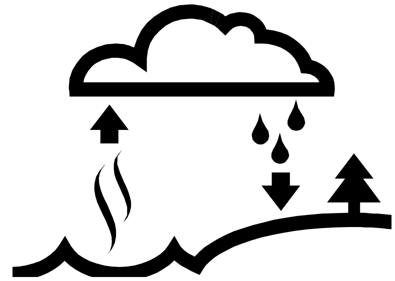
Heat Balance – Convection & Density Lesson
(and the Water Cycle)



As the Sun heats different materials on the Earth's surface differently, the atmosphere and oceans act as agents that even out the distribution of heat. As part of this process, molecules of water from the ocean and other bodies of water evaporate to water vapor and eventually condense to form clouds and precipitation. We all know this process as the ***water cycle*** – evaporation, condensation, precipitation, and run-off.

In this lesson, you will learn more about convection and density to see how these processes are connected to the water cycle and to weather on Earth. You will also look at computer simulations to observe what's happening at the molecular level. Keep this focusing question in mind as you proceed through the various activities.

? How does the molecular behavior of gases and liquids in the atmosphere and ocean relate to the water cycle and moisture reaching the interior Southwest **?**

MATERIALS

Materials are listed with each section of the lesson.

Part A: Convection and Density in Air

Materials: computers or tablets

Web site: http://mc2.cchem.berkeley.edu/Java/molecules/index.html

PROCEDURE

1. Review your observations from Weather Station #1 (smoke box video) in Module 3. Talk to your partner and share several things that are important to studying convection and density of air when thinking about weather.

2. Review your observations from Weather Station #2 (cloud chamber) in Module 3. Talk to your partner and share several important things about air pressure.

3. You will now explore the Kinetic Theory of Gases using a simulation. Computer simulations of gas molecules moving in closed containers can help with our understanding of what's happening in the atmosphere and its connection to weather. The simulations use the Kelvin temperature scale. For your reference:
   0°C (freezing temperature of water) = 273K
   100°C (boiling temperature of water) = 373K
   22°C (room temperature) = 295K

4. Go to http://mc2.cchem.berkeley.edu/Java/molecules/index.html to access the simulation. You will use the sliding bar to change the values on the screen or type in the value (but be sure to hit "enter" after doing so). Increase the "mass" value to 40 for both the red and blue gases in order that you can see them more easily.

5. Keep the blue gas values constant as you experiment with the values of the red gas. Record the following relationships in your science notebook.
   a. Describe the relationship between temperature and speed of molecules.
   b. Describe the relationship between the number of molecules and the internal pressure (within a closed container).
   c. What is the relationship between gas temperature, gas pressure, and speed of gas molecules?

5. Set both temperatures to 300K. Set the number of molecules to 20 red and 100 blue.
   a. Describe the relative pressures of the gasses.
   b. Which sample corresponds to high altitudes and which to low altitudes?

6. Click the "for fixed pressure" button at the bottom of the screen. This makes the sample of air behave more like a parcel of gas in the atmosphere which is surrounded by the atmosphere and not by a solid wall. You will need to reset the number of molecules and their mass.
   a. Describe the relative densities of the two gases.
   b. Set the temperature of both gases to 300K, then slowly raise the temperature of the red sample and observe.

ANALYSIS

1. Imagine that the red sample represents the air inside a hot-air balloon and the blue sample the air outside the balloon. Explain why the balloon would begin to rise.
2. Explain why hot-air balloon events take place in the early morning on summer days.

Part B: Convection and Density in Water

Materials: tap water, one clear plastic shoebox, rectangular tuppperware, or small aquarium; paper cups, crushed ice, masking tape, measuring spoons, non-yellow food coloring, salt, fine dirt or mud, 3 100-mL graduated cylinders, triple beam or electronic balance

PROCEDURE

1. Fill a plastic shoebox three-quarters full with room temperature water. Poke several pencil-size holes in the bottom of the paper cup, then tape it into one of the corners of the shoebox so that the bottom of the cup sits in the water. Add crushed ice and two drops of food coloring to the paper cup.
   a. Observe the shoebox at eye-level. Describe what you see.

b. Watch this video of dye moving in water. The aquarium in this video is heated from the left side. http://www.youtube.com/watch?v=7xWWowXtuvA

b. Use your observations to explain how temperature affects the density of water.

