Meteorology Curriculum

TEACHER GUIDES





Module 1 Storyline

Content Key











Activity Key











Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

 Meteorology is the study of the atmosphere and its processes.

Topic Standards Key Concepts · Weather is the state of the **Computer Science:** Weather and atmosphere at any given time. 6.IC.CU.01 Meteorology • The components of weather are 6.IC.CU.02 temperature, atmospheric Lesson 0 pressure, wind, humidity, precipitation and cloudiness.

Vocabulary: Weather, Meteorology

Lesson Navigating Question: What is weather?

Student Artifacts

• Interest Survey of various careers in meteorology





Module 1 Storyline

Topic

Standards

Key Concepts

Student Artifacts

Temperature



Lesson 1

Lesson 2

Vocabulary: Temperature, Fahrenheit, Celsius, Kelvin, Absolute zero

Science:

6.PS3.3 6.PS3.4

Math: 6.N.1.1 6.D.1.1

Computer Science: 6.DA.CVT.01

6.DA.IM.01

 Temperatures differ in the sun and shade.

- Different substances absorb different amounts of energy from the sun.
- Temperature can be measured in Celsius or Fahrenheit.
- Temperature readings of air, water, and soil in varying amounts of sunlight.
- Initial models to explain why temperature differs in sun and shade.
- Comparison of temperature readings in Celsius and Fahrenheit.











Lesson Navigating Question: How do we measure weather?

Topic

Standards

Science: 6.PS1.4

6.PS3.3

6.PS3.4

6.PS4.2

Student Artifacts

Heat Transfer





Energy from the sun powers all weather - it heats the air, increasing the energy of the molecules which then increases the temperature of the air.

Key Concepts

- Heat is transferred through radiation, conduction, and convection.
- Convection currents are caused by warm air rising and cool air sinking.
- Convection currents create air masses that affect weather patterns.
- A mirage is evidence of convection.

- Adaptation of initial temperature models to include modes of heat transfer.
- Simulation of convection current.

Vocabulary: Radiation, Conduction, Convection, Convection current, Warm front, Cold front, Mirage





Lesson Navigating Question: What happens after air heats up?

Module 1 Storyline

Topic

Standards

Student Artifacts Key Concepts

Heat Index



Lesson 3

Lesson 4



Vocabulary: Humidity, Water vapor, Relative humidity, Saturation, Heat index

Science:

6.PS3.4 6.FSS2.4

Math:

6.N.3.1

Computer Science:

6.DA.S.01 6.DA.CVT.01 6.DA.IM.01

- Relative humidity is another component of weather.
- Humidity affects how the outside temperature may feel, but does not affect the actual temperature.
- Heat Index is a measure of temperature combined with relative humidity.

 A variety of models and simulations that compare temperatures, relative humidity, and heat index in Oklahoma and Arizona.

Lesson Navigating Question: Why does hot weather in Oklahoma feel different than hot weather in Arizona?











Topic

Wind Chill





Standards

Science: 6.PS3.4

Computer Science:

6.DA.S.01 6.DA.CVT.01 6.DA.IM.01

Key Concepts

- Wind chill is a measure of how air temperature feels to human skin due to wind.
- Higher wind speeds increase heat loss from the skin, decreasing body temperature.

Student Artifacts

 Windchill forecasts based on temperature and wind speed data.

Vocabulary: Wind chill

Lesson Navigating Question: Does heat index work the same in winter?





Module 1 Storyline

Topic

Standards

Student Artifacts

Temperature Advisory Alerts



L

Lesson





Computer Science:

6.DA.CVT.01 6.DA.IM.01 6.IC.CU.01 6.IC.CU.02 6.AP.PD.01 High temperatures, humidity, and/or heat indexes can create unsafe conditions that put people at risk for heat exhaustion or stroke.

Key Concepts

 High wind speeds and low temperatures or wind chill can create unsafe conditions that put people at risk for hypothermia and frostbite. Creation of either summer or winter temperature alerts for the public.

Vocabulary: Excessive heat warning, Wind chill warning, Heat exhaustion, Heat stroke, Hypothermia

Lesson Navigating Question: How do we keep people safe in the extreme temperatures of summer and winter?







Meteorology Curriculum

Teacher Guide: Module 1 Lesson 0

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 0 - Weather and Meteorology

Lesson Navigating Question: What is weather?

Grade Levels:

6-8

Time Required:

50 Minutes

1 Class period

STEM Content Areas:

Technology

Overview

Students will gain an understanding of what weather is and it is studied through the field of meteorology. Students will explore various career options in the field of meteorology.

Oklahoma Academic Standards

Computer Science Standards

- 6.IC.CU.01 Explain how computing impacts people's everyday activities and careers.
- 6.IC.CU.02 Identify and discuss the technology proficiencies needed in the classroom and the workplace, and how to meet the needs of different users.

Learning Objectives

- 1. Define weather.
- 2. List the components used to describe weather.
- 3. Define meteorology.
- 4. Name some examples of careers in the field of meteorology.

Vocabulary

Weather - the state of the atmosphere including temperature, pressure, wind, humidity, precipitation, and cloud cover

Meteorology - the study of the atmosphere and all its processes, especially phenomena related to weather.

Materials

- Computers with internet access
- Student Handouts: How's the Weather?

Preparation

On slide 7 (Experience), insert a weather forecast clip from your local TV station. Most news stations have short, up-to-date weather forecast clips available online.

Phase	Time	Slide	Description
Enroll	10 min.	3	 Allow students to ponder the question, "What is weather?" Have students write some thoughts in their notebooks. What does it include? What does it not include? Students turn and talk to share their ideas or may share ideas as class discussion. Ask the class, "Does everywhere have the same weather?" Allow class discussion. When a student makes a claim that weather is or isn't the same everywhere, ask for examples or evidence. Why do they think that? Have students turn and talk with a partner to make a list of places that might have different weather than Oklahoma. Ask students, "Why might the weather be different in these places?" Have students share their thoughts with the class. Make a list of student responses on the board. Ask students if they notice any patterns with places that have different weather than Oklahoma. Accept all responses.
Experience	10 min.	4	 5. Ask students to describe what the weather is like today. Allow students to think silently for a few minutes while they write a response on the What's the Weather? Handout. Have students share their responses with a partner, then with the class. Accept all responses. 6. Next, ask students to describe what the weather was like yesterday and 3 months ago. Have students share their responses with a partner or group. 7. Ask students to identify what their descriptions have in common. After giving groups some time to talk, ask students to share with the class the patterns that they noticed. What words or characteristics do we use to describe the weather? Make a list of responses on the board. Accept all responses.

Phase	Time	Slide	Description
Label	2 min.	5	8. Define weather and the different characteristics or components that can be used to describe weather. Tell students that they will learn about each of the characteristics of weather as they learn about the science of meteorology.
Enroll	5 min.	6	 9. Ask students what they think a meteorologist does. Allow students to talk with a partner for a minute before sharing ideas with the class. Students will likely say that a meteorologist is the person on TV that gives the weather report. 10. Ask students if they would like to learn how to create a weather forecast.
Experience	10 min.	7	 11. Watch a clip of a local weather forecast. This can usually be found on your local weather station's website. 12. As students watch the clip, ask them to record what they notice and what they wonder. You may need to show the clip more than once. After giving students a chance to think silently, have them share with a partner before sharing with the class. Accept all responses for what students notice, but focus discussion around the types of information that is included in the forecast. Use questioning such as, "Did anyone else notice what kind of weather information was included in the report?" Ask students to share what they wondered. Accept all responses, but focus discussion around how the weather information was obtained or why it's important. Teaching Tip: There is no right or wrong way to notice and wonder. If this is students' first experience with notice and wonder, they may feel pressure to find a "correct" answer. You can help alleviate this pressure by responding positively to all ideas, even if they seem "off topic". Although there is a direction you hope the conversation will flow, allow students to share their thoughts and build off each other's ideas. If discussion is not moving in the direction you want, use questioning techniques to draw out certain topics.

Phase	Time	Slide	Description
Label	2 min.	8	13. Define meteorology as the study of the atmosphere and all its processes, especially phenomena related to weather.
Demonstrate	10 min.	9	 14. Have students explore some example careers in meteorology. The following are useful web pages: American Meteorological Society: All About Careers in Meteorology indeed: 9 Jobs in Meteorology (Plus Salaries and Responsibilities) Students should explore what they think they would be most interested in and what they find most surprising.
Celebrate	1 min	10	15. Celebrate every effort! High fives, team chants, have a treat, etc.

Meteorology Curriculum

Teacher Guide: Module 1 Lesson 1

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 1 - Temperature

Lesson Navigating Question: How do we measure weather?

Grade Levels:

6-8

<u>Time Required:</u>

125 Minutes

2-3 Class periods

STEM Content Areas:

Science, Technology, Math

Overview

Students will learn that there are several components that can be used to describe the weather, one of which is temperature. Students will compare the Celsius and Fahrenheit temperature scales. Using a thermometer, students will collect temperature data in the sun and in the shade, constructing an explanation of how energy from the sun heats the surface of the Earth.

Oklahoma Academic Standards

Mathematics Standards

- **6.N.1.1** Use manipulatives and models (e.g., number lines) to determine positive and negative numbers and their contexts, identify opposites, and explain the meaning of 0 (zero) in a variety of situations.
- 6.D.1.1 Interpret the mean, median, and mode for a data set.

Science Standards

<u>Disciplinary Core Ideas</u>

- **6.PS3.3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
 - o Temperature is a measure of the average kinetic energy of particles of matter
- **6.PS3.4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample
 - o Temperature is a measure of the average kinetic energy of particles of matter
 - The relationship between the temperature and the total energy of a system depends on the types, states, and amount of matter present
 - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment

Science and Engineering Practices

• Planning and Carrying Out Investigations - Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.

Crosscutting Concepts

- Energy and Matter the transfer of energy can be tracked as energy flows through a designed or natural system.
- Scale, Proportion, and Quantity Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Computer Science Standards

- 6.DA.CVT.01 Collect data using computational tools and transform the data to make it more useful.
- 6.DA.IM.01 Use data to highlight or propose cause-and-effect relationships, predict outcomes, and communicate ideas.

