their shells removed with vinegar. After de-shelling, the eggs will be soaked in various solutions. Some of the materials will pass into the eggs, some will not, and some will draw water out of the eggs, thus demonstrating the semi-permeable membrane. Students will speculate on the results they observe, read further about osmosis, and then explore further in the next two exercises.

North Carolina Essential Science Standards:

7.L.1.2 Compare the structures and functions of plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, chloroplasts, mitochondria, and vacuoles).

Background

Diffusion is a random process. Imagine an enormous number of molecules of a gas, such as oxygen, all moving around freely in a confined space, like a glass box. In Figure 1, the dots are molecules; the arrows show the random directions they are moving—up, down, left, right, backward, forward, or at any angle in three dimensions. In the confined space, these molecules sometimes bounce off each other and/or the walls of the container.

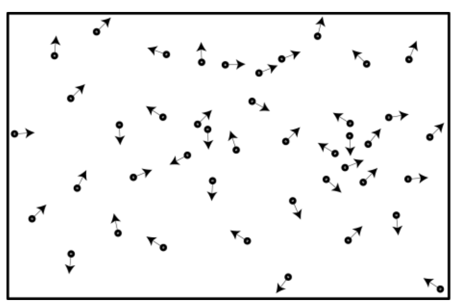

Figure 1.

Now, if we remove one of the walls of the container (Figure 2), as the molecules continue their random motion, some of them will 'escape' through the opening and pass out into the room. Others will continue to bounce around inside the container and amongst themselves. If we were to watch for a while, we would see that most of the original molecules might eventually leave the container, though this might take a very long time. If we could have marked the original molecules, and if the motion is truly random, we might actually see that some of the ones that escaped have actually *come back into* the container!

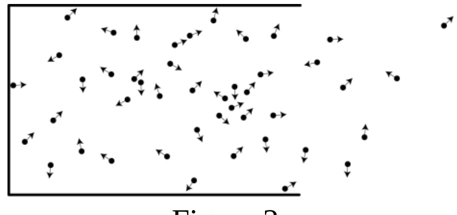

Figure 2.

Since we were using our imagination in devising the scenario above, we do not have to account for all the real life problems inherent in this model. In reality, oxygen molecules are so tiny and their random movements cover such short distances, the time it would take to empty our container might be weeks or months! C*onvection* (the bulk flow of air due to temperature gradients), not diffusion, is the prime mover of molecules of perfume into a room from a bottle left open on a tabletop. When dealing with systems the size of cells, however, diffusion does move molecules at rates that are meaningful, and our model is an attempt to understand this.

Diffusion across a membrane is an essential process in the lives of all cells. Movement of water, oxygen, carbon dioxide, or nutrients is often the result of diffusion across a cell membrane. Though this movement may seem to flow in a particular direction (in or out of the cell), it is still based on *random* movement of molecules. Imagine a container filled with water, with a partition dividing it in half. This partition has a window in it, covered with a membrane (Figure 3). The membrane has microscopic pores in it that allow water to pass through freely. So if we could label water molecules, we would see just about as many moving from left to right as from right to left across the membrane. However, since there is essentially the same number of water molecules on each side to start with, this random back and forth movement would result in *no net change* in water level on either side of the membrane. It would look as if nothing were happening, but in reality, water molecules *are* moving back and forth.

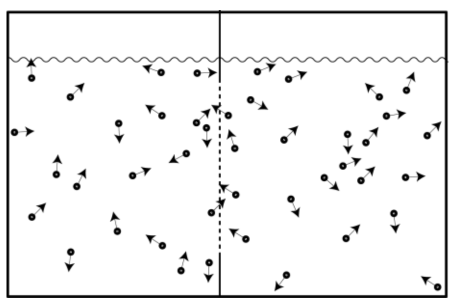

Figure 3.

To experiment further, imagine plain water on the left side of the container and a sugar-water solution on the right side (Figure 4). There are now more water molecules *per unit volume* on the left than on the right, because some of that volume on the right is taken up by sugar molecules. What makes this interesting is that we have used a membrane that *does not* allow sugar to pass through, even though water can pass through freely. The random motion of water molecules still produces movement in *both directions*, but because there are more water molecules impacting the membrane from the left, more of them, *by chance alone*, will move to the right than vice versa. It is purely a numbers game! Water is still moving from right to left, but the number of molecules moving from right to left is less than the number moving from left to right. The result is that the level of fluid on the left *decreases* while on the right it *increases*.

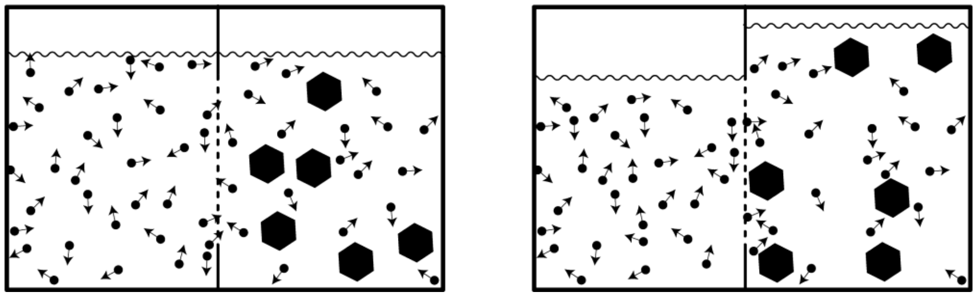

Figure 4.

