Taking Temperatures

Summary:
Students use a thermometer to investigate how shading, coloring and other factors affect temperature.

Grade Level: 4-8

Subject Areas: Science, Mathematics, Environmental Literacy

Setting: Classroom and outside on a sunny day

Time:
Preparation: 30 minutes
Activity: 60 minutes

Vocabulary: Celsius, Centigrade, Degree, Fahrenheit, Heat (thermal) energy, Kinetic energy, Molecule, Temperature, Thermometer, Bulb, Hypothesis, Control

Major Concept Areas:
- Natural laws that govern energy
- Energy flow in nonliving systems
- Quality of the environment

Connections to Standards:
Wisconsin Standards for Science
- CC2: Cause and Effect
- SEP3: Planning & Conducting Investigations
- SEP4: Analyzing & Interpreting Data
- DCI: ESS2.D: Weather & Climate

Wisconsin Standards for Environmental Literacy and Sustainability
- Connect; Standard 1
- Engage; Standard 6

Objectives
Students will be able to
- use a thermometer to measure and record the temperature in a variety of locations
- describe how heat energy affects temperature
- describe the role of CO_2 as a greenhouse gas

Rationale
Understanding temperature gives students greater insight into the properties of thermal energy.

Materials **(K)**=materials in DEN Kit
- 2 jars of water (same size / temperature) & saran wrap lid **(K)**
- Container of hot water and container of cold water
- red/blue dye (optional)
- **Thermometer Student Sheet**
- **Reading Thermometers Student Sheets**
- **Taking Temperatures Student Sheet**

Each group of students will need:
- Thermometer **(K)**
- Container of hot water
- Container of cold water
- Ruler (cm) **(K)**

Background
What if you asked someone if it was hot outside, and they responded, "The air molecules are moving around faster than they were yesterday!" How would this help you know what the weather is like? Temperature is actually a measurement of how fast molecules move back and forth. Molecules move faster when they have more energy. The faster molecules move around, the higher the temperature. So if air molecules are moving around faster today than yesterday, today's temperature is higher.

A thermometer is a tool for measuring temperature. A thermometer is usually composed of a tube that contains alcohol colored with red dye. The base of the thermometer, where the liquid settles, is called the **bulb**. Air molecules hitting against the bulb cause molecules of the liquid alcohol to move faster. This is similar to when one ball strikes another, causing the second to move (energy of motion—kinetic energy—is transferred from the first ball to the second). Faster moving molecules need more space than slower moving ones, so the liquid will climb up the tube as it expands. NOTE: The thermometer measures molecular movement, but it does not measure the total amount of heat energy there is in a substance (see Temperature, Thermal Energy and Heat).

To provide consistent measurements of temperature, scientists developed a scale. The scale is like a ruler that divides temperature into equal increments. Instead of inches or centimeters, the increments for thermometers are called degrees. The symbol for degree is °. The scale most commonly used around the world and by scientists is Celsius or Centigrade (C). To develop this scale, the freezing point of water was given a temperature of zero degrees Celsius (0 °C), and the temperature of boiling water was recorded as 100 degrees Celsius (100 °C). Then the scale was divided into even increments between zero and 100. In the United States, a scale called Fahrenheit (F) is used. On this scale, freezing is 32 degrees F and boiling water is 212 degrees F.

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Getting Ready:

Educators:

Day prior: Fill the 2 jars with water and leave them out (uncovered) overnight so that on the day of this activity the water will be at/close to room temperature. Make sure you have a saran wrap lid for one jar on the day of the activity.

If possible, obtain thermometers with plastic frames, large numbers, and easy-to-read scales. All thermometers should have the same scale, preferably Celsius (Centigrade). A possible source for thermometers is your local high school science department. **Caution: Use thermometers with red liquid alcohol filling (not mercury [silver]), which is a toxic substance.**

On the day of the activity, make sure you have a source of hot and cold water. It may help students if you dye the hot water red and the cold water blue. *Note: It takes time for thermometers to return to ambient air temperature. During the activity discuss this with students. Instruct students to use the container of liquid left overnight to return their thermometer to ambient air temperature more quickly between trials.*

Students:

Day prior: The day before this activity, ask students to listen to the weather report the next morning or to ask a family member what the temperature for the day is expected to be.

