Visibility

TEACHER SECTION

OBJECTIVES: To be able to explain the meteorological conditions necessary for fog and clouds to form; how visibility is affected by particles in the air; and, how visibility is related to air quality and/or weather conditions.

Visibility can be defined as the farthest horizontal distance at which prominent dark objects are visible against the horizon. Visibility is affected by the amount of pollution in the air, revealing much about the nature of the air mass over a location. In this investigation, students will have the opportunity to see how visibility, air quality, and weather are related. Students will create fog in a bottle, and they will learn that condensation nuclei is necessary for fog, clouds, and precipitation. Students may also consider the affect of increasing and decreasing the pressure in the bottle as well as adiabatic cooling. They will then model visibility by controlling the amount of particulate matter in an aqueous solution. By collecting field data and designing their own forms for recording data, they will also consider how visibility is affected by weather and pollution.

STANDARDS

PHYSICAL SCIENCE

Chemical reactions...such as the burning of fossil fuels releases large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as...the evolution of urban smog. (p.179)

In a sense, poor visibility is a sign of poor air quality. As with the environmental equity issues presented in Investigation Three (page 13), your students should consider the following question: Do I have a right to clean air? The fact that people continue to live in and move to large cities with poor air quality indicates that some people are willing to trade air quality for the benefits they derive from living in that city. Could this be used to justify a lack of effort to improve air quality, or the continued use of poor air quality technology? What about those who have no choice about where they live?

TIME MANAGEMENT

The first two parts of this investigation can be completed in two class periods. Observations for Part C should be collected over the course of several weeks. You will need a few minutes in several classes to disseminate collected data. Additional class time needed will depend on how you choose to complete this part.

CLASSROOM ORGANIZATION

Part A can be done as a demonstration or by groups of two to three students. Part B should be done in groups of two or three students, and Part C in groups of four or five.

SAFETY

This investigation requires using matches and working with electricity near water. In Part A, matches should be extinguished before students drop them in the bottle, and the contents of the bottle should not be inhaled. If more than one student uses the apparatus, disinfect the mouth of the bottle with alcohol, and rinse it with water. In Part B, make sure that students do not attempt to lift filled aquariums in order to empty them. You may also wish to check all lamps and wires before they are used.

DATA CHART 9.1

Part A Observations

TRIAL	CONTENTS UNDER INCREASED PRESSURE	CONTENTS UNDER NORMAL PRESSURE
Dry Air		
Moist Air		
Moist Air plus Smoke		

■ Part A

The amount of materials needed will depend upon whether the activity is done as a demonstration or by several student groups. Different bottles should be used for each demonstration/student group so that the activity can be done with a bottle of dry air. The results obtained using this apparatus to model fog formation can be enhanced in a darkened room using a flashlight or slide projector shining on one side of the bottle.

MATERIALS

4- to 5-liter glass jug or 3-liter plastic bottle (must have small top)
Sheet(s) of black construction paper (approximately 20 x 30 cm)
Large rubber band(s) or clear tape
Water
Matches
Alcohol
Paper towels
Flashlight(s) or other source of bright light
Wax pencil

PROCEDURE

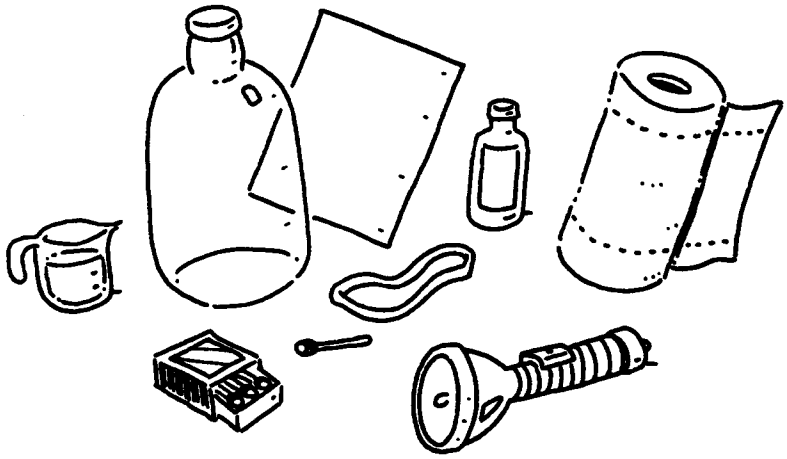
1. Use a rubber band or clear tape to secure a piece of black construction paper to one side of the bottle.

