Name ______________________________ Date _______________ Class ___________

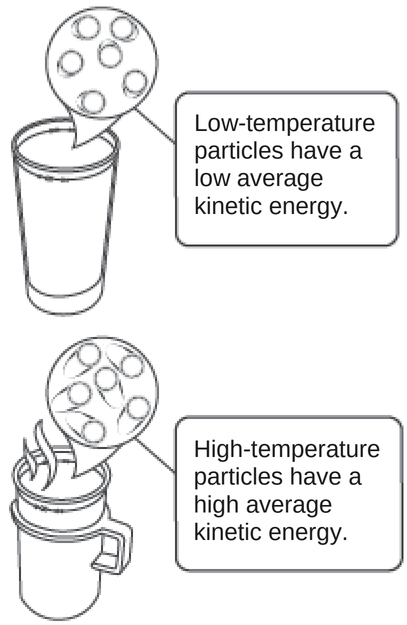
PRE LAB

Build Your Own Thermometer

Reviewing Content

The particles of matter are in constant motion. The energy of motion is called kinetic energy, so the particles of matter have kinetic energy. As matter becomes warmer, its particles move faster. As a result, their kinetic energy increases. Temperature is related to kinetic energy. As temperature increases, kinetic energy also increases.

One way to measure the temperature of matter is to place a thermometer in contact with it. Some of the matter's kinetic energy is transferred to the thermometer if the matter is warmer than the thermometer. The increased kinetic energy causes the particles of the liquid in the thermometer to move farther away from each other. As a result, the liquid in the thermometer expands and rises up the tube. If the matter is colder than the thermometer, the thermometer loses energy to the matter. This makes the particles of the liquid in the thermometer move closer to each other, causing the liquid to contract and drop in the tube.



Reviewing Inquiry Focus

When you analyze a model, you determine how well the model can be used to predict what happens in the real world. In this lab, you will put together a combination of materials that simulates how a real thermometer works. Then you will test it to see if it behaves like a real thermometer when it is placed in contact with warm water and then cold water. With these statements in mind, preview the Lab Investigation. Then answer the questions.

1. How do you expect the water level to change when the apparatus is placed in warm water? In cool water?

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2. If you had a real thermometer that was accurate, how could you modify your experimental thermometer to read actual temperatures?

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Name ______________________ Date ______________ Class ____________

DIRECTED Inquiry — 45 min

Build Your Own Thermometer

Problem

INQUIRY FOCUS
Analyze Models and Systems

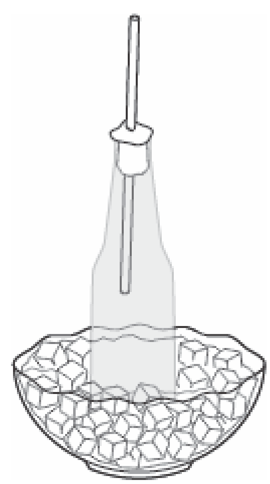
Can you build a thermometer out of simple materials?

Materials

- bowl of hot water
- bowl of ice water
- water of unknown temperature
- tap water
- 600-mL beaker
- clear glass juice or soda bottle, 20–25 cm tall
- clear plastic straw, 18–20 cm long
- food coloring
- plastic dropper
- cooking oil
- modeling clay
- metric ruler
- fine-point marker

Procedure

1. Mix four drops of food coloring into a beaker of tap water.
2. Fill the glass bottle with the colored water.
3. Use a dropper to adjust the level of colored water in the bottle so that it is completely full to the top of the bottle.
4. Place a straw in the bottle. Use modeling clay to position the straw so it extends at least 10 cm above the mouth of the bottle. Do not let the straw touch the bottom. The clay should completely seal off the bottle's mouth. Make sure there is as little air as possible in the bottle.
5. Using a dropper, add colored water into the straw to a level 5 cm above the bottle.
6. Place a drop of cooking oil in the straw to prevent evaporation of the water.
7. Place your thermometer into a bowl of hot water.
8. When the colored water reaches its highest level, use the fine-point marker to place a mark on the straw.
9. Place your thermometer in the bowl of ice water.



10. Place a mark on the straw when the water reaches its lowest level.

11. Create a scale for your model thermometer. Divide the distance between the two marks into 5-mm intervals. Starting with the lowest point, label the intervals on the straw 0, 1, 2, 3, and so on. Describe your scale below.

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12. Measure the temperature of two unknown samples with your thermometer.

13. Record both temperatures using the scale on the straw.

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Analyze and Conclude

1. **Analyze Models and Systems** Do you think your model accurately represents an alcohol thermometer? How is it like a manufactured thermometer? How is it different?

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2. **Infer** How can you use the concepts of matter and the kinetic energy of particles to explain the way your model works?

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3. **Measure** Approximately what Celsius temperatures do you think your model measures? Explain your estimate.

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4. **Redesign** Examine the structure and materials used in your model. Propose a change that would improve the model. Explain your choice.