One of the reasons people want to know the temperature of substances such as the air is so they can make decisions. For instance, knowing air temperature helps people decide what clothes to wear. Therefore, when you hear that the air molecules are moving faster today than they were yesterday, you know that today is a warmer day than it was yesterday. So you'd better dress appropriately!

Procedure

Orientation

The day before this activity, ask students to listen to the weather report or to ask a family member what the temperature for the day is expected to be.

Discuss different types of weather with students. If available, read trade books about weather (see **Resources**). Note if students use the term "temperature." Hold up a thermometer and ask students if they know what it is and what it is used for. Emphasize that the purpose of the thermometer is to measure temperature (or how hot or cold something is).

To help students get a basic understanding of temperature, show or ask students to think of a pan of cold water and one that is boiling. Without being able to feel the water, how would they describe the difference between the two pans of water? Students should note that they can see more movement in the pan of boiling water. Remind students that movement is evidence of energy.

Water is actually made up of tiny particles called molecules. Molecules are moving very fast when water boils. Explain that although we can't see them, the air contains tiny particles (molecules) that move around too. Ask students to imagine how the molecules in warm air would move compared to the ones in cold air. They should say that molecules in warm air move faster because the molecules contain more energy. NOTE: Stress that the molecules are moving randomly back and forth around the students and that warm air is not necessarily windy air; wind is a mass of air molecules moving primarily in the same direction.

Tell students that a thermometer measures how fast molecules are moving. The molecules can be in water, air, or our bodies. When the moving molecules hit the bulb of the thermometer, it makes the molecules of the liquid inside move faster. The moving molecules need more room, so the liquid flows up the tube.

Physical Activity: Have students stand up and pretend they are air molecules. Air is a gas so the molecules move around the room. Tell students the air is cold. How should they move? Very slowly. Now tell students the air is heating up. The molecules move faster. Students may notice they need more room to move around quickly than when they moved slowly. Announce that the air is cold again and have students return to their seats.

Taking Temperatures

Steps for Educators

1. Show students the Thermometer Diagram or draw a large picture of a thermometer on the board and tell students the basic parts of the instrument. These include the tube, scale (degrees Celsius or Fahrenheit), bulb and the red liquid inside the tube.
2. Ask students if they know what the lines and numbers represent. Introduce the term "degree" and explain the degree scale. In other words, explain what the space between two lines represents (one degree, two degrees, five degrees). NOTE: You may want to introduce terms "Centigrade," "Celsius" and "Fahrenheit," and the symbol for degree (°). Explain to students that Celsius is used over centigrade today but that the Celsius scale IS a centigrade scale (with 100 degrees between the freezing point and boiling point of water).
3. Draw a line across the tube of the Thermometer Diagram and tell students what temperature this represents. Draw lines at other locations within the thermometer and have students report what temperature the line represents. Students can also complete the **Reading Thermometers** sheet.
4. Demonstrate how to properly use a thermometer:
    - The bulb should only touch what is being measured (if the bulb is not touching anything it is measuring air temperature)
    - Each time you measure something, hold the thermometer in place for at least one minute or until the red liquid alcohol stops moving
    - Allow thermometer to return to room temperature before a new measurement is taken (you are waiting for the red liquid alcohol to move back down the tube)
    - **Hint:** Keep your hands away from the bulb, otherwise you will measure the temperature of your hand rather than what is intended
5. Provide students with the following safety tips:
    - Handle the thermometers carefully
    - Always walk when carrying a thermometer
6. Divide students into groups of two or three. One student can be responsible for collecting materials, another for using the equipment and a third for recording information. However, each student should practice using the thermometer at some time during the activity. Model how to use the thermometer a few times prior to letting students practice.

Resources:

All About Weather; Way Cool Science
https://www.youtube.com/watch?v=XxELVix36tI

Global warming and greenhouse effect background (from Climate Science Concepts Fit Your Classroom)
http://scifun.org/ClimateWorkbook/greenhouse-effect.html

Related KEEP Activities:

There are many opportunities throughout the school year for students to continue their temperature measuring skills. One avenue is through studying seasonal changes.

