Cloud Formation

Strands		Force, Motion, and Energy; Matter
Topic		Investigating the atmosphere, clouds, and weather
Primary SOL	6.3	The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on Earth's surface. Key concepts include d) cloud formation.
	6.6	The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include e) the relationship of atmospheric measures and weather conditions,
Related SOL	6.1	The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which d) hypotheses are stated in ways that identify the independent and dependent variables; i) models and simulations are designed and used to illustrate and explain phenomena and systems.

Background Information

The water cycle plays an important role in determining climatic patterns. Water evaporates from the surface of the Earth, rises, cools, and condenses into rain, sleet, hail, or snow. Then, it falls again to the surface.

Clouds are important indicators of atmospheric conditions. Clouds form from warm, moist air that rises from Earth's surface as it is heated. This warm, moist air is less dense than cold, dry air, so it rises, gives off some heat energy, and starts to cool. As it cools, the water vapor changes into droplets of water or crystals of ice. These droplets collect around tiny bits of dust floating in the air. As the drops condense, a cloud is formed. Clouds are not gaseous water vapor; rather, they are minute, condensed water particles. When the water droplets or ice crystals become too heavy to remain suspended, they fall to the ground in the form of precipitation.

Clouds are found at various levels within the troposphere. Three major types of clouds are *stratus*, *cumulus*, and *cirrus*, which are recognizable by their shape and height.

- *Stratus clouds* form a layer or sheet across the sky. They are found at low levels in the troposphere and often produce light rain and drizzle.
- *Cumulus clouds* are found at different heights within the troposphere. They are individual, rounded clouds with fairly flat bases. They are often seen on dry, sunny days.
- *Cirrus clouds* are high-level clouds, usually found above 6,000 meters. They are made up of ice crystals and have a feathery, wispy appearance.

Many different combinations of cloud types may exist in the sky at the same time. Their names refer to the height at which the cloud is found and the type of cloud. For instance, the word *alto* in a cloud name indicates that the clouds are middle-level clouds, found between 2,000 and 6,000

meters. *Stratus* means layered, and *nimbus* indicates rain or snow is falling from the cloud; therefore, *nimbostratus* cloud is a low-level, layered cloud that is dropping precipitation.

Materials

- Clear, 1-liter plastic bottles with caps
- Cold and hot water
- Beakers
- Matches
- Zip-top plastic bags
- Ice
- Copies of the attached handouts
- Resource materials on cloud types

Vocabulary

alto, atmosphere, cirrus, condensation, cumulus, evaporation, nimbus, precipitation, stratus, troposphere, water cycle

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction

1. Review the water cycle, using the following questions:
   - If water absorbs radiant energy and increases in temperature, what happens to the water molecules near the surface? *(Due to the increase in energy, the liquid water molecules move from the liquid phase into the gas phase as they break free of other water molecules.)*
   - What do we call it when a liquid becomes a gas? *(evaporation)*
   - What does the warm water vapor do? *(It rises.)*
   - What happens to the water vapor as it rises higher in the atmosphere? *(It begins to cool.)*
   - What happens when the water vapor cools? *(The molecules move together to form droplets.)*
   - What do we call the process of water vapor becoming a liquid? *(condensation)*
   - What occurs due to condensation? *(Clouds form.)*
   - What happens when the droplets get too large? *(They can no longer be suspended and fall, due to their size. We call this precipitation: it rains.)*
   - What forms does precipitation take? *(Rain, sleet, snow, hail)*
   - What phases of water are present in the water cycle? *(Solid, liquid, and gas)*
2. Use the following "cubing" activity to facilitate a discussion regarding the water cycle. "Cubing" asks that the topic be probed from six different perspectives, as follows:
   - First, select a topic (an issue, person, idea, event, problem, object, or scene), and write it at the top of a sheet of paper to help keep it firmly in mind.
   - Then, take three to five minutes to write from each of the perspectives listed below. Start from what you know, but do not limit yourself: identify those areas that will need research and further thought, and speculate about where to find this information.

- Try not to sabotage yourself; that is, keep going until you have written about your topic from all six perspectives. As in free-writing, it is important to reread what you have written. Look for surprises, unexpected insights, and momentum.
  - *Describing*: Physically describe your topic. What does it look like? What color, shape, texture, size is it? Identify its parts. This will work nicely for the water cycle.
  - *Comparing*: How is your topic similar to other topics/things? How is it different? How is the water cycle similar to other cycles?
  - *Associating*: What other topic/thing does your topic make you think of? Can you compare it to anything else in your experience? Don't be afraid to be creative here; include everything that comes to mind. How does the water cycle relate to you and your life?
  - *Analyzing*: Look at your topic's components. How are these parts related? How is it put together? Where did it come from? Where is it going? How are the parts of the water cycle related? What are the stages in the water cycle?
  - *Applying*: What can you do with your topic? What uses does it have? How is the water cycle useful to humans? To nature?
  - *Arguing*: What arguments can you make for or against your topic? Present a scenario, and argue for or against the scenario being a part of the water cycle. For example, talk about a snowy day, and say that this represents the stage in the water cycle in which water molecules are evaporating. Others will have to argue against this idea and provide ideas to substantiate their views.

