Molecular Movement in Water
Part 1 – Diffusion

Purpose

To observe that temperature and salinity have an effect on diffusion rates.

Overview

In this activity learners will observe and compare molecular movement within water at various temperatures and of varying salinity. Students will then discuss movement of water on a larger scale (discussion of mixing) which can affect the movement and concentrations of microbial populations within water. Students will make inferences about these effects on fecal bacteria entering water near Hobie Beach related to the sewer pipe break incident.

Time

2 two-hour block class periods plus home assignment

Key Concepts

Temperature and salinity have an effect on diffusion rates. Molecular movement increases when heat energy is added and decreases when energy is removed. Solutes go into solvents faster at higher temperatures.

Skills

Making observations
Measuring solutions
Collecting data
Tabulating data
Forming hypotheses
Testing hypotheses
Communicating observations and interpretations orally and in writing

Materials

| 20 250ml beakers (two for each team) | 50ml beakers or small plastic cups |
| Water at room temperature | 4 or 5 boxes of table salt |
| Hot plates | Plastic spoons |
| Pans (for heating water) | White paper |
| Chilled water | Several empty jars (to hold 3 liters) |
| Food coloring | Labels for jars |
Facilitator Preparation

**Diffusion/Temperature Related:**
You will need to heat enough water for each team to have approximately 150mls of very warm water in a beaker. You will also need to ice enough water so that each team will have 150mls of chilled water in another beaker.

**Diffusion/Salinity Related:**
You will need to prepare a supersaturated solution, using table salt, adding food coloring to this solution for easier observation of diffusion (mixing).

**Preparation of a Saturated Solution**
1.) Heat a large pan of water. You will need approximately 3 liters of salt solution. Excess can be stored.
2.) Add table salt, stirring to dissolve. Continue to add salt to the hot water until you see that the salt you add is no longer dissolving, it is no longer going into solution.
3.) Remove the pan of saturated solution from the heat and allow to cool. This preparation can be done as a demonstration the day before the observation experience. It helps if the learners see you preparing the solution.
4.) Add food coloring. This enables learners to track the mixing, diffusion of the salt solution and water.

**Set-up Preparation for Salt Solution as a Solute**
1.) Pour about 30mls of the colored saline solution into enough beakers/cups so that each team will have a cup.
2.) Pour approximately 150mls of water into beakers so that each team will have a beaker of water.
3.) Place enough spoons and white paper in the material space.
4.) Each team will be directed to collect a large beaker, a small beaker, a spoon, and a piece of white paper. It is best if these materials can be placed on a cart and delivered to each team table.

**Set-up Preparation for Water as a Solute**
1.) Pour about 30mls of the water into enough beakers/cups so that each team will have water.
2.) Pour approximately 150mls of colored salt solution into beakers so that each team will have a beaker of salt solution.
3.) Place enough spoons and white paper in the material space.
4.) Each team will be directed to collect a large beaker, a small beaker, a spoon, and a piece of white paper. It is best if these materials can be placed on a cart and delivered to each team table.

**Background**
What happens when you try to dissolve four or five spoons of sugar in iced tea? (You really have to stir it a lot to get it to dissolve.) What happens when you try to dissolve four or five spoons of sugar in a cup of hot tea? (It’s easy.) Why the difference? (Temperature) So? What has temperature got to do with dissolving? Why the difference? Have small groups of students discuss their ideas and come up with hypotheses.
**Background on Solutions**

**Unsaturated Solutions** – When we add salt to water, the salt is actually moving into the spaces between the water molecules. As long as there is room between the water molecules and space for the salt, our water is unsaturated - we have not used up all the space available between molecules.

**Saturated Solutions** – We can continue to add salt until we have filled up all the spaces in our water sample. At this point, there is no vacancy for any more salt. We have now saturated our water with salt. There is no more room to add more salt. If we add more salt, it will settle to the bottom and will not dissolve, no matter how much we stir.

**Supersaturated Solutions** – We can create more space by heating the water. When we heat the water, we are actually energizing the molecules. Heat is energy. So the energized molecules begin to move around more rapidly, colliding and ricocheting off each other. These collisions cause the water to expand, providing more space for more salt. We can now add more salt, and if we continue to increase the heat, we can add more and more salt. Eventually our heated water will feel thick with salt, and it is. We now have a supersaturated solution.