K–5 Energy Sparks for Theme II: "Sunvestigations" describes teaching ideas for investigating how the sun's position in the sky changes throughout the year. Students can also monitor these changes through temperature readings. Build a solar cooker and have students compare temperatures inside and outside the box (see "Shoebox Solar Cooker").

The activity "Exploring Heat" lists several suggestions for learning more about heat. Make sure students understand the difference between heat and temperature (see **Temperature, Thermal Energy, and Heat**).

Credit:

Adapted from KEEP Taking Temperatures K-4 lesson; KEEP Staff, 2023.

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Steps for Students

7. Students responsible for collecting materials should get a copy of **Taking Temperatures, Student Sheet** and a thermometer. They should also obtain containers of hot and cold water, and a ruler.
8. Instruct students to hold the thermometer about 15 cm (6 inches) in front of their eyes while seated. They should wait a minute and record the temperature in the correct location on their student sheet (air inside the classroom). Check around the room to see if temperatures are being read correctly. Tell students that this is room temperature and their thermometer should be near this temperature before they measure anything else. Students may notice that temperatures vary throughout the room. Ask students what this means about the movement of the air molecules around the room. (It varies throughout the room). NOTE: If you set up a container of water the day before, you can instruct students to use this to return their thermometer to room temperature after each trial.
9. Provide students with the following directions: Place your thermometer in the container of cold water and observe what happens to the red liquid. Hold the thermometer in the water (not touching the sides of the container) until the red liquid stops moving. Record the temperature in the correct location on their student sheet. Use the room temperature water jars to return your thermometer to room temperature. Repeat the process using hot water.
10. Instruct students to put away their containers of water but keep their thermometer and rulers. Once this is done, draw student attention to the jars of room temperature water. Ask student volunteers to take the temperature of the water in both jars. Have all students record this on their student sheet.
11. Put both jars in a sunny (or warm) location next to each other in the classroom. Put a lid (plastic wrap)on one jar.

Head Outdoors

12. Take the class outside. Groups should bring along their thermometer and ruler. Discuss what the air outside feels like. Encourage students to note how the sun warms their skin and casts shadows. **Caution: Students should never look directly at the sun.**
13. Ask students to guess what they think the temperature is. Instruct them to record this guess on their activity sheet ("Guess / Hypothesis" column). Explain that scientists use guesses to guide their investigations and their incorrect guesses often lead to better understanding.
14. Instruct students to take the temperature of the air outside about 15 cm (6 inches) in front of their face (preferably while standing in the sunshine) and record this measurement on their student sheet in the "Actual Temperature" column. Tell students this is the **control**, or first, air temperature measurement.

Main Activity

15. Tell each group to find a location where they think the air will be warmer than the control, or first, air temperature. This location may be near the ground, by a tree, close to a window, above the pavement, etc. When they have found a spot, they should draw or describe the spot on their activity sheet and explain why they think the air will be warmer here. They should consider shade, color, moisture, etc. They should also record a guess or hypothesis of what they think the temperature will be.
16. When all groups have found a location, instruct the groups to take the temperature and record the measurement. Make sure students measure the temperature of the air and do not put the thermometer directly on a surface. Remind students to hold the thermometer about 2-3 cm (1 inch) away from the surface they are measuring.

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16. If they are not measuring a surface and instead are just measuring air, they can measure 15 cm (6 inches) in front of their eyes.
17. Repeat this process for a spot where they think the air will be cooler.
18. Return to the classroom.

Climate Connection

19. Draw students' attention to the room temperature jars (1 with a lid and the other without a lid). Ask them what they think the temperature of the water in each jar will be now. Have them record a guess / hypothesis and explanation why on their student sheet.
20. Uncover the covered jar and have the same students who measured the temperature of the jars of water before heading outside measure the temperature of each jar now. Have students record these temperatures on their student sheet. Recover the jar that was covered.

