The Education Program at the
New Jersey Sea Grant Consortium
22 Magruder Road, Fort Hancock, NJ 07732 (732) 872-1300
www.njseagrant.org

UNDERSTANDING STORM SURGE

ACTIVITY #1- OCEANS OF PRESSURE
A Review of the Water Cycle, Air Pressure, and Weather

OVERVIEW

In this experiment, students will observe how temperature affects the density of air. They will also discover how temperature causes air to rise or sink to create low pressure systems that result in warm, cloudy, and wet weather or high pressure systems that bring cool, dry, fair weather. Students will also get the opportunity to review the water cycle.

MATERIALS

- Glass bottle or 250ml Erlenmeyer flask
- Water
- Bowl of cold water (to immerse the bottle or Erlenmeyer flask)
- Balloons
- Hot plate

PROCEDURE:

1. Explain to students that this experiment will demonstrate how low and high pressure weather systems form over an area on Earth, as well as how the weather we observe is created. This experiment creates a closed system so students will be able to see and explain how air molecules move when heated or cooled and how this affects weather. This experiment is also a good review of the water cycle. A vocabulary review of words associated with the water cycle, such as condensation, saturation, and precipitation may be helpful prior to performing this activity.
2. Fill a glass bottle or Erlenmeyer flask with about 4 cm (1.5 inches) of water and place the balloon securely over the mouth of the bottle. Center the balloon over the mouth of the bottle so air may easily enter the balloon. The bottle represents the Earth's lower atmosphere where humans observe weather; the balloon is the Earth's cool upper atmosphere.

3. Place the bottle on a hot plate and turn the hot plate to medium high heat. The hot plate represents the heat of the sun that has warmed the Earth. Students should answer questions 1-5 as they observe the warming of the flask. Do not turn the heat up too high—you do not want to cause the water to boil. Also, do not allow the balloon to inflate so that it pops.
4. Students should next answer question 6 to hypothesize what they think will happen inside the bottle and to the balloon if the bottle is taken off the hot plate and placed into a bowl of cool water.
5. Carefully take the bottle off the hot plate and place it into a bowl of cool water. The cool water represents areas such as those near the Earth's poles. Students should observe the changes and answer questions 7-10.

The Education Program at the
New Jersey Sea Grant Consortium
22 Magruder Road, Fort Hancock, NJ 07732 (732) 872-1300
www.njseagrant.org

UNDERSTANDING STORM SURGE

ACTIVITY #1- OCEANS OF PRESSURE

Student Questions:

1. In this experiment the bottle represents an area with a weather system in place. How are the Earth's oceans, lakes or rivers represented in this experiment?
2. What do you think will happen to the balloon as the bottle is warmed? What do you think will happen to the water as it is warmed?
3. Which direction did the air move when warmed in this experiment? How do you know the air moved in this direction? Why do you think air moved in this direction?
4. High pressure air is dense and will sink; low pressure air is less dense and will rise. When the bottle is warmed, does it represent a high or low pressure weather system?
5. Using weather terms, explain the weather you observe inside the bottle when it was warmed. How do you think the warming temperatures cause this type of weather?
6. Based on results from Step 1 of the experiment, hypothesize what you think will happen inside the bottle and to the balloon when placed into cool water. Explain your reasoning.
7. Which direction did the air move when cooled in this experiment? Explain your reasoning.
8. When the bottle is cooled, does this represent a high or low pressure weather system?
9. Using weather terms, explain what happens inside the bottle when it is cooled.
10. Imagine an Earth without an ocean. Hypothesize how the results of this experiment would change if we didn't use water in this experiment.
11. Based on the results of this experiment, what causes a low pressure weather system? What kind of weather is observed when a low pressure system is in place?
12. Based on the results of this experiment what causes a high pressure weather system? What kind of weather is observed when a high pressure system in place?

The Education Program at the
New Jersey Sea Grant Consortium
22 Magruder Road, Fort Hancock, NJ 07732 (732) 872-1300
www.njseagrant.org

UNDERSTANDING STORM SURGE

ACTIVITY #1- OCEANS OF PRESSURE

Student Answers:

1. The Earth's ocean, lakes and rivers are represented by the water in the bottle. Water is added because the water on Earth affects the weather on Earth.

2. The balloon will inflate as air is warmed and rises into the balloon. The water will warm and slowly evaporate, condense, and form a precipitate.