2. Mixing in the oceans is related to different densities of water. Besides temperature differences, there are other things that cause density differences in ocean water. In this step, you will investigate the density of different liquids commonly found flowing into the ocean and in ocean currents.

   a. Place tap water into three paper cups. Into one, add 3 teaspoons of salt and stir until dissolved. Into a second, add 3 tablespoons of fine dirt or mud and stir until suspended. Leave the water in the third cup plain. Place an equal amount of each cup's water into three different graduated cylinders.

   b. Predict which of the three liquids will have the highest, middle, and lowest densities.

   c. Use the balance to take measurements of each liquid. Use any of the following formulas to calculate the density of each liquid. Record the densities in your notebook.

$$\text{Density} = \frac{M}{V}$$

Circumference of a circle $C = \pi d$

Diameter of a circle $d = 2r$

Volume of a cylinder $V = \pi r^2 h$

ANALYSIS

1. Name places on Earth where you might naturally find each of these types of water.
2. Based on the liquid densities, describe how the three liquids would float in relation to each other if they were carefully mixed. Dye the fresh and salt water different colors and try it!

Part C: The Water Cycle – Evaporation and Condensation

Web site: http://www.chm.davidson.edu/ronutt/che115/Phase/Phase.htm

PROCEDURE

1. Review with your partner your observations of the Cloud Chamber, from the Weather Stations Lesson in Module 3.

2. Go to this web site: http://www.chm.davidson.edu/ronutt/che115/Phase/Phase.htm
   This simulation shows the evaporation of a liquid with either strong or weak

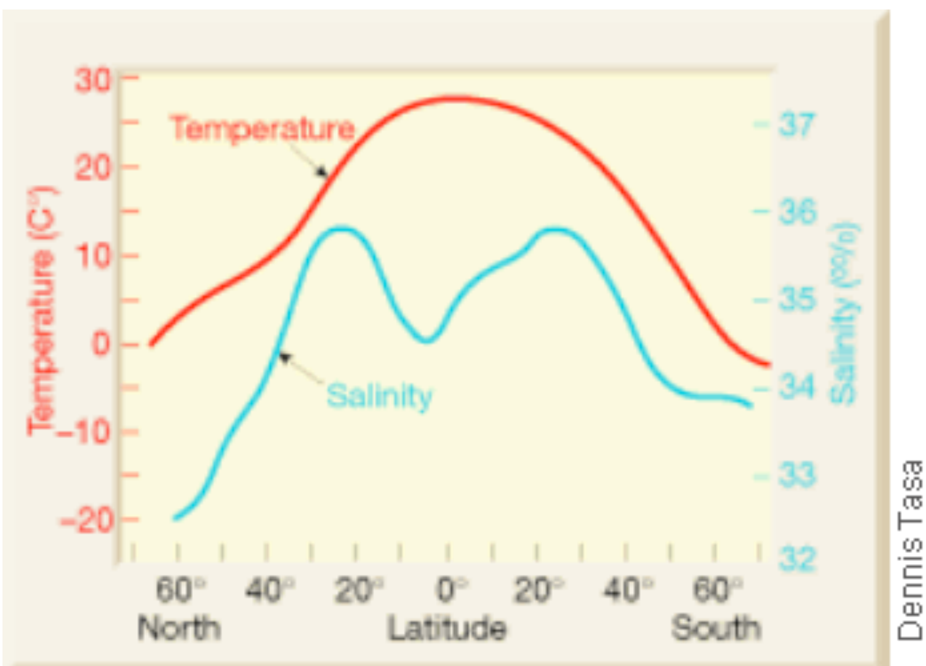
intermolecular forces and at three different temperatures. T1 is the coolest, and T3 is the warmest.

3. Because water is a molecule with strong intermolecular forces, set the "Intermolecular Forces" to **strong** and the "Temperature to **T1**—then click "Start."
   a. Describe what you observe. What part of the liquid evaporates?
   b. Change the temperature of the liquid. Describe the effect of temperature on evaporation using molecular behavior.

ANALYSIS

1. Use molecular motion, convection, density, and winds to explain the water cycle **without** using the terms evaporation and condensation.

2. Study the figure below and answer the following questions:
   a. Based on the temperature and salinity graphs, at what latitudes are ocean waters the most dense?
   b. Based on the temperature and salinity graphs, at what latitudes are ocean waters the least dense?
   c. Explain why the Equatorial regions have lower salinity.



CONCLUSION

Use what you learned in this lesson to write a conclusion to the focusing question.