Temperature, Thermal Energy and Heat

Thermometers measure temperature; they measure the level or degree of thermal energy in a substance. In other words, they measure how fast the molecules that make up the substance are moving. The molecules move faster in hot objects than they do in cooler materials. So, a thermometer helps us understand how hot or cold something is by letting us know how fast (the degree to which) its molecules are moving. The unit of measurement in a thermometer is degrees.

To measure the total amount of thermal energy in a substance, a different instrument is needed. A calorimeter determines the total quantity of energy contained in all the moving molecules within a substance. The measurement unit for thermal energy is calories.

For example, let's say you put a large pot of soup on the dinner table. If you remove one ladleful of the soup, the temperature of the soup in the pot and in the ladle will be the same because the molecules in both are moving at the same rate. The large pot of soup has more thermal energy, though. This difference in thermal energy is simply because there is more soup in the pot—the more soup, the more moving molecules, the more thermal energy. Proof of this is seen after some time has passed. The ladle of soup (with less thermal energy) cools off more quickly. The pot of soup will stay warm longer because it has more thermal energy.

Both soups will eventually cool down, of course. This is because of heat energy moving from the hot soup to the cooler surrounding air. Heat is the transfer or flow of energy from one object to another (such as from the hot soup to your tongue or from a radiator to the surrounding air). When something is "heated" this means energy flowed into it. You can measure the change in temperature by using a thermometer to record how fast the molecules are moving now compared to before the heat transfer. It is incorrect, however, to say a thermometer measures heat.

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Closure/Reflection

After all measurements are complete, have students think about and try to answer the questions in Part 1 of the reflection sheet. Discuss the questions as a class.

Use this information on this page to facilitate a discussion of questions 1 - 3 of the student reflection sheet where students compare sets of measurements from the various locations outdoors and what contributes to differences or similarities in measurements. *Surfaces that are receiving direct sunlight may be warmer. Students may notice that the air near dark-colored surfaces is warmer than a surface that has a light color. Students should find that shaded areas are cooler than locations in direct sunlight. Throughout the discussion, emphasize how the heat from the sun makes the molecules in air move faster.*

Use this information to facilitate a discussion on the results of the experiment with the two jars. *If enough time has passed, the water in the jar with a lid should be warmer than the water in the jar without a lid. The lid represents the greenhouse gases in Earth's atmosphere. Greenhouse gases are like a blanket that absorbs infrared radiation from the sun. This warms the Earth's surface and atmosphere. This is called the greenhouse effect. The greenhouse effect is what makes Earth's temperature suitable for life.*

A good diagram that shows the Greenhouse Effect can be found at: https://energyeducation.ca/encyclopedia/Greenhouse_effect

Explain to students that while Earth relies on greenhouse gases to have temperatures that are capable of sustaining life, human activities have raised the atmosphere's carbon dioxide (a greenhouse gas) content by 50% since the start of the Industrial Age (18th Century). *Source: NASA Global Climate Change Vital Signs of the Planet https://climate.nasa.gov/vital-signs/carbon-dioxide/)* Ask students if they know HOW humans have increased the amount of CO_2 in Earth's atmosphere. Share that burning fossil fuels for electricity, heat and transportation is the largest source of CO_2 emissions in the United States. *Source: US EPA Sources of Greenhouse Gas Emissions https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#:~:text=The%20largest%20source%20of%20greenhouse,electricity%2C%20heat%2C%20and%20transportation.*

Have students think about and try to answer the questions in Part 2 of the reflection sheet. Discuss the questions as a class.

Use this information to facilitate a discussion about part 2, question 7 of the student reflection sheet. *If more greenhouse gases (CO_2) build up in Earth's atmosphere, Earth's temperature will get even warmer and the trends we have seen happen due to climate change will continue to increase.*

Use this information to facilitate a discussion about questions 8-10. *Increasing temperatures can cause built environments (like black top surfaces) to get even hotter which may impact student comfort when playing, exercising or being in these areas. Depending on what students enjoy doing outdoors, increased temperatures can also have an impact on those activities. For example, an increase in winter temperatures can cause snow to melt faster or more precipitation to fall as rain than snow. This would impact anyone who enjoys participating in snow-related activities that depend on temperatures below freezing. On the other end, increased temperatures during the summer can make it less comfortable to participate in outdoor activities.*

Plants are unable to "get up and move" if the environment they live in becomes less habitable. This can impact animals who depend on plants for food and/or shelter. If waterways aren't connected, fish cannot move to find cooler waters. While other animals may be able to move to cooler areas, those areas may not have the food, shelter, etc that they need to survive. Warmer temperatures also allow species adapted to warmer climates to expand their ranges into Wisconsin. Invasive species may be able to tolerate warmer temperatures better than native species.