Learning Objectives

- 1. Compare Celsius and Fahrenheit temperature scales.
- 2. Explain the meaning of zero in different contexts.
- 3. Collect temperature data using a thermometer.
- 4. Analyze data using measures of central tendency.
- 5. Produce graphical representations of temperature data.
- 6. Explain how different substances absorb different amounts of energy from the sun.

Vocabulary

- Temperature a measure of the average kinetic energy of particles of matter
- **Fahrenheit** a scale used to measure temperature in which the freezing point of water is 32 degrees and the boiling point is 212 degrees
- **Celsius** a scale used to measure temperature in which the freezing point of water is 0 degrees and the boiling point is 100 degrees
- **Kelvin** a scale used to measure temperature in which 0 is the lowest temperature possible (molecules have no kinetic energy)
- Absolute zero the lowest temperature possible, in which molecules have zero kinetic energy

Materials

- 1-2 Glass Thermometers for each group of students separate thermometers for Celsius and Fahrenheit, if possible
- 2 cups or beakers for each group of students
- Ice
- Water

- Sand or soil
- 12 plastic shoebox containers
- Masking tape
- 12 Ring stands (optional)
- 3 heat lamps (optional)
- Student Handouts: Taking Temperatures, What I Know, Heat Absorption, Developing Ideas

Preparation

- 1. Record the temperature of the room in both Celsius and Fahrenheit. Ensure that students cannot see the thermometer or thermostat settings.
- 2. For each group of students, prepare two cups or beakers of water that are at different temperatures, such as ice water and room temperature water.
- 3. Fill 2 plastic shoebox containers with sand or soil, 2 with water, and leave 2 empty.
- 4. Place one of each (water, empty, and sand/soil) somewhere sunny and somewhere in the shade.
- 5. Using tape or a ring stand, attach a thermometer to each container so that the bulb is just below the surface of the water and soil. For the empty container, place the bulb in approximately the same position as the other containers. Ensure the bulbs are not touching the side of the container or the ground. In the case of inclement weather or lack of sun, heat lamps may be used indoors.

Teaching Tip: Students can also set up the samples, which will add approximately 10-15 minutes to this step. Allow the thermometers to adjust for at least 5 minutes before recording data.

Module 1 Lesson 1.1

Phase	Time	Slide	Description
Enroll	5 min.	3-4	1. Show a weather forecast with some heat index temperatures listed. Ask students, "Are these temperatures safe for outdoor activities? How can we be sure?" 2. Show a weather forecast with colder weather and some wind chill temperatures. Ask students, "Are these temperatures safe for outdoor activities?" 3. Inform students that it is sometimes too hot or too cold to be working or playing outside. Ask if they would like to learn how to read a weather report to determine if outdoor activities are safe on a hot or cold day.

Phase	Time	Slide	Description
Experience	5 min.	5	 4. Ask students how we measure temperature. Most students are likely familiar with the concept of a thermometer. 5. Next, ask students where we should measure temperature. Students will likely say, "outside." Have students think more deeply by asking where you should measure temperature outside. "Does it matter where we place a thermometer?" Continue accepting responses until students identify that the shade usually feels cooler than in the sun. If students are not making the connection to different areas outside feeling warmer or cooler, have students close their eyes and picture a nice warm area outside. Have them describe what it looks like, feels like, where they are, etc. Next, ask them to picture a cool area outside and have them describe it in the same way. Responses will probably be somewhere sunny and somewhere shady. Ask again, "Does it matter where we place a thermometer outside?"
Label	15 min.	6-9	6. Ask students what they think the temperature of the room is. Give two answer options and allow students to vote. One option should be in Celsius, and the other in Fahrenheit. Both options should be the actual temperature of the room. Do not provide the Celsius and Fahrenheit labels. For example, "Do you think the temperature in this room is 68 degrees, or 20 degrees?" Teaching Tip: Anonymous voting reduces risk for students and increases engagement from all learners.

Phase	Time	Slide	Description
Label (cont.)	15 min.	6-9	7. After students have submitted all of their votes, reveal the answer - both options are true! 8. Ask students, "How can the room be both [68 degrees] and [20 degrees]?" Have students turn and talk to come up with ideas. Have groups share their ideas with the class, or rotate to discuss with another group.
			Teaching Tip : Students that have lived in other countries are likely familiar with the Celsius temperature scale. By having the chance to discuss their ideas with other students, they get to be "the experts in the room." This expertise can be leveraged later, when students practice comparing the Celsius and Fahrenheit scales.
			 9. Introduce the Celsius and Fahrenheit temperature scales on a thermometer. 10. Explain that Celsius is used in science and in most countries around the world. 11. Show students an image of a thermometer and ask how it is similar to a number line. 12. Explain that a thermometer is like a vertical number line. Unlike number lines they may be familiar with, a thermometer also includes negative numbers, which are numbers below zero.
			13. On the Celsius scale, zero represents the temperature at which water freezes, which is why Celsius is used for science. Negative temperatures are temperatures below freezing. (On the Fahrenheit scale, it is possible to have temperatures below freezing that are not negative.)
			14. Some sciences work with extreme temperatures, so they instead use the Kelvin scale. Negative temperatures are not possible on the Kelvin scale, as 0 Kelvin is the lowest possible temperature, also known as absolute zero.
Demonstrate	15 min.	10-11	15. Handout the student handout titled <i>Taking Temperatures</i> . 16. Students will compare the two temperature scales and convert between them.

Phase	Time	Slide	Description
Demonstrate (cont.)	15 min.	10-11	Teaching Tip: If students are struggling to read the thermometer, explain that it works like a ruler. Students may need help determining the scale of each mark on the thermometer. 17. Students will take the temperature of two water samples in Celsius, such as ice water vs. room temperature water. If using hot water, ensure the water is not boiling for student safety. If possible, use a thermometer that only displays Celsius. Teaching Tip: Digital thermometers can be used, but glass thermometers will better support math concepts related to measurement, number lines, integers, and positive/negative numbers. 18. Students will now estimate the temperature of each sample in Fahrenheit. For a true estimation, ensure students are not able to measure the samples with a Fahrenheit thermometer. They may, however, use the thermometer image on their handout. 19. Have students discuss their estimates with a partner. 20. Now allow students to measure the temperature of the samples in Fahrenheit. This can also be accomplished by revealing what the Fahrenheit temperatures are.
Review	5 min.	12	21. Students reflect on their learning using the handout, What I Know.
Celebrate	5 min.	13	22. Celebrate students' efforts with high fives, team chants, a treat, awards, etc. Make sure every student's effort is celebrated.

Module 1 Lesson 1.2

Phase	Time	Slide	Description
Enroll	5 min.	15	 On the handout Heat Absorption, students recall their thinking from Lesson 1.1 to predict how temperature will differ in the sun and in the shade. Students will draw an initial model using words and pictures to explain their thinking.
Experience	40 min.	16-17	3. Take students outside to collect temperature data of 6 different samples that have been prepared in advance (water, soil, and air in both the sun and shade) 4. Have students enter their data into a spreadsheet such as Excel or Google Sheets. Students may need assistance if they have little experience with spreadsheets. See Resources for Google Sheets at the end of this document. 5. Students analyze their data and create graphs using the spreadsheet. Teaching Tip: Data analysis and graphing can be done on paper, but utilizing a spreadsheet supports computer science standards and digital literacy skills.
Label	10 min.	18-20	6. Explain that air, water, and soil absorb heat differently. Air heats up and cools down more quickly than soil, which heats up and cools down more quickly than water.
Demonstrate	5 min.	21	7. Revise initial models to explain temperature differences in the sun and in the shade.
Review	10 min.	22	8. Compare models with a partner. 9. Update What I Know handout
Celebrate	1 min	23	15. Celebrate every effort! High fives, team chants, toasts, have a treat, etc.

Meteorology Curriculum

Teacher Guide: Module 1 Lesson 2

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 2 - Heat Transfer

Lesson Navigating Question: What happens after air heats up?

Grade Levels:

6-8

Time Required:

265-280 Minutes

5-6 Class periods

STEM Content Areas:

Science

Overview

Students will continue developing their understanding of how the sun heats the earth by exploring the concepts of radiation, conduction, and convection. Students will investigate how heat is transferred through each of these modes. Students will demonstrate how convection currents are formed and will explain how convection creates weather fronts. Students will observe multiple mirage phenomena and explain how a mirage is evidence of heat transfer.

Oklahoma Academic Standards

Science Standards

Disciplinary Core Ideas

- **6.PS1.4** Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
 - Gasses and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the
 molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid,
 atoms are closely spaced and may vibrate in position but do not change relative locations.
 - The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.
 - The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material.
 - Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.
- **6.PS3.3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
 - o Temperature is a measure of the average kinetic energy of particles of matter
 - The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
 - o Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- **6.PS3.4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample
 - o Temperature is a measure of the average kinetic energy of particles of matter
 - The relationship between the temperature and the total energy of a system depends on the types, states, and amount of matter present
 - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment

Oklahoma Academic Standards (cont.)

- **6.PS4.2** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
 - When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
 - The path that light can travel can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

Science and Engineering Practices

- **Developing and Using Models** Develop a model to predict and/or describe phenomena.
- Analyzing and Interpreting Data Analyze data produced through a scientific investigation in order to derive meaning.
- Constructing Explanations and Designing Solutions Construct theories to provide an explanation of natural phenomena.
- **Engaging in Scientific Argument from Evidence** Engage in reasoning and argument based on evidence in order to identify explanations for natural phenomena.

Crosscutting Concepts

- Cause and Effect Cause and effect relationships are routinely identified, tested, and used to explain change.
- Energy and Matter The transfer of energy can be tracked as energy flows through a designed or natural system.
- **Structure and Function** Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
- **Systems and System Models** Define the system under study and make an explicit model of that system to provide tools for understanding and testing ideas.

Learning Objectives

- 1. Identify that energy from the sun powers all weather.
- 2. Explain how heat is transferred through radiation, conduction, and convection.
- 3. Create models of convection currents that show warm air rising and cool air sinking.
- 4. Understand that convection currents create air masses that affect weather patterns.
- 5. Demonstrate that a mirage is evidence of convection.

