A Model of Matter: Part 9 Diffusion

Over the last several weeks we've been looking at a model of mater (tiny particles in motion) to help us explain phenomena in the physical world, specifically evaporating and melting. But tiny particles in motion are not limited to the physical world; we find them in the living environment as well. Last week, in preparation for this discussion, we asked you the following questions:

We want to add **fabric dye to water**, but we're not going stir it to mix it up. (We don't want to clean up the mess from any splashes.) We want the dye to mix uniformly throughout the water.

- Will hot or cold water allow this to happen more quickly?
- How can we use our model of matter to explain this?

Here is a great website that shows movies of this investigation. You can compare the rates of the dye mixing into both hot and cold water:

http://www.pt3.gse.rutgers.edu/physics/matter/diffusion/diffusionindex.html

You see that the dye mixes throughout the hot water much more quickly than it does in the cold water. Why? Our model of matter (tiny particles in motion) tells us that molecules in a substance move more quickly when they are at a high temperature compared to when they are at a low temperature (see *A Model of Matter: Part 3*).

This still concerns the physical world, however. You may be asking yourself how this relates to the living environment. It all relates to the process of **diffusion** that you just witnessed…

Diffusion

In order to carry out certain life functions, substances, such as oxygen, carbon dioxide, water and proteins must move in and out of cells. Molecules have to pass through the membranes surrounding cells. The job of this membrane is to let certain substances in, let others out, and interact with the environment surrounding the cell.

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One way molecules can pass through the membrane is by **passive transport**. The cell does not have to use energy from food to engage in this process.

Passive transport depends upon the movement of the molecules themselves. Remember, our model of matter revolves around the idea of constant motion of all molecules. **Diffusion** is the primary process for **passive transport**, and it depends upon this random motion of molecules, resulting in a uniform mixture:

"Diffusion is the movement of molecules from a region in which they are highly concentrated to a region in which they are less concentrated. It …continues until the system in which the molecules are found reaches a state of [dynamic] equilibrium…"[1]

There is a particular type of **diffusion** that is extremely important to the life processes that involve water; it's called **osmosis**. Let's do a thought experiment that examines **osmosis**…

You'll need[2]:

- Potato
- Knife
- Cutting board
- Sugar solutions made with
  - 6 T of sugar per cup of water
  - 2 T of sugar per cup of water
- Water
- Beakers
- Ruler
- Paper towel

Procedure:

1. Cut three large slices of potato that will fit into the beakers. (As far as is practical, both pieces should be the same length, width, and thickness.)
2. Pat each piece of potato dry and measure its longest length. Note the measurements.
3. Place each potato slice in a separate beaker.
4. Pour plain water into one beaker, completely covering potato slice.
5. Pour 6T sugar solution another beaker, completely covering potato slice.
6. Pour 2T sugar solution the third beaker, completely covering potato slice.
7. Leave the potato slices in the liquids for at least half an hour.
8. Remove the potato slice from each beaker and carefully blot it dry without squeezing. What changes in measurements do you predict you will find when you re-measure the pieces? Why?

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So what happens?

- The potato slice immersed in the plain water will be largest. This suggests that **more water has entered** the potato than has come out.

- The slices immersed in the sugar solutions will be smaller than the one in plain water. The greater the sugar solution, the smaller the slice. This indicates that **more water has left** the potato than has gone in.

Why? Because of **osmosis**, which is essentially the **diffusion** of water. When large molecules such as sucrose (table sugar) are dissolved in water, the sucrose molecule is too large to pass through the cell membrane. The water molecules, however, can move freely. (We refer to this membrane as **semi-permeable**, since some molecules can pass through and some can't.) The large molecules also interfere with the movement of water; they can "plug" some of the pores of the membrane, making it harder for the water on the "sucrose-side" to get through the membrane.

Remember, according to our definition of **diffusion**, water moves out of the cell, through the cell membrane, until equilibrium occurs. In the beakers with the sugar-water solution, there is more water *inside* the potato cells than outside them, so water flows *out* of the potato cells, reducing the potato's size.

Osmosis is a natural process that occurs in the cells of organisms. But, as humans, can we manipulate this process to our advantage? This leads us to a question to consider for next week. We'll continue looking the molecules in motion within the living environment.

Coming up

Preserved foods are often packed in salt or sugar.

- How does this method keep food from spoiling?
- How can we use our model of matter to explain this process?

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What do the New York State standards say?

In the Elementary and Intermediate Core Curricula, Standard 6, Interconnectedness: Common Themes,

Key Idea 2 states:

- Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

In the Elementary Core Curriculum, Standard 4, The Living Environment,

Key Idea 5 states:

- Organisms maintain a dynamic equilibrium that sustains life.

In the Intermediate Core Curriculum, Standard 4, The Living Environment,

Major Understanding states:

- 5.1a Animals and plants have a great variety of body plans and Internal structures that contribute to their ability to maintain a balanced condition.

[1] http://biology.arizona.edu/sciconn/lessons/mccandless/reading.html

[2] adapted from http://encyclopedia.thefreedictionary.com/Osmosis%20experiment

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