Use this information to facilitate a discussion about question 11. *People can reduce the amount of fossil fuels they use by implementing more energy efficient practices (turn off lights, use power strips, lower the thermostat, insulate, use public transportation, carpool, etc). People can also opt to use different sources of energy, specifically renewable sources like Solar, Wind, Geothermal, and Hydro.*

Taking Temperatures

Assessment
Formative

- Can students read a thermometer correctly?
- Did students use the thermometer correctly?
- Are students able to describe how heat energy affects the movement of molecules? *Increased heat energy increase motion of molecules*
- Are students able to explain what they are measuring when they take a temperature? *Temperature is a measure of how fast the molecules in an object are moving*

Assessment
Summative

Conduct an ice cube melting contest. Have students identify a spot where they think the ice cube will melt the fastest and record why. They should develop a cause-effect statement such as "My ice cube will melt the fastest when I place it ___ because ___.

Extensions

Have students create a data table and measure and record the temperature outdoors at a specific time and place daily for a week.

Encourage students to use metric measurements in their daily lives. Help students associate particular Celsius (centigrade) temperatures with familiar activities or objects. For example, what is the average body temperature? What are today's high/low temperatures? How warm would you want water to be before you would swim in it?

Show students different types of thermometers such as candy, meat, freezer, etc.

North American Association of Environmental Educators (NAAEE) Environmental Education Materials: Guidelines for Excellence

KEEP strives to create lessons that meet the NAAEE Environmental Education Materials: Guidelines for Excellence. This lesson meets the following guidelines under the six key characteristics of high-quality environmental education instructional materials.

- 1.1 Accurate
- 2.1 Thinking and process Skills
- 2.4 Skills for addressing environmental challenges and opportunities
- 3.1 Awareness
- 3.2 Focus on concepts
- 3.3 Concepts in context
- 4.1 Sense of personal stake and responsibility
- 5.1 Learner-centered instruction
- 5.2 Different ways of learning
- 5.3 Connections to learners' everyday lives
- 5.4 Expanded learning environment
- 5.7 Goals and objectives
- 5.8 Appropriateness for specific learning settings
- 5.9 Assessment
- 6.1 Clarity and logic
- 6.2 Easy to use
- 6.3 Long lived
- 6.4 Adaptable
- 6.5 Accompanied by instruction and support
- 6.6 Make substantiated claims