Vocabulary

- Radiation the transfer of energy across space in the form of waves
- Conduction the transfer of heat from one object to another through direct contact
- Convection the transfer of heat by the movement of fluids (liquids and gasses)
- Convection current the pattern of warm fluids rising and cool fluids sinking
- Warm front a large mass of warm air created by a convection current
- Cold front a large mass of cold air created by a convection current
- Mirage an optical illusion that causes us to see images that aren't really there

Materials

For each group of 3-4 students:

- Heat lamp with clamp
- Ring stand
- Hot plate
- 2 glass beakers or 2 aluminum pans
- Stopwatch
- Stainless steel washers or hex nuts
- Medium clear plastic tub
- 2 small cups or beakers
- 2 disposable pipettes

Miscellaneous:

- Ice
- Food coloring
- Small paper or plastic cups
- Pony beads
- Computer and internet access
- Candle and lighter or matches
- 2 Large glass flask or beaker
- Student Handouts: Heat Transfer, Make it Melt!,
 Make it Melt (Again)!, What I Know Lesson 2,
 Simulating Air Movements, Notice & Wonder Chart,
 Are Invisibility Cloaks Real?, Putting It All Together

Preparation - Module 2 Lesson 2.2

- 1. Obtain enough ice for 2-4 ice cubes per group of students. Cubed ice is preferable to crushed ice.
- 2. Obtain a small paper or plastic cup for each student in class.
- 3. Partially fill (about halfway) each cup with pony beads. Try to make sure each cup is evenly filled.
- 4. Draw a line on the outside of each cup to note the "fill level" of the pony beads. This can also be accomplished by using a ruler to measure to a certain height.
- 5. Transfer all pony beads to a larger container. Add some extra pony beads to the larger container to ensure there are enough for each student.

Preparation - Module 2 Lesson 2.3

- 1. Determine if any students have severe asthma or allergies that may be aggravated by a candle. Consider using an unscented candle to alleviate student sensitivity to smell.
- 2. Determine if open flame (even briefly) is allowed in your classroom.
- 3. Set up a hotplate with a large flask or beaker filled with water. Add enough red food coloring to the water so that it is visibly and completely red. Heat the water so that it is hot but not boiling or scalding.
- 4. Place another large flask or beaker into an ice bath and fill with water. Add enough blue food coloring to the water so that it is visibly and completely blue.

Module 1 Lesson 2.1 - 50 min.

Phase	Time	Slide	Description
Enroll	5 min.	3	 Show sample images of a mirage effect. Ask students what they think is going on in the images. Discussion can be generated through a Turn & Talk or Think-Pair-Share activity. Continue eliciting responses until students have identified the shimmering air above the fire and the false image of water in the desert. Students may or may not identify that these images represent forms of mirages. Help students notice different parts of the image as needed until they name the shimmering/wavy air and fake water. Ask students if they have ever seen something similar. Accept a few examples. Ask students when we normally see this type of phenomenon. Guide students to identify that it usually happens around hot things or places, such as the fire and desert.
Enroll	10 min.	4	 4. Ask students what else they know about heat. Have students write their ideas in their notebook. Give students 2-3 minutes to think individually. Then ask students to turn to a partner to share ideas. Students should place a star or dot next to each idea that both they and their partner had. Have a few students share ideas that they and their partners had in common.
Experience	13 min.	5-6	 5. Ask students why they can feel heat from a hot object when they're not touching it. Accept a few responses. Students may have some initial ideas about heat being transferred through the air. 6. Using the student handout <i>Heat Transfer</i>, students will work in groups to set up a heat lamp and test if they can feel heat coming from the lamp without touching it. This may also be setup as a demonstration with students taking turns at 1 lamp station. • Students will place their hands 12 inches from the heat lamp when it is both off and on.

Phase	Time	Slide	Description
Experience (cont.)	13 min.	5-6	Students will then create an initial model to explain why they can feel heat from the lamp without directly touching it.
			Safety First! All other objects should be kept away from heat lamps, as it is possible for fires to start. The lamps and shades can get very hot and should not be touched. Students should not hold their hand or other objects closer than 12 inches in front of the bulb. This should allow them to feel warmth from the lamp without experiencing unsafe levels of heat.
			Misconception Alert: The heat from the lamp is not coming from the visible light itself. Heat and light radiation are different types of waves. While many objects emit both heat and light radiation (such as the sun or a candle), this is not always the case. A curling iron or oven emits heat radiation but not light.
Label	5 min.	7	7. Explain the concept of radiation as a method of heat transfer.
			Teaching Tip: Add the word and definition to a Word Wall. Instead of making the Word Wall yourself, have students make their own Word Wall posters to hang in the classroom.
Demonstrate	10 min.	8	8. Have students think about the investigation from Lesson 1 when they compared temperatures in the sun and in the shade.
			 Ask students how we're able to feel warmth from the sun if we're not actually touching it? Students should identify that we are feeling radiation from the sun. Have students complete the "Putting It All Together" portion of their handout.
			Assessment opportunity: Students should be able to identify that the heat we feel from the sun is radiation. We feel more heat in the sun vs. in the shade because trees and other objects block the sun's radiation (rays).

Phase	Time	Slide	Description
Review	5 min.	9	 10. Students propose other examples of radiation and discuss with a partner. Assessment opportunity: Students should only name examples of heat transfer in which there is no direct contact with objects.
Celebrate	2 min.	10	11. Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure every student's effort is celebrated.

Module 1 Lesson 2.2 - 80-95 min.

Phase	Time	Slide	Description
Enroll	5 min.	13	 Play the video of wax melting and ask students to write some observations in their notebooks. Play the video 2-3 times to give students adequate opportunity to observe. Ask students if they can explain what is happening. Students will likely say the wax is melting. Ask why the wax is melting. What is heating the wax to make it melt? Students may or may not identify that the saucer is hot, but will likely say there is something inside the warmer that is heating it (such as a candle or bulb). Tell students that they are going to investigate what causes the wax to melt.
Experience	15 min.	14	3. Students will investigate whether ice melts faster on a hotplate or on the table using the handout <i>Make It Melt!</i> Teaching tip: Glass beakers are best for this activity as it is more obvious that there is a barrier between the ice cube and the surface of the hotplate. Aluminum pans also get hotter than glass beakers, increasing the risk of burns if students touch the pan while hot.

Phase	Time	Slide	Description
Experience	10 min. (25 w/ ext.)	15	 4. Ask students why they think the ice on the hotplate is melting faster. Students will likely say the hotplate is heating it up. Ask students, "Is the ice touching the heat source?" Continue guiding discussion until students identify that the ice is not directly touching the hotplate. The glass/aluminum is touching the hotplate, and the ice is touching the glass/aluminum. Ask students why the ice melts if it's not directly touching the hotplate. Play the video of the wax melting again to show the wax is not directly touching the heat source. Students may say that it's radiation, or that the hotplate is heating up the container, which then melts the ice. If students think radiation is melting the ice, replay the wax video and point out where the wax is melting - it's only melting from the bottom, where it is touching the bowl. While there may be some radiation, the ice is mostly melting because it is touching Extension Activity: Demonstrates that air can conduct heat, but not as well as solid objects. Ask students if the ice would melt as fast if the glass or aluminum were not directly touching the hotplate, with a thin layer of air between them. Complete the activity Make It Melt (Again)! The ice suspended above the hotplate will melt slower than the container directly on the hotplate.

Phase	Time	Slide	Description
Label	10 min.	16-17	5. Explain the concept of conduction. Teaching Tip: Draw a class model of how conduction works to melt the ice cube. Ask students to share what they included in their own models from the <i>Make It Melt</i> activity. Include a zoomed in portion of what is happening to the molecules. A separate section can be included to show air also conducts heat.
Demonstrate	20 min.	18-19	 6. Students will demonstrate their knowledge of how energy changes the movement of molecules and what happens when energy is transferred. Give each student an empty cup with a pre-drawn line. A gas will be demonstrated first. Tell students they can move anywhere in the classroom. Demonstrate how students are able to move when they have little or no energy vs. when they have lots of energy. Little or no energy might look like very slow steps, very small steps, or swaying back and forth. Lots of energy might look like very quick steps or very large steps. Have students keep their hand raised for a high-five until their cup is full to the line with beads. The activity will continue until all students' cups are full to the line. Have students start moving. Pour some beads into a student's cup and say you are introducing a heat source. Start a timer when you do this.

Phase	Time	Slide	Description
Demonstrate (cont.)	20 min.	18-19	 That student should then start moving faster and transferring energy to other students. Keep introducing more beads until all beads are in circulation. Stop the timer when all students put their hands down to show their cups are full. Write this time on the board. Repeat the activity, this time with the class representing a solid. Make a much smaller area for students to move. Students should be close together without a lot of space in between them. Time the activity and write the new time on the board. Ask students if solids or gasses are better at conducting heat. The times should show that heat is transferred faster through a solid than through a gas. This is because the molecules in a solid are much closer together and collide more frequently.
Review	15 min.	20	 7. What I Know handout Extension Activity: Read the UCAR article on conduction. Have students do a GIST activity. Read the article and highlight important points. Summarize the highlighted points in 3-4 sentences. Summarize the summary in no more than 30 words. For students below level in reading: Have them highlight important points in the article. Then have them choose the 3 most important points they highlighted. For advanced students, shorten their summaries to 2 sentences and no more than 20 words.

Phase	Time	Slide	Description
Review (cont.)	15 min.	20	Extend the Extension: Have students share summaries with a partner or a small group. Have the groups summarize their summaries in no more than 30 words.
Celebrate	5 min.	21	8. Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure every student's effort is celebrated. This lesson was a lot of work - make it a big celebration!

Module 1 Lesson 2.3 - 70 min.

Phase	Time	Slide	Description
Enroll	10 min.	22-24	 Show students the video of heat shimmer in the desert. Ask them to write in their journals what they observe and what they think is happening. Have a few students share their ideas with the class. Briefly review radiation and conduction. Ask students what happens to air after it heats up. Light a candle and let it burn for a few seconds, then blow it out. Have students observe what the smoke does. You may need to do this a few times for students to see what is happening. Students should note that the smoke is rising. Ask students why they think that is happening. Tell students they are going to investigate what happens to air when it heats up and cools down. Teaching Tip: If you have concerns about students with asthma or if candles are not allowed in your classroom, you can show a video clip of a candle being blown out with smoke rising.