Procedure

1. Organize students into groups of four, and distribute copies of the attached Cloud Investigation handout and other materials to each group. Cooperative learning roles are optional.
2. Ask students to respond to the following question: "What conditions would need to be present in a bottle half-filled with water in order for a cloud to form in the bottle?" List on the board all reasonable answers, and create a class list of these independent variables they propose. Possible answers may include hot water, cold water, warm air, cold air. Through class discussion, help students understand that the temperature of the water will affect the temperature of the water vapor in the bottle. For example, they could not have hot water in the bottle and cool water vapor at the same time.
3. Instruct students to write a hypothesis to answer the question posed in step 2, for example, "If the water in the bottle is cooled, then the vapor inside the bottle will also cool, and a cloud will form."
4. Review directions for the experiment. Explain to students that only you may handle the matches. Also, explain that as soon as the match is extinguished and dropped into the bottle, the cap must be replaced immediately to trap the smoke.
5. Have students conduct the experiment and record their observations.

Observations and Conclusions

1. Use the following questions and student responses as a basis for class discussion:
   - Why was it necessary to shake the bottle? *(To saturate the air inside the bottle)*

- What did squeezing the bottle do? *(Increased the air pressure inside the bottle, which increased the air temperature. With the air heated, more water moved into the air, saturating it.)*
- What did releasing the bottle do? *(Decreased the air pressure, lowered the temperature, and caused condensation in the bottle)*
- Why was smoke added to the bottle? *(Smoke is made of tiny particles that act as condensation nuclei. They give the water something around which to condense.)*
- How did hot water affect the cloud formation? Explain. *(Hot water heated the atmosphere inside the bottle. When saturation was reached, more water condensed, and a larger cloud formed.)*

Assessment

- **Questions**
  - What ingredients are needed in order for a cloud to form?
  - How would you explain cloud formation?
- **Journal/Writing Prompts**
  - Write a story about a cloud formation from the perspective of a water molecule.
  - Make a flow chart to show how clouds are formed.
- **Other**
  - Have students write recipe cards for types of clouds, including lists of ingredients, directions for preparations that are specific for different elevations, and the sizes and numbers of servings that will be created.
  - Present a sock puppet show that compares the formation of different types of clouds.

Extensions and Connections (for all students)

- Have students participate in activities related to clouds and cloud types, available via NASA's *Ceres S'COOL Project.*

Strategies for Differentiation

- Have students create foldables to compare and contrast cloud types with relative weather conditions.
- Use a streaming video to show convection and cloud formation.
- Have students use the Internet to witness sequencing of cloud formation and to complete research on types of clouds.
- Invite a meteorologist to talk about cloud formation and the water cycle.

Cloud Investigation

Name: _____ **Date:** _____ **Class:** _____

Hypothesis

Materials

One-liter clear plastic bottle with cap, beaker for measuring, cold and hot water, matches, zip-top plastic bag, ice

Procedure

1. Pour 100 ml of *cold* tap water into the clear plastic bottle, and put the cap on tightly. Put ice into the zip-top bag, and seal.
2. Shake the bottle for 30 seconds, and set it on a table.
3. Squeeze the bottle, and then release it slowly. Repeat this process several times. Hold the ice bag around the top of the bottle.
   a. Do you notice anything different about the bottle? _____ If so, describe:

   b. Do you notice anything different inside the bottle? _____ If so, describe:

4. Remove the cap from the bottle.
5. With your teacher or another adult helping you, hold a burning match in the bottle's mouth.
6. Quickly squeeze and release the bottle to blow out the match and draw in the smoke.
7. Drop the match into the bottle and quickly replace the lid.
8. Squeeze and release the bottle several times, holding ice around the top of the bottle.
   a. What is different about the bottle now?

   b. Did a cloud form in the bottle? _____
   c. If a cloud did form, why did it form after you added smoke?

9. Clean out the bottle thoroughly.
10. Pour 100 ml of *hot* tap water into the bottle.

11. Repeat steps 2–8, using hot water.
    a. What happened differently this time?

    b. Was there a bigger cloud than before? _____
    c. If it was bigger, what do you think was the reason?