Student Sheet
Thermometer Diagram
Temperature, Thermal Energy and Heat

Temperature, Thermal Energy and Heat

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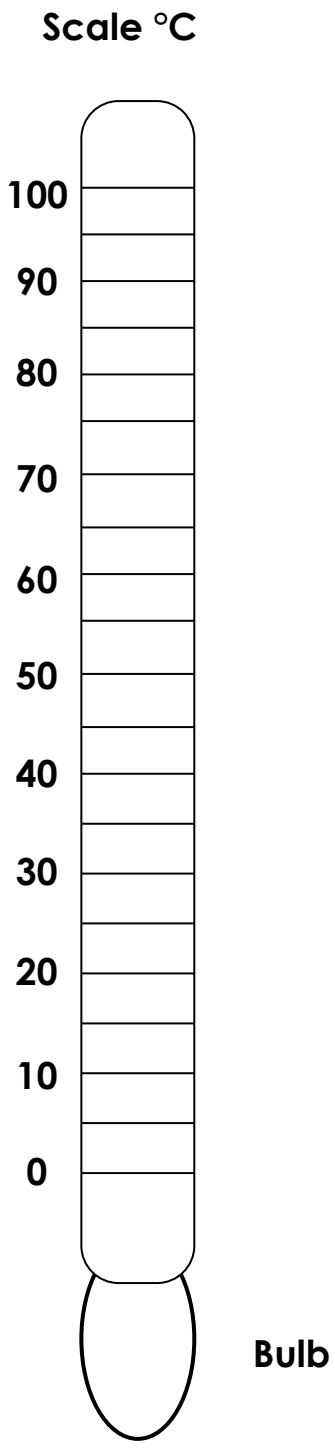
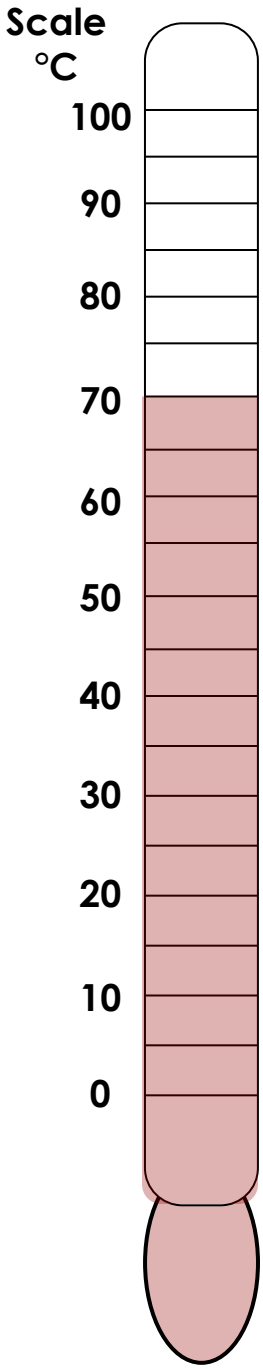
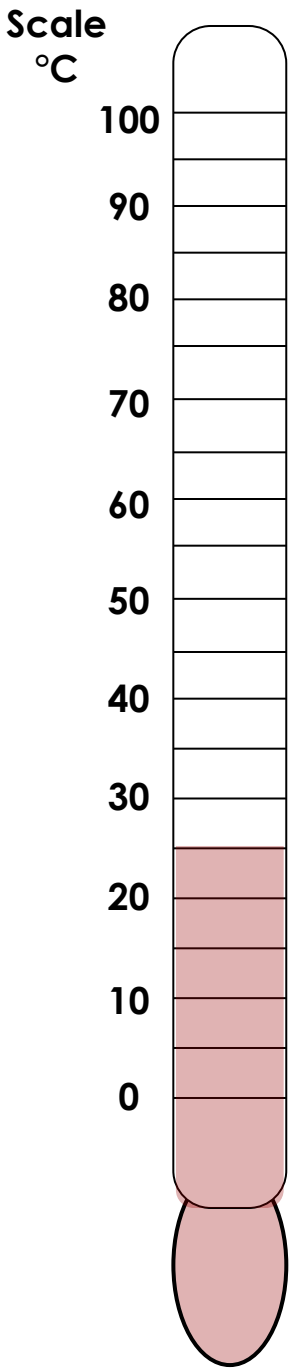


Reading Thermometers Student Sheet



What temperature does the thermometer read? Include units.

_____



What temperature does the thermometer read? Include units.