Phase	Time	Slide	Description
Experience	20 min.	25	 9. Students will use water to simulate air movement in the activity Simulating Air Movements. Prepare the hot and cold water ahead of time. 10. Have students practice proper pipetting technique prior to doing the activity. 11. Because this activity uses food coloring, their clothes may be stained if they do not use the pipettes properly. Also, improper technique may result in mixing of the water, which will make the results less obvious. Students should see the hot water rise to the surface and spread towards one end of the container. The cold water should sink to the bottom and spread to the other side of the container. Students can add multiple pipettes-full of hot and cold water. If they make a mistake while pipetting and the water all starts to mix together, they can easily dump their container and try again. Teaching Tip: Results are more dramatic the hotter and colder your water is. You may want to pour the hot water for students so they don't burn themselves. Proper Pipetting Technique: Hold the pipette vertically, never horizontally when there is liquid in the pipette. The tip should be facing down. Liquid will not come out unless the bulb is squeezed. Students usually want to turn the pipette over so the tip is facing up. This will actually cause water to shoot out of the end of the pipette, making a mess and possibly staining clothing. If a hazardous substance were being used, injury could result. Emphasize that proper technique in a laboratory is important for safety. Squeeze the pipette bulb before inserting the tip into the liquid, then release the bulb to suck liquid into the pipette. Squeezing the pipette should not create bubbles in the liquid.

Phase	Time	Slide	Description
Experience (cont.)	20 min.	25	 Bubbles can be a safety hazard if a harmful chemical is being used (because of possible splashing). Hold the pipette upright while transferring liquid to another container. When releasing the liquid from the pipette, make sure the tip is submerged before squeezing the bulb. Steadily squeeze the bulb until the liquid is released. Again, try not to create bubbles. It is better to leave some liquid in the pipette than to create bubbles. The best way to avoid bubbles in this step is to squeeze slowly in a controlled manner and stop squeezing just before the air bubble in the pipette is released. This takes some practice. With the bulb still squeezed, remove the tip from the liquid, then release the bulb. This will prevent liquid from being sucked back up into the pipette, which will create mixing.
Label	10 min.	26-28	12. Define convection and convection current. Ask students to explain how the results of the Simulating Air Movements activity is evidence of a convection current. 13. Have students recall what they know about molecule movement in a warm substance – molecules move faster. Explain that when the molecules move faster they spread out and the fluid becomes less dense. 14. Show the video of water boiling, where students can see warm water rising to the surface. 15. Using this knowledge, have students predict why cold fluids sink. Students should be able to explain the opposite process, that cold molecules move slower so they get closer together. The cold fluid becomes more dense and sinks. 16. Masses of rising warm air and sinking cold air are called fronts. This concept will be explained in more detail in subsequent modules.

Phase	Time	Slide	Description
Demonstrate	10 min.	29	17. Show the video of mixing warm and cold water. Pause the video at 0:18. Have students predict what will happen in the two systems (warm water on top of cold and cold water on top of warm). They should have time to record their thoughts individually before sharing with a partner or with the class. 18. Pause the video again at 0:25. Ask students to reflect on what just happened. Why did one system mix together but not the other? Give students time to record their thoughts individually before sharing with a partner or with the class.
Demonstrate (cont.)	10 min.	29	 19. Ask students what will happen if the system that is still separated is flipped over, so that cold water is on top of warm water. 20. Play the remainder of the video. Ask students for evidence that convection happened. You may need to play the whole video more than once so students can see how the mixing occurs. Extension Activity: After showing the video, repeat the demonstration in class so that students can see the water moving up close.
Review	15 min.	30	21. Have students read the <u>article</u> from NOAA about heat transfer, then record what they've learned on their <i>What I Know</i> handout.
Celebrate	5 min.	31	22. Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure <i>every</i> student's effort is celebrated.

Module 1 Lesson 2.4 - 65 min.

Phase	Time	Slide	Description
Enroll	2 min	32-33	 Revisit the heat shimmer video from Lesson 2.3. Ask students if they can explain what is happening. Students should note that warm air is rising. Ask students why we're able to see the warm air. Can they always see warm air rising? Tell students we're going to find out why we can sometimes see warm air rising.
Experience	5 min.	34	 4. Show the video of the carbon nanotube cloaking device. Have students record their observations on the Notice & Wonder Chart handout. You may need to show the video multiple times to give students plenty of time to make observations. Play the video with sound, as there is a faint click in the background. 5. Students should notice that the tubes become "invisible" and the water at the top is rippling. Students may connect the rippling water to the video of water boiling or to the heat shimmer effect in the desert. It's not necessary that they make that connection at this time.
Label	30 min.	35	6. Have students read the Science Daily article about the carbon nanotube cloaking device and complete the handout Are Invisibility Cloaks Real? 7. After completing the handout, have students share with a group or with a whole class. Note that the "On the Page" and "Between the Lines" sections have correct answers, whereas the "Beyond the Lines" section will not have definitive answers that can be found in the article. In this section, how students justify their response is what matters most. Teaching Tip: Have students circle or underline words from the article that are new to them or that they are unsure about the meaning and create a class glossary as you discuss the meanings together.

Phase	Time	Slide	Description
Label	8 min.	36-37	8. Explain what a mirage is and how conduction is involved. 9. There are many types of mirages, including the appearance of water on the roadway, floating objects just above the horizon, reflected objects "below" the horizon, and heat shimmer.
Review	5 min.	38	10. Replay the video of the carbon nanotube (CNT) cloaking device. Ask students why it turns invisible.11. Students should be able to explain that the CNT are heating the water, which causes light to be reflected and creating a mirage, making it appear as if the CNT are invisible.
Demonstrate	10 min.	39	12. Students complete a model of what happens after air heats up using the handout <i>Putting It All Together</i>.13. This can be used as a summative assessment for this lesson.
Celebrate	5 min.	40	14. Celebrate students' efforts with high fives, team chants, a treat, awards, etc. Make sure every student's effort is celebrated.

Meteorology Curriculum

Teacher Guide: Module 1 Lesson 3

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 3 - Heat Index

Lesson Navigating Question: Why does hot weather in Oklahoma feel different than hot weather in Arizona?

Grade Levels:

6-8

Time Required:

310 - 365 Min

6-7 class periods

STEM Content Areas:

Science, Technology, Engineering, Math

Overview

Students will discover that there is a relationship between temperature and humidity, and will explore how changes in temperature affect relative humidity. Students will develop models to explain why relative humidity changes with temperature. Temperature and relative humidity will then be measured using a device that students design. These values will be used to determine the heat index for a given day.

Oklahoma Academic Standards

Mathematics Standards

• 6.N.1.3 - Explain that a percent represents parts "out of 100" and ratios "to 100."

Science Standards

<u>Disciplinary Core Ideas</u>

- **6.PS3.4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample
 - Temperature is a measure of the average kinetic energy of particles of matter
 - The relationship between the temperature and the total energy of a system depends on the types, states, and amount of matter present
 - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment
- **6.ESS2.4** Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
 - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, and crystallization, and precipitation, as well as downhill flows on land.

Science and Engineering Practices

- **Planning and Carrying Out Investigations** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
- Developing and Using Models Develop a model to describe unobservable mechanisms

Crosscutting Concepts

- Energy and Matter Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.
- Scale, Proportion, and Quantity Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Oklahoma Academic Standards (cont.)

Computer Science Standards

- 6.DA.S.01 Create multiple representations of the same data.
- 6.DA.CVT.01 Collect data using computational tools and transform the data to make it more useful.
- **6.DA.IM.01** Use data to highlight or propose cause-and-effect relationships, predict outcomes, and communicate ideas.

Learning Objectives

- 1. Identify that relative humidity is an important component of weather forecasts.
- 2. Compare percent saturation and relative humidity.
- 3. Model the relationship between temperature and relative humidity.
- 4. Explain that humidity does not affect the outside temperature, but it can affect how humans perceive the temperature.
- 5. Use a heat index chart to determine heat index values when given temperature and relative humidity.

Vocabulary

- Humidity the amount of water in the air; AKA absolute humidity
- Water vapor water in gaseous form
- **Relative Humidity** the amount of water vapor present compared to how much the air could hold at that temperature
- Saturation when air holds as much water vapor as it can for a given temperature; 100% relative humidity
- **Heat Index** a measure of what the temperature feels like to the human body when relative humidity is combined with the air temperature; AKA apparent temperature

Materials

Student Handouts: It's Not The Heat..., ...It's The Humidity, Studying Saturation, Lesson 3 - What I Know, It's All Relative (Humidity), Think Like A Meteorologist

Lesson 3.1 materials needed per lab group:

- Medium beaker
- Disposable pipette
- Dry sponge

Lesson 3.2 materials:

- Large beaker or graduated cylinder
- Small beaker or graduated cylinder

Lesson 3.2 materials needed per lab group:

- 2 analog thermometers
- Cardboard, plastic bottle, cup, or other sturdy material
- Cotton balls or gauze
- Strong twine or string
- Strong tape
- Rubber bands

Preparation - Lesson 3.1

- 1. Ensure sponges are completely dry.
- 2. If desired, set up a "Research and Development" station with multiple sponges, pipettes, and a beaker of water. These materials should be separate from the student sets of materials.

Preparation - Lesson 3.2

It's All Relative (Humidity)

- 1.Determine if the demonstration will be completed as a class demonstration or by student groups. Having students complete the demonstration is preferable but works best with access to multiple sinks, or in a location where spills don't matter (such as outside).
- 2.If students are completing the demonstration themselves, fill a large pitcher with water. You can streamline the activity by using this pitcher to add water to students' beakers at appropriate times in the activity.

Preparation - Lesson 3.2 (cont.)

Think Like A Meteorologist

- 1.Obtain a variety of sturdy materials such as cardboard, chipboard, 2 liter bottles, plastic cups, etc. Consider cutting the materials to appropriate sizes ahead of time, especially if using plastic bottles.
- 2. Test your string or twine to ensure it is strong enough to withstand swinging a weight without breaking.
- 3. When going outside to use the psychrometers, bring a container of water so students can wet their cotton.