2. Blow into the bottle and observe what happens. Record your observations, including what happens when you stop blowing and remove your mouth.

3. Place about 1 cm of water in the bottom of the bottle and shake it vigorously. Repeat step 2. Record what happens when the contents of the bottle are under increased pressure, and when the pressure in the bottle is allowed to return to normal.

FIGURE 9.1

Part A Materials



4. Light a match, blow it out, and quickly drop it in the bottle. Repeat this two or three times until you are sure you have some smoke in the bottle. Observe what happens when you blow into the bottle and the air pressure is increased. Then observe what happens when the pressure returns to normal.

5. You may wish to increase the air pressure in the bottle again to see if the process of fog formation is reversible.

■ Part B

To save time, prepare liquid milk of a known concentration by mixing measured amounts of water and powdered milk. This investigation works best if done in a darkened room so that you can control light levels.

MATERIALS

Rectangular aquarium, approximately 25 x 50 cm and 25 cm deep
Large beaker or other container (at least 1,000 ml)
Dry powdered milk (approximately 500 ml)
Graduated cylinder (100 ml or larger)
Balance (optional)
Large wooden or plastic spoon for stirring
Desk lamp or other light source
Flashlight (optional)
Black construction paper
Clear tape
Marking pencil
Visibility Chart (see Figure 9.3, page 56)
Rubber or plastic tubing, approximately 75 cm long

PROCEDURE

1. Place the aquarium on a table near a sink with a water tap and drain, and position it so you can look through one side and one end. Do not plan to move the aquarium once it has been filled with water—doing so may cause it to leak or even break.

2. Fill the aquarium with water to about 2–3 cm from the top and mark the water level with a wax pencil. Place a desk lamp about 50 cm above the aquarium so it shines down on the surface of the water.

3. Tape a visibility chart like the one on page 56 on one end of the aquarium and another on a side. You may wish to use black construction paper to cover the remainder of the end and the side on which the charts were placed.

4. Place a measured amount of water in a large beaker. Stir the water and slowly add a measured amount of powdered milk until the mixture is completely opaque.

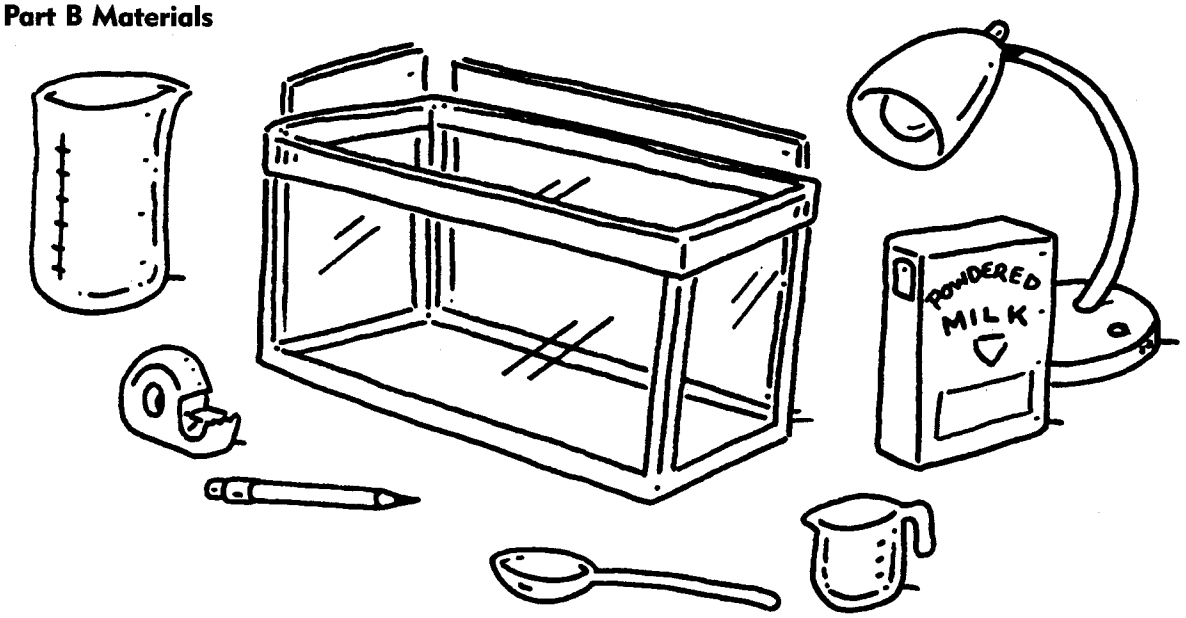
5. Add a measured amount of the liquid milk to the water in the aquarium and stir, with the light on above the aquarium. Observe the clarity of the water and the charts on the end and side of the aquarium. Record what you observe.