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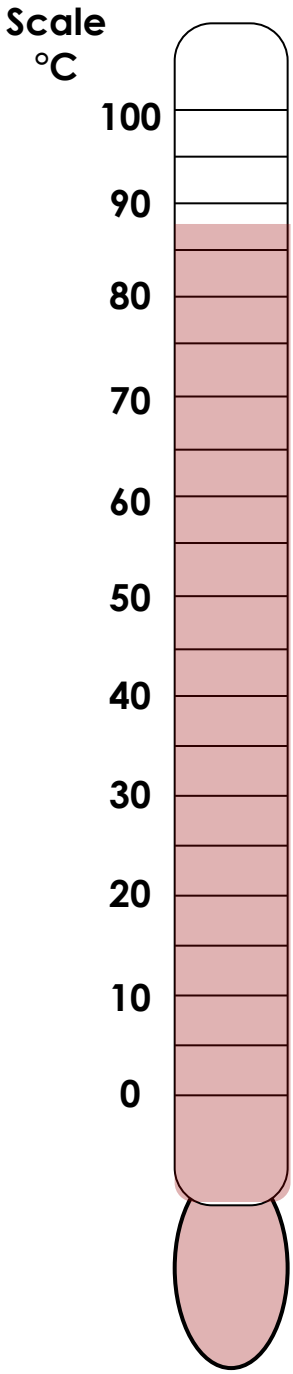
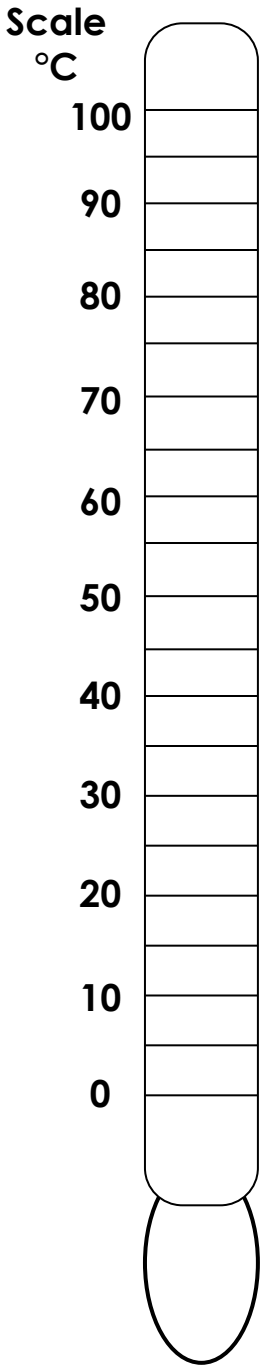


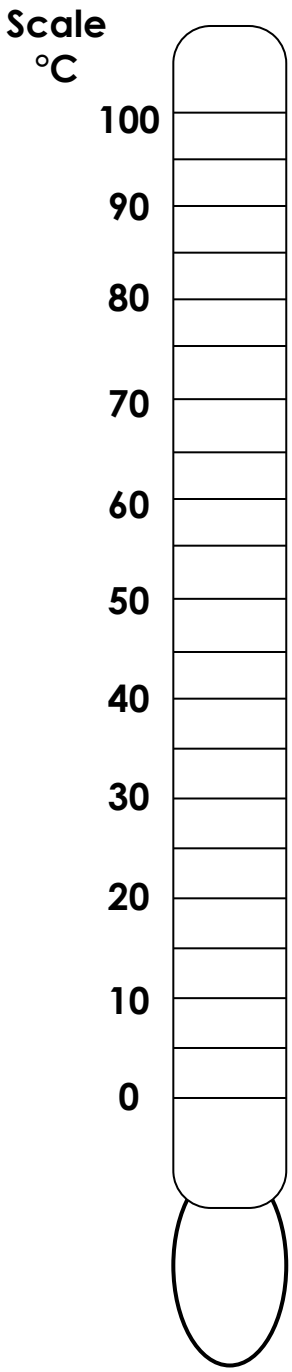
What temperature does the thermometer read? Include units.

_____

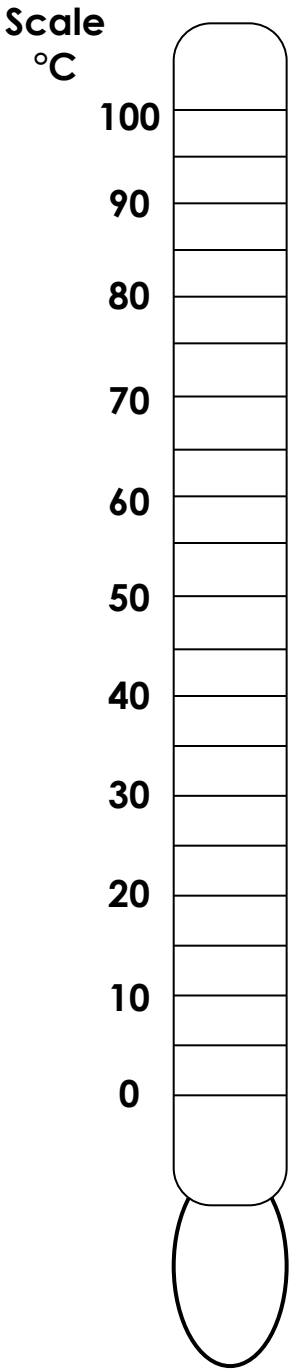
Reading Thermometers Student Sheet



Fill in the thermometer so it reads 40°C.