Module 1 Lesson 3.1 - 165 to 220 minutes

Phase	Time	Slide	Description
Enroll	10 min.	3-4	 Show the map of the U.S. with Arizona and Oklahoma highlighted. Have students record what they know about both states on the handout, It's Not The Heat These are initial thoughts that students may have. It's okay if they don't know anything about either state, they can imagine what they think it might be like. If you have students that have lived in AZ, they can share their experiences with the class if they are comfortable doing so. Have students share some of their responses with the class. Keep eliciting responses until students have at least identified that Arizona contains desert and most of Oklahoma does not. Students will likely identify that deserts are dry. If they don't, ask students which state they think would get more rain. It is important for students to identify that AZ is drier than OK. Ask students which state they think would be more comfortable in the summer and in the winter. Show the weather forecasts for Phoenix and for Tulsa.

Phase	Time	Slide	Description
Enroll (cont.)	10 min.	3-4	Teaching Note: The weather forecasts are fake. They are intended to be from the same day in summer. The graphs to the side are just background images and do not relate to the forecast.
			4. Have students individually record what they notice and what they wonder. Then have students share some of their ideas with the class.
			Students should notice that the humidity in Tulsa is higher and the "Feels like" temperature in Tulsa is higher.
			Ask students why the temperature in Tulsa would be lower than in Phoenix, but it would feel hotter in Tulsa.
			 Some students may describe Phoenix as being a "dry heat." Students may or may not identify that the humidity makes Tulsa feel hotter. If they don't, ask if there is any information in the weather forecasts that could possibly explain why it feels hotter in Tulsa.
			 After students have identified humidity as an important factor, tell students that they are going to investigate how temperature and humidity are connected, but first they are going to explore the concept of humidity further.
Experience	10 min.	5-6	5. Have students visualize a time when they've taken a shower and the bathroom was very steamy afterwards, and a time it wasn't steamy afterwards (slides 5 and 6, respectively).
			6. Have students discuss their experiences of what the air felt like, if they cooled off quickly, if they dried off quickly, etc. Give students time to discuss slides 5 and 6 separately.
			 After students have discussed both scenarios, ask students why the air would feel different if everything else is the same.

Phase	Time	Slide	Description
Experience (cont.)	10 min.	5-6	 Students may suggest that the bathroom stays warmer and more steamy in the summer and cooler in the winter. Point out that they have an air conditioner and heater in their home, which keeps it about the same temperature year round. Point out that the water temperature will also be about the same. Ask how summer and winter might affect the air inside their house if they have a thermostat to control the temperature. Allow multiple ideas to emerge. 7. At this point, students will probably not connect how the air in the bathroom feels to the weather conditions outside. That's okay. Refer students back to the weather forecasts for Tulsa and Phoenix, where they noticed a higher humidity and higher "feels like" temperature for Tulsa. Suggest that there may be some connection with temperature and humidity that we should investigate.
Label	30 min.	7	 8. Define humidity, which is the amount of water vapor in the air. Explain why the word "moisture" is an inaccurate description for humidity. 9. Ask students to think about the states of matter. Pause the lecture at this point to have students write on their handout everything they know about the states of matter. This should be a familiar concept for students, but you may need to clarify that you are referring to solids, liquids, and gasses. Allow students to share their ideas with a partner before sharing as a class. Write their ideas on the board. The most important idea to look for is that gasses can't be seen (some gasses actually do have color, but it is unlikely that students will know this). 10. Now ask students what state of matter water vapor would be. Refer students back to the list they just made and ask if water vapor matches the characteristics of gasses they just listed.

Phase	Time	Slide	Description
Label (cont.)	30 min.	7	 Students will likely name that water vapor can sometimes be visible in the form of clouds and steam. Ask students to imagine if we could zoom in on air molecules to see them under a microscope. Have students draw a model on their handout of what they think water vapor (that they can't see) would look like compared to steam. Have a hot plate with water boiling so that students can observe steam. Alternatively, show a video clip of steam rising. Give students some time to work on their models, then ask them to include what happens to the water molecules after they can no longer see the steam. Have students share ideas with a partner before sharing as a class. The main idea to look for is the molecules being closer together when the steam is visible. Now ask students to reflect on their learning throughout the unit so far. Have they experienced other examples of molecules being closer together and farther apart? Examples should include when they investigated conduction through a solid versus a gas. The molecules in a solid were very close together and the molecules in a gas were very far apart. Now ask students to take another look at their models of steam. Do their models show the characteristics of a gas? Have students make a claim about the state of matter of the water in steam. Students should say that it is liquid. Whatever their response, ask them to support their claim with evidence. They may still claim that steam is a gas at this point. As previously stated, this is a very complex concept that will be explored more later. It is okay if student ideas are not yet concrete or accurate at this point. Allow students to share claims and evidence with the class. There are likely to be some conflicting ideas. The most important aspect of this discourse to focus on is the evidence that students use to support or refute their claims.

Phase	Time	Slide	Description
Label (cont.)	30 min.	7	 Return to the lecture slide. Explain that water vapor is a gas and not a liquid. "Water" is simply the name of the substance, whether it is a solid, a liquid, or a gas. It may be helpful to have liquid water and ice available as a reference point. You could also have an empty container to represent water vapor in the air, which can't be seen but is still present. Now explain that when water vapor is visible, like in the case of the picture on the slide or steam, it is no longer a gas, but tiny droplets of liquid water. Have a cold glass with condensation on it available as a reference point. These concepts will be explored further in future units when the water cycle, cloud formation, and precipitation are covered. Optional extension activity: Give students a glass object and ask them to use their breath to fog the glass. Have students record observations. Ask students to fog the glass again and then wipe the fog with their finger. Does it feel wet? Have them wipe their fingers on glass without fog for comparison.
Experience	60-120 min.	8	 13. Ask students if they have ever heard, "It's not the heat, it's the humidity." Ask students what they think that means. Accept all responses. 14. Next, ask students to recall what humidity means. (water vapor in the air) 15. Ask students if they think there is a limit to how humid the air can be. Ask students to justify or expand on their responses. Why do they think there is (or isn't) a limit? Is there any evidence or observations they can provide to support that idea? Answers may involve things like clouds, fog, rain, or other times water vapor becomes visible. There are likely to be conflicting ideas. Tell students that it sounds like we have some questions about water vapor in the air, so we should investigate further.

Phase	Time	Slide	Description
Experience (cont.)	60-120 min.	8	16. Give students theIt's the Humidity handout. Explain that in order to investigate how much water vapor the air can hold we will need to design a simulation since we can't see air. 17. Students will design this investigation. Designs can be different for each group or the whole class can decide to use the same design. Either way, most groups' designs will be very similar. • If students have little experience with designing an investigation, it might be best to decide on a procedure as a class. 18. Point out the Investigation Question and available materials. Point out that the question does not specifically say water vapor or air. Ask students why they think that is. • Continue probing students until they identify that "water" doesn't specify if it is solid, liquid, or gas, and/or that water vapor is still water. • Students should also identify that we use the word "substance" instead of "air" because we are not testing air in our investigation. • Students may need support to reach this conclusion. Designing an investigation that addresses a question is a difficult concept that takes a lot of practice. • Point out that air is a kind of substance, so we should be able to apply the results of this investigation to air. 19. Have students start by brainstorming some ideas for how to design their investigation. This should be done individually or with a partner. • Ideally, students will decide on the following uses for the materials: • Water - represents water vapor in the air • Sponge - represents the air • Beaker - used to obtain water • Pipette - drizzle water over the sponge

Phase	Time	Slide	Description
Experience (cont.)	60-120 min.	8	 Have each student or student pair share their brainstorming ideas with another pair. The group should decide on the best ideas they want to use for their investigation. If the whole class will use the same procedure, numbers 2-8 of the handout can be completed together as a class. Consider having students complete these steps as a think-pair-share before creating class procedures. If each group will be doing their own investigation, check in with each group to have them explain their procedure to you before they begin. Make sure students have a clear plan that details how they will be using materials, what they will be looking for, what data they will collect, how they will drizzle water over the sponge (will they cover the entire sponge or continue adding to the same place?), etc. Student investigations should be designed to directly answer the Investigation Question. If students are unable to explain their plans, seem confused, or appear to be randomly playing with supplies, have them consult with another group to get ideas. Check back in with them to see if they have a clearer picture of how they should proceed. Teaching Tip: Adopt a "look but don't touch" policy when students are brainstorming investigation designs. Students have a tendency to jump straight into tinkering without having a clear plan. Allow students to view the materials but not take them to their desk until their procedure receives teacher approval. Alternatively, allow students to have all materials except water at their desk. You can also create a Research & Design station with an extra set of materials that students can tinker with to get ideas during their brainstorming. Make sure students understand that R&D happens before collecting data, so they should not use the R&D station to conduct their investigation. It should only be used to see how the materials might be used together or to try out an idea to see if it works.

Phase	Time	Slide	Description
Experience (cont.)	60-120 min.	8	 20. After students have completed their investigations and analyzed their results, have groups share their results with the class. If groups have all completed the same experiment, average the class data for analysis. If groups have completed slightly different experiments, ask students if their data can be compared with groups that did a different investigation. Are the results still useful if the investigations were different? In this case, data should not be averaged, but patterns can be identified. A possible extension is to repeat the experiment with each group using the same procedure. Possible differences in data include groups counting number of pipettes-full while others measured milliliters. These numbers wouldn't represent the same information and should not be averaged together. However, the pipettes have measurement indicators, so the number of pipettes-full could be converted to an equivalent measurement in milliliters. 21. Discuss what students observed in their investigation. What happened when the sponge was full of water? How do they know it was too much water? Ask students to provide specific evidence or data from their investigation. Possible Extension: Emphasize the importance of writing clear procedures by having groups trade investigation plans. Groups will use another group's procedures to attempt to replicate their investigation. Students should follow the instructions exactly as written. They should then share their results with the original group. Are their results significantly different, or were the original results replicated? It is unlikely that the results will be exactly the same, but is it close enough that their conclusions would be the same? Groups should also provide feedback on how the procedures were written. Was it clear and easy to follow? What are some suggestions for improvement?