The membrane we have described above is *semi-permeable*. It lets some molecules pass (water) but does not let others move through (sugar). This process is so important in living systems it is given a special name: *Osmosis—the movement of water across a semi-permeable membrane*. As we have seen, though water does move in both directions, the *net flow* is from the region of *higher water concentration* to the region of *lower water concentration.* This can sometimes be confusing, because we tend to think of a concentrated solution from the point of view of the *solute* (the sugar in our example) rather than the *solvent* (the water). Just remember that a higher concentration of sugar means a lower concentration of water, relatively speaking.

Materials

*Materials marked with an asterisk must be supplied by the teacher or the students.

Materials for the whole class

- Vinegar
- 24 cups (9 oz)
- Tube of blue water color paste
- Blue food coloring
- Corn syrup
- Digital Scale
- *Tap water
- *18 eggs
- *Bucket that will hold 18 eggs

Materials for individual students

- *Science notebook

Preparation and class procedure

Start this preparation on a Monday for use on the following Monday. At least 18 eggs will be needed for teachers who have five classes.

- Place the raw eggs in a bucket and cover them with vinegar. The vinegar will dissolve the calcium carbonate in the egg shells. Some bubbling may occur at first and some foam may form—all of which are harmless.
- The shell removal may take 2-3 days. It's a good idea to move the eggs around a bit *very gently* a few times each day, so that parts that touch get exposed to the vinegar. Move them with your hands; a spoon may not be gentle enough.
- As the shells get thin (day 2), rub them *gently* to help speed up the process. Replacing the old vinegar with fresh may also help. Eventually, the shells should come off completely and the eggs

should be exposed, enclosed in their outer membranes. They are fragile, but they can be held in the hand.

- Rinse the de-shelled eggs in water and then set them in a container for another day so that any excess water or vinegar they have absorbed can drain out.
  - **Weigh and record the mass of each egg to the nearest tenth of a gram. (Initial mass)**
- If you started your eggs on a Monday, you can do the following steps on Thursday or Friday.
  - Add water color paste to water to make a darkly colored solution. You will need enough to cover 2 eggs in cups.
  - Add food color to water to make a solution approximately the same color and intensity as with the water color. You will need enough to cover 5 eggs in cups.
- Class introduction:

  Tell students that the next activities will demonstrate some aspects of how cell membranes work. Explain that an egg is a good model of a very large cell with a cell membrane. [The actual chick embryo in a fertilized egg sits on top of the egg yolk, surrounded by the yolk membrane. The yolk is a very large cell, and the yolk membrane is a real cell membrane. (The yolk in an ostrich egg is the largest single cell on Earth.) The membrane surrounding the egg white is actually made up of several layers of cells and a protein called collagen. It is not a real cell membrane, but its characteristics as a semi-permeable barrier are very similar.]

  Ask the class to list some things that a cell needs to survive and how it obtains those things. Discuss how a cell removes waste that is produced. The goal of the discussion is for the class to understand that cells need to take in and get rid of various materials.

- Show the students the de-shelled eggs and ask them what they think will happen if you soak them in the various solutions outlined below.
- Place eggs into individual cups and cover them with the following liquids/solutions:
  - 2 control eggs in cups with no liquid (1 extra in case of breakage).
  - 2 eggs covered with plain tap water (1 extra in case of breakage).
  - 2 eggs covered with corn syrup (1 extra in case of breakage). These eggs may float, that's okay.
  - 2 eggs covered with the water color solution (1 extra in case of breakage).
  - 5 eggs covered with the food color solution (You will break the outer membrane of one of these eggs in each class period to look inside.)
- Leave the eggs to soak for 2-3 days (perhaps over a weekend).
- On Monday have the class observe each egg as you remove it from the solution. Then weigh each egg and compare with the mass before it was placed in solution. Students will see that some eggs have gained and some have lost weight. In addition the egg that was in the blue watercolor solution will not be blue, while the egg in the blue food coloring solution will be blue, even though both eggs have gained weight. *Very gently* break open the blue food coloring egg membrane. Be careful; the egg will burst open. The egg white (albumen) will have turned color a bit, but the food color probably will not have gotten through the yolk membrane. (It is a good idea to wash hands after handling raw eggs.)

  [The table below shows typical changes in mass of the various eggs. Your measurements may be different due to differences in egg size, room humidity, etc.]

Soaking liquid	Initial mass (g)	Mass after soaking in various liquids over a weekend (g)	Net change (g)
no liquid	76.5	63.5	-13.0
water	71.6	80.0	8.4
water	72.9	78.8	5.9
corn syrup	77.3	42.6	-34.7
corn syrup	72.3	38.8	-33.5
water color	75.6	85.6	10.0
water color	68.2	80.2	12.0
food color	72.7	82.6	9.9
food color	72.8	84.4	11.6

- Things students should have noticed:
  - All eggs gained mass except for the egg in corn syrup and the control egg.
  - The egg in water color *has not* turned color itself even though it has gained mass.
  - The egg in food color *has* turned color inside and it has gained mass.
  - The egg in corn syrup looks shriveled and has lost mass.
- DO NOT EXPLAIN ANY OF THESE RESULTS YET. This is an exploration demonstration, meant to get the students thinking and speculating.

Reflection/Discussion

Before students share their speculations, have them record their egg observations in their science notebooks, and then have them write their speculations as to what they think is going on. During the following discussion, they may then read from their notebooks.

Ask students to speculate on what caused the various results. DO NOT tell students the correct reasons at this time.

- Why did the egg in water get heavier?
- Why did the egg in corn syrup get lighter and shrivel up?
- Why did the eggs in the two colored solutions behave differently? Both gained weight, but only one changed color!

At this point, to gather more information about what may be going on, have students read the appropriate section in the textbook about cell membranes.

Assessment

Look at students' notebooks to see if they have recorded their observations and their speculations. NOTE: Their speculations need not be correct at this point. They can add more information as their understanding develops.