Fill in the thermometer so it reads 85°C.



Fill in the thermometer so it reads 8°C.

S4

Taking Temperatures Student Sheet Part 1

Measurements Taken Indoors	
Water/Location	**Temperature** (be sure to record units)
Air inside the classroom (describe the location)	
Container of Cold Water (describe the location)	
Container of Hot water (describe the location)	

Measurements of Water in Jars			
Water / Location	**Temperature before going outdoors (include units)**	**Guess/Hypothesis about Temperature after going outdoors & explanation**	**Temperature after going outdoors (include units)**
Jar 1 (no lid) (describe the location)			
Jar 2 (lid added) (describe the location)			

Taking Temperatures Student Sheet Part 2

Measurements Taken Outdoors		
Location	**Guess/Hypothesis & Explanation**	**Temperature** (be sure to record units)
Air Outside (describe/draw the location)		
Location you predict to be warmer (describe/draw the location)		
Why do you think this location will have a warmer temperature?		
Location you predict to be cooler (describe/draw the location)		
Why do you think this location will have a cooler temperature?		

S6

Taking Temperatures Student Sheet Reflection - Part 1

1. Look at the measurements you took outdoors and compare your measurements with those from at least one other group. Do you see any similarities in measurements? Explain.

2. Do you see any differences in measurements? Explain.

3. What do you think contributes to the similarities/differences in measurements?

4. Look at the measurements you took with the two jars. Was the temperature of the water in the jars the same before you placed the lid on one jar and went outdoors?

5. Was the temperature in the jars the same when you returned from the outdoors? If so, explain.

6. If enough time has passed, the water in the jar with the lid should be warmer than the water in the jar without the lid. Why do you think this should be the case?

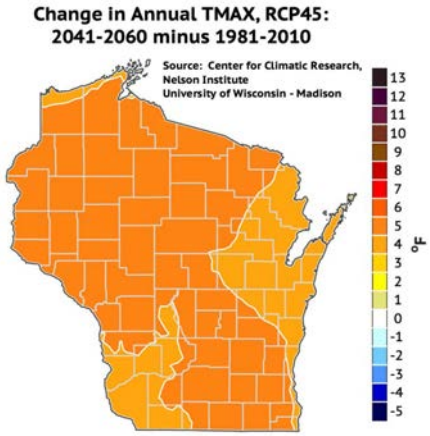
Participate in a class discussion before moving on to Reflection - Part 2 on the back side of this sheet.

S7

Taking Temperatures Student Sheet Reflection - Part 2

During the class discussion, we learned that burning fossil fuels for electricity, heat and transportation has significantly increased the levels of CO_2 in Earth's atmosphere. The increase in greenhouse gases like CO_2 drives climate change. Climate scientists at the Wisconsin Institute for Climate Change Impacts (WICCI) have found that our state is becoming warmer and wetter and projects continued warming, increases in rain and snow and more frequent extreme rainfall events.

7. What do you think will happen if more and more CO_2 and other greenhouse gases continue to build up in Earth's atmosphere?



The map at the right created by the Nelson Institute Center for Climatic Research and published on the WICCI site shows the projected changes in average annual Temperatures (in °F) for the State of Wisconsin in 2041-2060. https://wicci.wisc.edu/wisconsin-climate-trends-and-projections/

8. Think about how you use the outdoor spaces around your school. How might an increase in temperature, like those projected, change the way you (or others) are able to use your school grounds?

9. Think about what you enjoy doing outdoors. How might an increase in temperature, like those projected, change what you like to do outdoors?

10. Think about plants and animals and what their needs are. How might an increase in temperature, like those projected, impact them?

11. If burning fossil fuels for electricity, heat and transportation are the largest sources of CO_2 emissions in Wisconsin, what are some things we all can do to slow down or prevent the impacts of climate change?