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Name ______________________ Date ______________ Class ____________

DIRECTED Inquiry — Lab Investigation

POST LAB

Build Your Own Thermometer

1. **Draw Conclusions** In terms of thermal energy and heat, describe what happened when you placed your model thermometer in warm water.

2. **Infer** Do you think your model thermometer would be practical for measuring the temperature of small amounts of material? Explain.

3. **Summarize** Describe what you learned about how thermometers work and how they relate to the kinetic energy of particles of matter. List any questions you still have.

What I learned

What I still want to know

Communicate

Create a brochure to show how an alcohol thermometer works. Explain how the Celsius and Fahrenheit scales compare. For example, does 0° have the same meaning on each scale? What is normal body temperature on each scale? Use a diagram with labels and captions to communicate your ideas.

Name ______________________ Date ______________ Class ____________

OPEN Inquiry — 45 min

Build Your Own Thermometer

Problem

Can you build a thermometer out of simple materials?

INQUIRY FOCUS
Design a Solution, Evaluate the Design

Materials

- bowl of hot water
- bowl of ice water
- water of unknown temperature
- tap water
- 600-mL beaker
- graduated cylinder
- clear glass juice or soda bottle, 20–25 cm tall
- clear plastic straw, 18–25 cm long
- food coloring
- plastic dropper
- cooking oil
- modeling clay
- metric ruler
- fine-point marker
- alcohol thermometer

Design an Experiment

1. You are a geologist who wants to determine which of two springs is warmer. They are both too acidic to touch. Design and make a thermometer that will allow you to tell which liquid is warmer.

Part 1: Finding the Right Container Type

2. The levels in liquid thermometers change because liquids typically expand when they are heated and contract when they cool. However, these changes may be too small to easily see. First, you must determine what shape of container will allow you to better observe small changes in volume. Fill your graduated cylinder and your 500-mL beaker each halfway with water.
3. Add small amounts of water to each container. Observe what happens.
4. Based on observations, will it be easier to see small changes in a tall, thin container, or in a wide container?

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Part 2: Designing a Thermometer

5. ⚠ Work with your partner to design a thermometer. Keep in mind:

   - **a.** Food coloring can make water more visible.
   - **b.** Most thermometers consist of a narrow column and a bulb that feeds into the column. The bulb contains a large volume of water that expands into the column when heated.
   - **c.** The liquid in your thermometer should have no air bubbles.
   - **d.** A drop of cooking oil can be placed in your thermometer to prevent evaporation.

6. Draw your design in the space below.

Design

7. Have your teacher check your thermometer design. Then, build your thermometer.

8. Place your homemade thermometer in the bowl of hot water. Use the fine-point marker to mark the level that the water in your thermometer reaches.

9. Place your homemade thermometer in the bowl of cold water. Mark the level that the water in your thermometer reaches.

10. Using the manufactured thermometer, determine the actual temperatures, in °C, of the bowls of hot and cold water. Record them below.

Hot water: ____________ Cold water: ______________

11. Write these values next to the marks you made on your homemade thermometer in Steps 8 and 9.

12. Using the information from Step 10, determine a rough scale for your homemade thermometer. Make and label appropriately spaced marks along the side of your homemade thermometer so you can measure any temperature between those of the hot water from Step 8 and the cold water from Step 9.

13. Using your homemade thermometer, work with your partner to determine the temperature, in °C, of the bowl of water of unknown temperature. Record your result. ______________

14. Check your result with the manufactured thermometer.

Temperature according to manufactured thermometer: ______________

Analyze and Conclude

1. **Design a Solution** How did you use the two readings from the bowls of hot and cold water to determine the temperature of the unknown bowl of water?

2. **Evaluate the Design** Did your thermometer provide an accurate reading of the unknown water temperature? How could you design a more accurate thermometer?

3. **Observe** How is your thermometer like a manufactured alcohol thermometer? How is it different?

4. **Infer** Use the concepts of matter and the kinetic energy of particles to explain how your model works.

Name ______________________ Date ______________ Class ____________

OPEN Inquiry — Lab Investigation

POST LAB

Build Your Own Thermometer

1 **Evaluate the Design** What are the temperature limits of your thermometer in °C? Do alcohol thermometers have the same limits? Why or why not?

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2 **Design a Solution** Imagine you are cooking with a frying pan. Once it gets hot, you cover it with a lid, and the lid makes a complete seal around the frying pan. Within 2 minutes, the lid becomes stuck to the the frying pan, with your food inside! In terms of matter and kinetic energy, how did the lid become stuck to the pan? How could you fix this problem? *Hint: The lid is like a suction cup.*

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3 **Summarize** Describe what you learned about how thermometers work and how they relate to the kinetic energy of particles of matter. List any questions you still have.

What I learned ______________________________

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What I still want to know ______________________________

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Communicate

Evaluate the Design Join with another set of partners in your class. Compare and contrast your thermometer designs. Examine the data collected from both thermometers and decide which group built a better thermometer. What aspects made this thermometer better? Be prepared to share your results with the class.