Phase	Time	Slide	Description
Label	10 min.	9-10	 22. Ask students to recall the results of theirIt's The Humidity investigation. Ask students if we can apply those results to water vapor in the air to make a claim about whether there is a limit to how humid the air can be. Ask them to use data from their investigation as evidence to support their claim. Students should identify that the results indicate there is a limit. 23. Ask students if they have any data that tells us how much water vapor the air can hold. There may be some uncertainty here, but students should identify that they are not able to make any claims about how much water vapor the air holds. 24. Inform students that there is not a certain amount of water vapor that can be in the air, because it changes depending on the temperature of the air. Explain that warm air can have more water vapor molecules than cold air. Have students pause and reflect on why that statement might be true. Ask them to record their thoughts in their notebooks. Is there an analogy the statement makes them think of, have they personally experienced or observed something similar, etc. Ask students to draw a model of warm and cold air in their notebooks. Do they see anything in their drawings that they think might explain the statement? Allow students to discuss with a partner, and then share their thoughts with the class. They may not have clearly formed ideas at this point, but will likely involve how close the molecules are or how fast the molecules are moving. This is foundational knowledge for the concept of condensation, which will be explored more later. Accept all responses, but draw attention to responses that involve the closeness and/or speed of molecules. Define relative humidity as the amount of water vapor compared to how much the air could hold at that temperature. 26. Define saturation as the maximum amount of water vapor the air can hold at a certain temperature, otherwise known as 100%

Phase	Time	Slide	Description
Demonstrate	30 min.	11	 27. Give students the handout Studying Saturation and inform them that they will be analyzing the saturation of the sponge from theIt's The Humidity activity. 28. Begin by having students reflect on what it meant for the sponge to be saturated. They should recall their data from the previous investigation to include how much water it took to saturate the sponge. Data is likely to vary from group to group. They should use the data that their group collected, not the class average or another group's data. The "Setting the Stage" portion of the handout should be completed collaboratively in pairs or small groups so that students have the opportunity to discuss their ideas with others. Have groups discuss their ideas with the class. Teaching Tip: Notice that the questions in "Setting the Stage" do not have a correct answer, even #2 in which students should say 100%. All of the questions offer the opportunity for disagreement and debate. For example, some students may say the sponge was fully saturated when it dripped water. Others may say it was fully saturated just before it dripped water, since dripping water indicates that it can't hold any more. Students should say 100% on #2, but may reason that 99% was the most the sponge could hold, because at 100% it couldn't hold more and began to drip water. In either case, it is how students justify their answers that matters, not necessarily the answer itself. Both of the sample responses above indicate that students understand the meaning of 100% saturation. You can encourage alternate explanations and out of the box thinking by asking students if there are any other plausible ways to interpret or explain their observations.

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Phase	Time	Slide	Description
Demonstrate (cont.)	30 min.	11	29. Before moving to the next section of the handout, ask students if the saturation of the sponge remained constant throughout the investigation. Students should reason that it became more saturated as they continued adding more water. 30. Have students draw a model or chart of how they think the saturation of the sponge changed throughout the investigation, then have students share with each other and with the class. Call attention to any models that resemble a graph, but don't offer the word "graph" as a description. Ask students to explain what they've drawn and what it means. Look for graphical reasoning in nongraphical models, such as showing a sponge with a water level that is rising (similar reasoning of a bar graph).
			Teaching Tip: Graphing can be intimidating and confusing for students. They often fail to relate graphs to data sets or to infer meaning from a graph. Offering students the chance to produce a graph on their own and in context, without them realizing it is a "graph" can help alleviate some of their preconceived negative feelings about graphs. Ask questions such as, "What does this show?" "What does this mean?" "Why did you choose to draw it this way?" or "What does this part represent?"
			 31. In the "Let's Calculate" portion, it is important for students to understand not only how to calculate a percentage, but what it means. You may want to have students complete #6 as a Think-Pair-Share before moving onto the next questions.
			 After students have determined the answer is 90%, ask them to explain what 90% means or represents. What is 90%? 90% of what? Students should express that 9 points is 90% of the total possible points. 32. Have students calculate the % Saturation for each time they added water to the sponge. They
			should track this information using a data table or spreadsheet. • A spreadsheet can be programmed with a formula to do the calculations automatically when data is entered. • Using a spreadsheet can reduce the emphasis on correctly copying data and instead put more
			emphasis on interpreting data.

Phase	Time	Slide	Description
Review	10 min.	12	 33. Have students reflect on what they've learned so far using the What I Know handout for Lesson 3. Students should be able to respond confidently through the first 5 targets. Use their responses to determine any points that need more instruction.
Celebrate	5 min.	13	34. Celebrate students' efforts with high fives, team chants, a treat, awards, etc. Make sure <i>every</i> student's effort is celebrated.

Module 1 Lesson 3.2 - 145 minutes

Phase	Time	Slide	Description
Enroll	5 min.	14	 Start with the weather forecast images for Tulsa and Phoenix that were first introduced in Lesson 3.1. Ask students if we have enough information to answer the question, "Why does hot weather in Oklahoma feel different than hot weather in Arizona?" Students will likely say no. Ask students to list some things they learned in the previous lesson that they think might be relevant. Students will likely say humidity. Have students think about the % humidity listed on the weather forecasts. Ask students to imagine what 20% humidity would feel like compared to 67% percent humidity. Give students about a minute to imagine. Ask students how they think the difference in humidity might affect the "feels like" temperature. Allow students to think silently and write in their notebooks before they share ideas with a partner and with the class.

Phase	Time	Slide	Description
Experience	30	15	 Begin the It's All Relative (Humidity) handout by reviewing the meaning of relative humidity. Have students draw a picture that represents the meaning of relative humidity. Allow students to share their pictures with each other and explain what they drew. Have a few students share with the class. Go through the statements on #2 together. Have 2 measuring cups, beakers, or graduated cylinders (empty) on hand, one that is much larger than the other. Ask students which container they think would represent warm air and which would represent cooler air. The larger container represents warmer air, since it is able to hold more. Have students consider the scenario in #3 and record their thinking. This is a difficult concept for students to grasp, so it is okay if their thinking is not correct at this stage. Encourage students to record their initial thoughts and reasoning and to draw what they're thinking with a model. Allow students to discuss their models with a partner before sharing responses as a class. The following steps may be done as a demonstration or students may manipulate the materials themselves. If students are manipulating the materials, follow the same procedure, directing students to do the water pouring instead of yourself. While students are working, fill the smaller container to the top measurement line with
			 After students have discussed their responses to #3, show students the smaller container that is full of water. Ask students what they think will happen if you pour the water into the larger container. If necessary, prompt students to think about the water level in each container. Accept all responses.

Phase	Time	Slide	Description
Experience (cont.)	30	15	 8. Pour the water into the larger container. Ask students what they notice. Students should identify that the container is not as full, or that the water level is lower. Ask if it would be possible to pour more water into the container. Students should say yes. Add more water, until the level reaches the top measurement line. Ask students what would happen if you poured this water back into the smaller container. Pour it back in, allowing the water to overflow. 9. When the smaller container is completely full, ask the students what the % saturation of the container would be. Students should say 100%. Now ask if the container were to represent air, what would the % relative humidity be? Students should again say 100%. Point out that % saturation and % relative humidity are the same. 10. Pour the water in the smaller container back into the (now empty) larger container. Ask students if the % relative humidity would still be 100%. Students should say no, and may offer an estimated %. 11. Now refer students back to the models they drew on #3. Pour water into the larger container to represent 45%. You can measure this exactly if desired. Tell students the larger container represents 75 degrees with 45% humidity, and the smaller container represents 60 degrees. Now pour the water into the smaller container. Ask students if the relative humidity is more or less than 45%. If desired, you can have students measure this exactly. It should be obvious to students that it is more than 45%. 12. Have students revise their initial models about relative humidity using this new information.

Phase	Time	Slide	Description
Experience	15 min.	16-18	 13. Ask students to close their eyes and imagine playing outside in August in both Arizona and Oklahoma. Encourage them to think about how it feels outside. 14. Tell students to imagine they've been playing for a while. Ask them if they would feel sweaty and hot in each place. Students will likely say yes. Ask students why we sweat. What does it do for us, what purpose does it serve? Continue probing until students identify that it cools you off. Refer students back to the weather forecasts for OK and AZ. The "feels like" temperature is not the actual temperature, but how hot it feels to our bodies. Ask students if OK feels hotter, is sweat cooling you off the same in both places? Now return to the It's All Relative (Humidity) handout to have students think about why they could cool off easier in AZ than in OK. Give students time to consider their models. Allow students to discuss with a partner before sharing with the class. At this point, students should be starting to put together that higher humidity means there is less availability for more water vapor to enter the air. In other words, sweat will not evaporate as much.
Label	15 min.	19-20	 15. Explain that sweat helps cool you off because it allows water to evaporate from your skin, carrying heat with it. Because air becomes more saturated with water vapor as more water evaporates, sweat won't be able to evaporate as readily in high humidity. Therefore, it will not cool you off as much. This causes the temperature to feel warmer, which is called the heat index. 16. Show students the heat index table. Explain that it uses temperature and relative humidity to determine the heat index. The table also indicates unsafe temperature and humidity conditions for being outside.

Phase	Time	Slide	Description
Demonstrate (cont.)	75 min.	21	 17. Give students the handout Think Like A Meteorologist. Explain that students will be making a sling psychrometer, which is the same type of instrument a field meteorologist would use to collect weather data. More sophisticated digital instruments exist, but sling psychrometers are still widely used when working in the field. 18. Students should first look at the 2 sets of thermometers to predict which would have the higher relative humidity. This is a thinking space to get student ideas flowing. Have students think-pair-share to explain their ideas. Students may need help realizing that a larger difference between the dry and wet bulbs means more water evaporated, indicating the air is "drier" or has a lower relative humidity. When the dry and wet bulb temperatures are similar, it means there is a high humidity, so not as much cooling happens through evaporation. If students are struggling to come to this idea themselves, have them think of the moistened cotton around the wet bulb as sweat. Is the thermometer's "sweat" doing a good job of cooling it off? Does sweat cool you off better when it is humid or when it is dry?
			Teacher Tip: This is a good opportunity for a quick check to make sure students remember how to read a thermometer, and to make sure they understand the math involved. When you talk about comparing the temperatures of the dry and wet bulbs, use mathematical language. Ask students what the difference in temperature is between the thermometers, or how much warmer the dry bulb is than the wet bulb. Have students explain what they did to figure out the temperature difference. This will make the calculations seem more intuitive later. 19. Students will design their own sling psychrometers. How they attach the thermometers doesn't really matter, as long as both bulbs are exposed to the air.