6. Repeat adding measured amounts of liquid powdered milk, while stirring, until none of the letters on either chart are visible. Record your observations for each addition of liquid powdered milk.

7. Darken the room as much as possible, and shine a flashlight, or other focused light beam, into one end of the aquarium. Record your observations.

8. Use a rubber or plastic tubing to siphon out the contents of the aquarium. Do not attempt to lift or tip a filled-aquarium.

FIGURE 9.2
Part B Materials



■ **Part C**

You will need to determine the number of observation days in this trial, and how often observations should be made. The observations themselves can be done in five to ten minutes, depending on the distance from the classroom to the observation sight. (If possible, you might choose to have the groups record their observations immediately after or before school.) Before beginning, decide what the final product of this part will be and whether you wish to use technology in recording student observations.

PROCEDURE

1. In class, select landmarks at various distances and in different directions, which can be seen from the school on a clear day. Use maps to determine their distance and direction from the school.

2. Using the scale in Figure 9.4, record visibility estimates from the same place at the same time each day. Then, record the following data for each landmark:

- ▶ Location of observation
- ▶ Date
- ▶ Time
- ▶ Direction of observation

3. Record weather and pollution information for each visibility estimate. This data should be collected from a newspaper, the local news, or the Internet.

- ▶ Temperature
- ▶ Barometric pressure
- ▶ Relative humidity
- ▶ Wind speed and direction
- ▶ Sky cover
- ▶ Precipitation
- ▶ Pollution levels

EXTENSIONS

■ **Part A**

1. After completing Part A, place the lid on the bottle and let it stand for several days or weeks. What happens when you blow into the bottle and then remove your mouth so pressure inside the bottle returns to normal? If fog appears when you remove your mouth, is the fog as dense as when it was earlier just after the smoking matches were placed in the bottle?

2. Alter the apparatus so that the pressure inside the bottle is decreased rather than increased by blowing. This can be done by attaching a pump to the mouth of the bottle and removing a little bit of the air. Do not inhale contents of bottle. What happens to the contents of the bottle when the pressure is decreased? When the pump is removed and the pressure inside the bottle returns to normal? Are these results different than those obtained when you blew into the bottle and then let the pressure return to normal?

3. Design a new experiment to test other combinations of air, water, and smoke.

■ **Part B**

1. Have students consider ways to modify this part to make it more representative of what happens in nature, and to remove any biases. For example, rearrange the letters on the visibility chart so large and small letters are found on each line. Are some letters more visible than others? Does location matter? They may also choose to create a new visibility chart on different colored paper. Several colored sheets can be attached to the aquarium and observed at the same time. Does color affect visibility?

■ **Part C**

1. Instead of gathering weather data indirectly, set up a weather station.

2. Have students use field glasses or a small telescope to make their visibility estimates. They can also use a camcorder to make a permanent record of conditions on a particular day, or take photographs using a digital camera and store the images on a computer.

ASSESSMENT

Develop a rubric to evaluate student ability to: design and implement an experiment based on the assigned objective and supplied materials; understand what fog is, and how it is created; understand and explain the relationship between visibility and air quality; collect, organize, and disseminate field data.

Sample Data Sheet for Student Observations

Dimensions of aquarium _____ cm x _____cm x _____cm

Amount of powdered milk used to make liquid milk _____ ml or gm (specify which unit)

Amount of water used to make liquid milk _____ ml

Amount of liquid milk added to aquarium during each trial _____ ml

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Clarity of Contents of Visibility Chart

VISIBILITY OF CHART

	AQUARIUM CONTENTS	ON THE SIDE	ON THE END
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			
Trial 6			
Trail 7			
Trial 8			
Trial 9			
Trial 10			
Trial 11			
Trial 12			