Reflection Questions

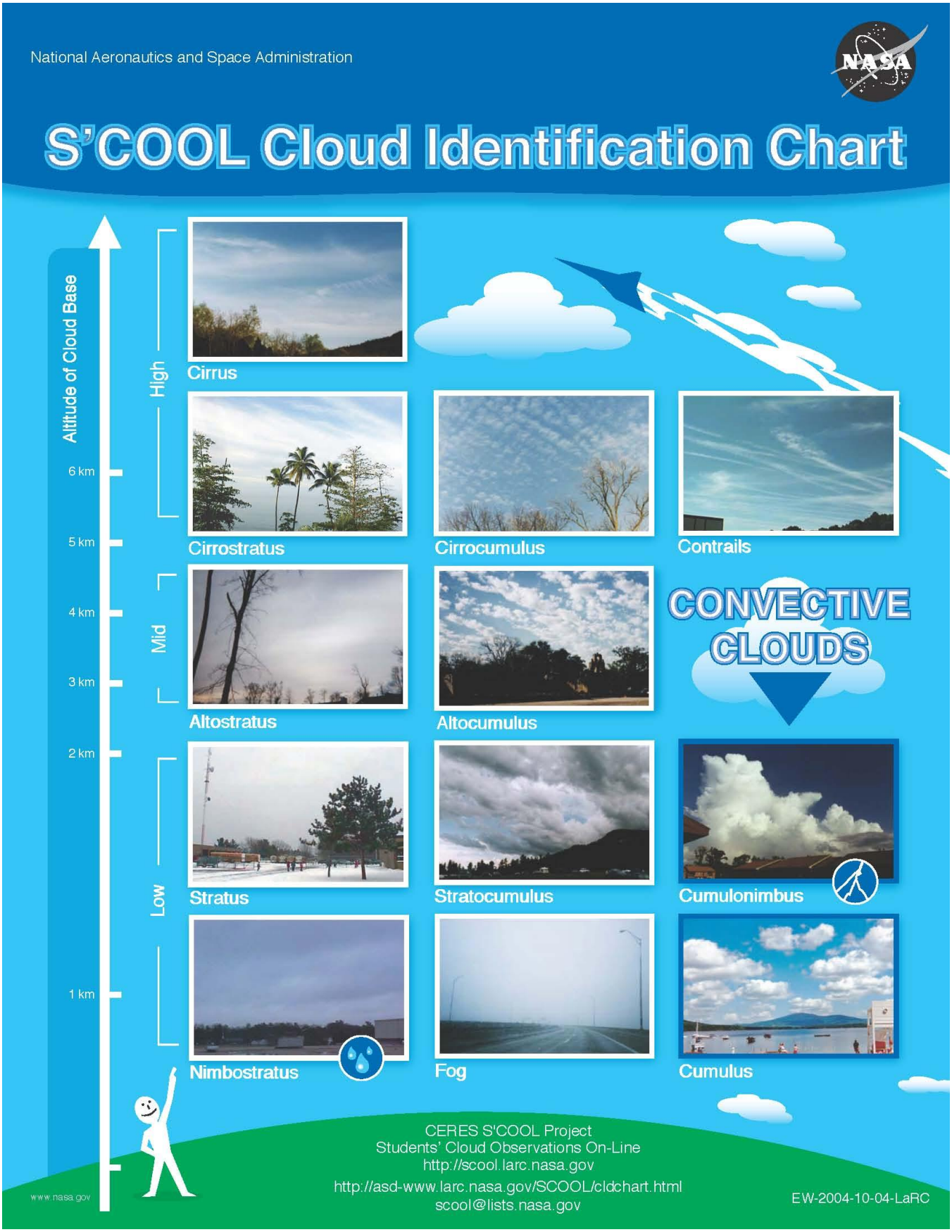
1. Why was it necessary to shake the bottle?

2. What did squeezing the bottle do?

3. What did releasing the bottle do?

4. Why was smoke added to the bottle?

5. How did hot water affect cloud formation?


National Aeronautics and Space Administration
S'COOL Cloud Identification Chart
Altitude of Cloud Base
6 km
5 km
4 km
3 km
2 km
1 km
High
Mid
Low
Cirrus
Cirrostratus
Cirrocumulus
Contrails
Altostratus
Altocumulus
CONVECTIVE CLOUDS
Stratus
Stratocumulus
Cumulonimbus
Nimbostratus
Fog
Cumulus
CERES S'COOL Project
Students' Cloud Observations On-Line
http://scool.larc.nasa.gov
http://asd-www.larc.nasa.gov/SCOOL/cldchart.html
scool@lists.nasa.gov
www.nasa.gov
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