Phase	Time	Slide	Description
Demonstrate (cont.)	75 min.	21	 Ensure that students have a written plan or blueprint of what they will be building. #2 is intended to be a brainstorming space where they can draft a plan before building. Try adopting the same "Look but don't touch" policy for supplies that you have used in previous activities. You can supply all materials for students, or you can have students scavenge their own materials (except the thermometers). 20. Allow students to practice with their designs before attaching the thermometers, or use shatter-proof thermometers. Students should describe and draw any changes they make to their designs on #3. This step should not be skipped! Engineering Design is an iterative process, so it is highly unlikely that students will not change anything about their design. Even if they change the position of the tape or the length of the string, they should record their changes on this step. Students' designs may go through multiple iterations. They should record all changes on this step. Recording changes and iterations does not come naturally to most students, so they may need help identifying where, when, and how their designs changed. 21. After designs have been tested to ensure the thermometers won't fly off, students should record data outside. Allow the thermometers to come to temperature for at least 5 minutes before applying the wet cotton or before slinging. It is important that both the wet and dry thermometers begin at the same temperature. Data collection should ideally be done in the shade. 22. To analyze results, students will subtract the wet bulb temperature from the dry bulb temperature. This result will be used with the Relative Humidity. Table to determine the % Relative Humidity. Notice that temperature readings are in intervals of 5. Students should round the temperature to the nearest multiple of 5 before using the chart.

Phase	Time	Slide	Description
Demonstrate (cont.)	75 min.	21	 23. Once students know the temperature and relative humidity, they can use the Heat Index Table to determine the heat index. Note that the heat index may actually be cooler than the ambient temperature, depending on the humidity that day. Optional Extension: Have students use their sling psychrometers daily for an extended period of time to track how temperature, RH, and heat index vary over time. Their data can be recorded in a spreadsheet and graphed.
Review	10 min.	22	 24. Ask students if they think they now have enough information to answer the question of why hot weather in OK feels different than hot weather in AZ. They should record their thoughts on the What I Know handout. You can have students discuss ideas with each other. Have students provide evidence from the data they've collected, charts they've analyzed, etc. You can make a list of evidence on the board.
Celebrate	5 min.	23	25. Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure <i>every</i> student's effort is celebrated.

WEATHERING THE STORM

Meteorology Curriculum

Teacher Guide: Module 1 Lesson 4

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 4 - Wind Chill

Lesson Navigating Question: Does heat index work the same in the winter?

Grade Levels:

6-8

Time Required:

95 Minutes

2 Class periods

STEM Content Areas:

Science, Technology

Overview

Students will investigate why heat index is not a value reported for temperatures below 76 degrees. Students will analyze data of various temperatures and relative humidities to identify patterns and construct an explanation of why heat index values have a lower limit. Students will use a standard chart to determine wind chill and will evaluate the safety of those weather conditions.

Oklahoma Academic Standards

Science Standards

Disciplinary Core Ideas

- **6.PS3.4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample
 - Temperature is a measure of the average kinetic energy of particles of matter.
 - The relationship between the temperature and the total energy of a system depends on the types, states, and amount of matter present.
 - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

Science and Engineering Practices

- **Planning and Carrying Out Investigations** Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.
- Developing and Using Models Develop a model to describe unobservable mechanisms.
- Analyzing and Interpreting Data Analyze and interpret data to determine similarities and differences in findings.
- Mathematics and Computational Thinking Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Constructing Explanations and Designing Solutions Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.

Crosscutting Concepts

- Patterns Graphs, charts, and images can be used to identify patterns in data.
- Energy and Matter The transfer of energy can be tracked as energy flows through a designed or natural system.
- **System and System Models** Models can be used to represent systems and their interactions such as inputs, processes, and outputs and energy, matter, and information flows within the systems.

Oklahoma Academic Standards (cont.)

Computer Science Standards

- 6.DA.S.01 Create multiple representations of the same data.
- 6.DA.CVT.01 Collect data using computational tools and transform the data to make it more useful.
- **6.DA.IM.01** Use data to highlight or propose cause-and-effect relationships, predict outcomes, and communicate ideas.

Learning Objectives

- 1. Interpret temperature and relative humidity data to explain why heat index is not reported in cold weather.
- 2. Recognize that wind chill is a measure of how temperature feels to human skin due to wind.
- 3. Create a model to demonstrate how wind increases heat loss from the skin, causing the air to feel colder than the actual temperature.

Vocabulary

• Wind Chill - what the air temperature feels like to humans due to wind blowing on exposed skin

Materials

- Fan
- Hair dryer
- Computer access
- Student Handouts: How Low Can You Go, Chilling with Wind Chill, Wind Chill Chart, Putting It All Together

Preparation

- 1. Ensure students have access to computers and the internet.
- 2. Set up a fan and hair dryer station. If possible, allow each group of students to have both a fan and hair dryer.

Module 1 Lesson 4.1 - 95 minutes

Phase	Time	Slide	Description
Enroll	5 min.	3	 1. Ask students to consider the lesson question, "Does heat index work the same in the winter?" Ask if we have any reason to think it wouldn't work the same based on what we've learned so far. Have students talk with a partner or with a group before sharing ideas with the whole class.
Experience	40 min.	4	 Have students examine the Heat Index Table, record what they notice, and wonder about the lower temperatures on the chart. Students should record their thoughts on the student handout How Low Can You Go? Students will create an initial model that they think explains why lower temperatures are not included on the table. Have students use a computer to access this heat index calculator. Students will use the calculator to investigate how heat index behaves with lower temperatures. Students should first plan how they will investigate. They should decide what temperatures and what %RH they wish to enter into the calculator. The intention with this step is to help students experiment methodically and with reason instead of randomly entering numbers. This step can be completed individually or with a partner. Have students record their results on a spreadsheet. Check with individual students to determine what their investigation plan is. If students appear to have selected random numbers, suggest that it may be easier to see patterns in the results if they use a pattern to select what values to test.

Phase	Time	Slide	Description
Experience (cont.)	40 min.	4	5. After students have entered their results, they should use colors and/or graphs to analyze their data. Color coding can easily be accomplished with conditional formatting. 6. Students have likely chosen different values to test. Consider having students submit their data to a class data set. This will allow them to analyze a wider range of data. 7. Students should make a claim about why they think lower temperatures are not included in the heat index table. They should use evidence they have collected to support this claim. Have students share their claims and evidence with the class.
Label	5 min.	5	 8. Explain that wind chill makes the air feel colder than it is because wind blows body heat away from our bodies. • Wind chills only affect animals like humans, which produce body heat. The temperature of inanimate objects will not change, no matter how strong the wind is. Inanimate objects will never be colder than the air temperature.
Demonstrate	30 min.	6	 9. On the handout Chilling with Wind Chill, have students consider how wind might have a cooling effect against our skin. Have students share their models with a partner and/or with the class. 10. Set up at least one fan and hair dryer. Allow students to feel the air from both. Make sure the hair dryer is set for warm air. Students should notice that the fan feels cool but the hair dryer feels warm. 11. Ask students to create a model that explains how heat is being transferred. Students may need a reminder of heat transfer, such as conduction and convection. Students should identify that the warm air from the hair dryer is transferring heat to our skin so it feels warm. The air from the fan is cooler than our skin, so heat from our skin is transferred to the air, making us feel cooler.

Phase	Time	Slide	Description
Demonstrate (cont.)	30 min.	6	 12. Have students share their models with a partner and with the class. Students should identify that heat is always transferred from warmer objects to cooler objects. 13. Students will practice determining wind chill using a wind chill chart. Students should create a color coding system to indicate the safety of outdoor activity in the given weather conditions. Students should determine what information they want to convey, such as safe vs. unsafe, frostbite times, exposure threshold time, etc. Ideally, they will create their own color coding system instead of copying the one on the wind chill chart.
Review	10 min.	7	 14. Have students reflect on what they've learned so far on the handout Putting It All Together. Students should identify that: Humans can perceive the temperature to be hotter or colder than it actually is. When the humidity is high, heat from our bodies is not conducted as readily to the surrounding air because not as much sweat evaporates. This causes a heat index (perceived temperature) that is higher than the actual temperature. When temperatures are low and wind speeds are high, more heat from our bodies is conducted to the surrounding air, causing a wind chill (perceived temperature) that is lower than the actual temperature. Humidity is an important factor for heat index because our bodies sweat to cool us down, but it is not important for wind chill.
			Teaching Tip: This activity can be used as a summative assessment.
Celebrate	5 min.	8	15. Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure <i>every</i> student's effort is celebrated.

WEATHERING THE STORM

Meteorology Curriculum

Teacher Guide: Module 1 Lesson 5

Module Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?

Lesson 5 - Temperature Advisory Alerts

Lesson Navigating Question: How do we keep people safe in the extreme temperatures of summer and winter?

Grade Levels:

6-8

<u>Time Required:</u> 155 Minutes 2-3 Class periods

STEM Content Areas:

Technology

Overview

After examining the work of a meteorologist in Oklahoma, students create a temperature advisory alert for either extreme heat index or wind chill temperatures. Students will decide how the alert should be designed and disseminated for equitable access for all.

Oklahoma Academic Standards

Computer Science Standards

- 6.DA.CVT.01 Collect data using computational tools and transform the data to make it more useful.
- **6.DA.IM.01** Use data to highlight or propose cause-and-effect relationships, predict outcomes, and communicate ideas.
- 6.IC.CU.01 Explain how computing impacts people's everyday activities and careers.
- **6.IC.CU.02** Identify and discuss the technology proficiencies needed in the classroom and the workplace, and how to meet the needs of different users.

6.AP.PD.01 - Seek and incorporate feedback from team members to refine a solution to a problem.