3. The air moved upwards from the bottle and into the balloon. You know the air moved upwards because the balloon inflates with air. Remember that warm air rises, so as the air in the bottle warms, the air molecules increase in energy and spread apart. As they move apart they become less dense and rise to the top of the bottle and into the balloon.

4. A low pressure weather system formed inside the bottle. The air inside the bottle represented the lower atmosphere. As it warmed it went upwards into the balloon. A high pressure system formed inside the balloon which represented the upper atmosphere.

5. You should observe evaporation and condensation. As the bottle is warmed, the water inside the bottle evaporated and the warm water vapor travelled up to the top of the bottle. The warm water vapor will fog or cloud up the bottle. Then as water vapor reaches the top of the cooler top of the bottle and/or balloon, the vapor condensed. When this vapor reached a saturation point, it formed back into water molecules and caused precipitation which was observed as water dripping back into the bottle. The condensing water vapor represents rain that falls when a low pressure system is in place over a location.

6. Answers are open-ended but students might hypothesize that the results of Step 4 will be the opposite of Step 1. The balloon will deflate and the bottle will clear of any fog, clouds, and/or precipitation to form a high pressure system. As the bottle cools, the molecules of air inside the bottle will decrease in energy and move closer together. This causes the air molecules to become dense and sink. The sinking air will cause the balloon to deflate. The

downward movement of cool air will clear up the fog and stop condensation and precipitation in the bottle.

7. As the bottle was cooled, the air moved down into bottle and the balloon deflated. This bottle is sealed by the balloon, but the air in the balloon had to go somewhere. Cool air is heavier and denser because as molecules cool they move closer together, so the air in the balloon sank back down inside the bottle as it cooled.

8. A high pressure weather system is represented inside the bottle. As the bottle cooled, the molecules of air inside the bottle decreased in energy and moved closer together. This caused the air molecules to become dense and sink. The downward movement of cool air cleared up the fog and clouds, stopping condensation and precipitation inside the bottle.

9. Clear and dry.

10. With no water there would be no water evaporation, and thus, no condensation, precipitation, or any form of wet weather. The Earth would be a dry place.

11. Warm or hot air creates a low pressure system; hot air rises and also causes water to evaporate. When water vapor rises, it will condense in the cool upper atmosphere and cause condensation and clouds to form. Clouds become saturated with water and this leads to precipitation (e.g. rain). Low pressure systems are often associated with warm, cloudy, rainy days.

12. Cool or cold air creates a high pressure system. As air cools, it becomes dense and sinks. The sinking cool dry air dries and clears up any water vapor in the lower atmosphere. High pressure systems are often associated with cool, dry, nice weather.

Further Explanation:

The atmosphere is full of air molecules that are always moving, and the weight of these air molecules creates pressure. All changes in air pressure create weather.

Air is made up of many invisible molecules, and these molecules are full of energy! When temperatures are cool, air molecules move together, become denser, and sink down towards land. Typically the mass of air flows downward, fans out, and gives us nice cool temperatures and sunny skies. This is the type of weather we enjoy when a high pressure weather system is in place.

When air is heated by the sun's energy, air molecules spread apart and take up more space. This makes the air less dense. The less dense and much lighter mass of air rises up into the Earth's atmosphere. Also consider that the Earth is made of 71% water, which is mostly ocean

water. When the Earth's water is heated by the sun, some of the water evaporates into the air. Air in the atmosphere is always moving up and down as it warms and cools. Cold air is dense and sinks; warm air is less dense and rises.

As the sun warms the cool air near the surface of the Earth, the newly warmed air will rise; as the air rises, there is less weight exerted onto Earth from the atmosphere. This is called a low pressure system. Low pressure systems are often associated with times of stormy weather and high winds. This is because as surface temperatures rise, they also cause more water to evaporate from our oceans and other bodies of water. The rising warm air is full of water vapor; as the warm air rises, it is cooled by the upper atmosphere and causes the water vapor to condense and create precipitation. Low pressure systems are found on the boundary between warm and cold air masses. As warm air rises up, cold air rushes into the area of low pressure, causing strong winds. The more warm air rises, the stronger the winds. The stronger the wind, the more water evaporates. If this cycle continues over very warm water, storms and even hurricanes can form. The Earth's rotation adds to this and causes the winds to spin counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. This is known as the Coriolis effect.

High pressure systems are the opposite of low pressure systems. They form as cool air sinks. The sinking air exerts more force on the atmosphere near the surface of the Earth. High pressure systems are often associated with cool, dry, nice weather.