**Procedure**

**Guided Observation – Diffusion/Temperature Related**
1.) Instruct each team to place a sheet of white paper in the center of the table for better observation.
2.) Place a hot and cold beaker on the sheet of paper at each team table.
3.) Explain that the water in each beaker must settle first. “Try not to jar the table so that the water will not be disturbed.”
4.) “Your task is to observe what is going to happen. Focus on the beaker in which the food coloring is placed.”
5.) Drop food coloring in the cold water first. “Watch closely what happens to the food coloring.”
6.) Go back and place a drop of food coloring in the hot water beakers. “Watch carefully. Focus as I drop the coloring into the beaker.”
7.) “What is happening?” “Why is it happening?” “What’s mixing the food dye in the hot water?” “How do you think this is happening?”
8.) Allow time for groups to discuss and construct what is going on.

**Guided Observation – Diffusion/Salinity Related When Salt Solution is the Solute:**
1.) Place the beaker of water on top of the white paper in the center of the table. Allow the water to settle down before continuing.
2.) Using the spoon, slowly pour the colored salt solution over the back of the spoon, allowing it to drip off the spoon into the beaker of water.
3.) Each team should observe movement for several minutes and then sketch the movement of the solute.
4.) Discuss and describe what was observed. Where did the solute go? Did it mix thoroughly?
5.) Teams compare results. Was there consensus?
When Water is the Solute:
1.) Place the beaker of colored saline on top of the white paper in the center of the table. Allow the solution to settle down before continuing.
2.) Using the spoon, slowly pour the water over the back of the spoon, allowing it to drip off the spoon into the beaker of colored saline solution.
3.) Each team should observe movement for several minutes and then sketch the spread of the solute.
4.) Discuss and describe what was observed. Where did the solute go in the solution? Did it mix thoroughly?
5.) Teams compare results. Was there consensus?

Student Assessment

1. Diffusion Lab – Temperature Related. Have students describe what they see happening in the two beakers. Students should sketch and label the hot and cold beakers and write a brief explanation under each sketch of the difference in diffusion rates. Students should be able to use these terms appropriately: molecular movement, diffusion, temperature, heat energy.

Home Learning: Have students rewrite their explanations of what happened in the diffusion experiment in class. They are to reproduce this experiment for an adult, explaining the reason that the food dye mixes in hot water but not in cold. The adult who listened, then needs to write a brief comment about the student’s presentation and sign the explanation paper the student wrote in the first part of the assignment. The student is to return the signed explanation and comment for a grade.

2. Diffusion Lab – Salinity Related. Students should be able to use these terms appropriately: solvent, solute. Present these examples to students, “When you pour cream into coffee, the cream is the solute, the coffee is the solvent. When you add lemon juice to your tea, the lemon juice is the solute and the tea is the solvent.” Then have students write a definition for “solvent” and “solute” based on these descriptions.

Students should answer the following questions:

- Compare and contrast the diffusion rates for the saline solute and the water solute.
- Did one diffuse faster than the other? Did they diffuse in the same way?
- What do you think would happen if we let the heated supersaturated solution cool? Write your predictions. How could you test your ideas?
- In which model did the solute mix vertically?
- In which model did the solute diffuse only at the surface?
- Why do you think this happened?
3. Discussion After the Lab / Real World Assessment

 Mixing refers to the intermingling of parcels of water as they are moved along the estuary under the influence of freshwater flows, tidal flows and secondary currents. Mixing not only involves an exchange of water mass, but also of any substance dissolved in it, such as salinity, dissolved pollutants, etc. Hence, mixing processes are of importance to the distribution of salinity and water quality levels throughout the estuarine water mass.

For Learners: We have observed the model of a sewage spill (fresh water based) into Biscayne Bay (the salt solution). In your opinion, do you think the fresh water sewage would behave as the model did? What other variables might increase mixing rates of the sewage vertically as well as horizontally in the bay? Discuss this with your team and create a two column list of variables that would increase vertical mixing and horizontal mixing in the bay. Share your lists in team presentations. All results to be compiled on overhead transparencies.

For Facilitators: Some variables can be listed in both columns by students. If possible, use an overhead to duplicate all the teams’ sorting of variables allowing the students to see the consensus as well as the discrepancies. This view of presented results allows for quicker discovery of discrepant events and therefore facilitates discussion of those differences. This strategy also allows visual learners to make sense of the experience. Place a connecting line to the same variable in both columns for emphasis.

4. Project Assessment:

For Learners: Working as a team, create a simulation of a sewage spill in a clear plastic shoebox. Prepare a narrative, a story to go with your project presentation as you present the sewage spill event with your model.

For Facilitators: Provide empty ketchup squirt bottles, clear plastic shoeboxes, white sand, salt, and food coloring.

Rubric for the Presentation:

- Were proper science terms used?
- Was the presentation easy to understand?
- Is each member actively taking part in the presentation?
- Were team members careful with equipment?
- Could the group answer questions from the audience?
- Was clean up appropriate?