Learning Objectives

- 1. Describe the health risks associated with extreme heat index and wind chill conditions.
- 2. Create an informational display to warn people of the effects of extreme temperatures

Materials

- Computer and internet access
- Student Handouts: Investigating Weather Warnings, Meet a Professional, Creating a Temperature Advisory Notice, Peer Evaluation Form

Vocabulary

- Excessive heat outlook excessive heat possible in the next 3-7 days
- Excessive heat watch excessive heat is likely in the 24 to 72 hours
- Heat advisory when the max heat index is 100°F or higher for at least 2 days
- Excessive heat warning When the max heat index is 105°F or higher for at least 2 days
- **Wind chill watch** there is potential for very cold air and strong winds to create dangerously low wind chill values
- Wind chill advisory low wind chill temperatures are expected but will not reach local "warning" criteria
- Wind chill warning very cold air and strong winds will create dangerously low wind chill values
- Heat exhaustion a serious condition in which the body overheats
- Heat stroke the body can no longer control its temperature and is unable to cool down
- Hypothermia when the body loses heat faster than it can produce heat

Module 1 Lesson 5 - 155 minutes

Phase	Time	Slide	Description
Enroll	10 min.	3-4	1. Tell students that they have learned a lot about temperature and how humans experience temperature. Remind students of the module driving question. Now we want to know how we can use that information to keep people safe during the extreme temperatures of summer and winter. 2. As a Think-Pair-Share, have students discuss if they have seen the words watch, warning, or advisory on weather alerts. Have students discuss what they think those words mean. Have they seen an extreme temperature advisory alert? Where did they see it? When was the alert announced? How or where do they normally get information about extreme temperature warnings?

Phase	Time	Slide	Description
Enroll (cont.)	10 min.	3-4	 First, give students time to think quietly, and then have them talk with a partner. You may want to have them discuss each question separately. Have some students share with the class. Make a list of responses on the board. Continue accepting all responses until all ideas have been listed. 3. Now ask students if there might be people who are unable to receive warnings in the ways they've listed. Examples may include people without cell service, or don't have a TV, people who speak a language other than English, people who are vision impaired, etc. Teaching Tip: It is important not to approach step 3 with a deficit view. If people do not have access to weather safety information, it is not a fault of their own. The goal is to help students see that there is not equitable access to safety information, such as weather reports that are only offered in English. If there are limited ways to access safety information, some people will be left out. This is a problem that students will attempt to solve.
Experience	45 min.	5	 4. Have students research temperature advisory alerts for either extreme heat or extreme cold. They should look for patterns, such as what kind of information is included, how the alerts are disseminated, terminology that is used, impact on humans, etc. The Investigating Weather Warnings handout may be used to help guide students' research if desired. Useful websites include: Heat Safety Tips and Resources (weather.gov/safety/heat) Cold Weather Safety (weather.gov/safety/cold) Have students share their findings. This could be in the form of class discussion or a short slideshow presentation.

Phase	Time	Slide	Description
Label	5 min.	6-8	6. Student research should identify the definition of advisories, watches, and warnings for both heat index and wind chill. If not, define with students what these mean. 7. Student research may also uncover heat exhaustion, heat stroke, and hypothermia. If not, define these with students as well.
Enroll	10 min.	8	 8. Now that students have seen examples of watches, warnings, and advisories, ask if the difference between those words was obvious to them. 9. Have students think about past experiences that helped them understand these words. Have they seen those words used before? • Students who have lived in Oklahoma for a while are probably familiar with severe storm watches and warnings. 10. Now, have students consider whether they would have the same innate understanding of the words if they had not had those past experiences (for example, maybe they recently moved to Oklahoma and have not seen severe storm watches or warnings). • Students who have lived elsewhere and are not familiar with the terminology (or have seen it used in a different context) may be able to share how their past experiences have given them a different understanding of the words. • Students whose primary language is not English may explain that the difference in meaning between the words is unclear. Teaching Tip: If students have different understandings of the words watch, warning, and advisory (such as in the examples above), do not put them on the spot to explain their past experiences. This can accentuate a feeling of "otherness" or that their personal experience and knowledge is not "correct." Instead, aim to create a classroom culture of respect so that all students feel safe in sharing their experiences. Treat student knowledge, culture, and experience as a valuable resource that they may share if they feel comfortable doing

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Phase	Time	Slide	Description
Experience	20 min.	9	 In the Meet a Professional Spotlight, students are introduced to Joseph Trujillo Falcón, a meteorologist specializing in bilingual risk communication. Joseph lives and works in Oklahoma with the Cooperative Institute for Severe and High-Impact Weather Research and Operations (CIWRO) at the University of Oklahoma. Watch MyRadar's interview with Joseph as he introduces his background and field of expertise, which involves removing barriers for Spanish speakers to access weather safety information. Have students read an article about Joseph's work. On the handout Meet a Professional, students will consider how Joseph's work could be used to make temperature advisory alerts more accessible for all.
Demonstrate	60 min.	10	12. Students will create a temperature advisory for either heat index or wind chill. 13. Using the <i>Creating a Temperature Advisory Notice</i> handout, have students first plan out their advisory notice before constructing a prototype. Allow students to create whatever type of advisory they think will be most helpful to people. This could be one of the examples listed on the handout, or they could come up with their own solution to the problem, similar to how Joseph changed the Spanish alert system. 14. Ideally, students should make a digital version of their advisory. That could be a video, sound recording, or graphic display.
Review	10 min.	11	 15. Have students evaluate the advisories of other students using the <i>Peer Evaluation</i> form. Every student can evaluate every advisory notice, or students could be assigned a few random evaluations. The form is designed to be anonymous, but names can be included if desired. Have students include specific information in the comments column explaining their scores. For example, if they give a 5, they could include a comment such as, "I like that you explained the difference between a warning and a watch. That should help people understand it better." 16. Peer evaluations should be returned to students so they can make any adjustments to their design.
Celebrate	5 min.	12	17. It's the final celebration! Celebrate students' efforts with high fives, team chants, toasts, a treat, awards, etc. Make sure <i>every</i> student's effort is celebrated.



Driving Question: How do we keep people safe in the extreme temperatures of summer and winter?



LESSON 0 - ENROLL

What is weather?

2

Does everywhere have the same weather?

3

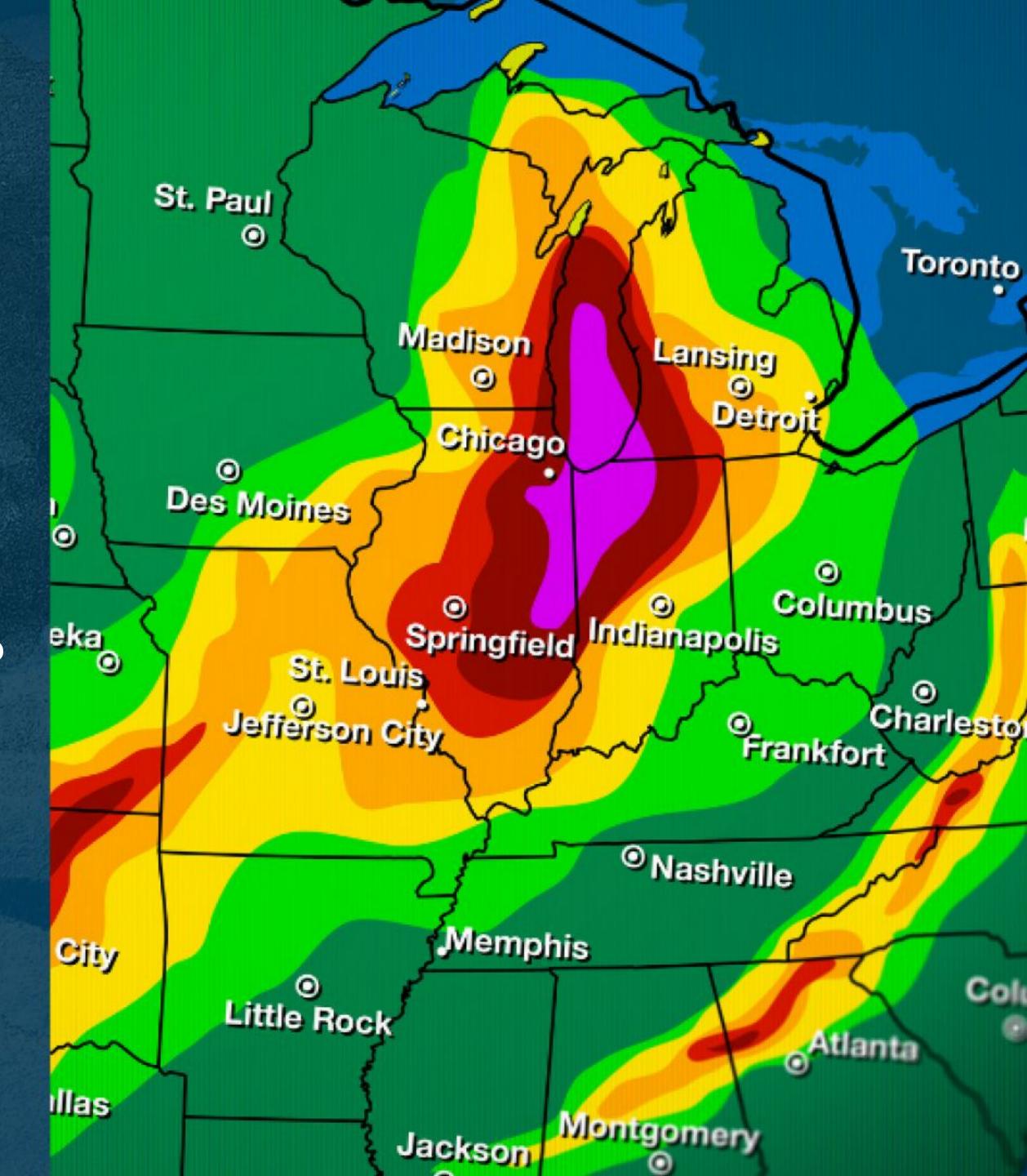
What kind of places might have different weather than Oklahoma?

LESSON 0 - EXPERIENCE

What is the weather like today?

What was the weather like yesterday?

What about 3 months ago?





LESSON 0 - LABEL

Weather is the state of the atmosphere including:

- Temperature
- Pressure
- Wind
- Humidity
- Precipitation
- Cloud cover



LESSON 0 - EXPERIENCE

Insert your local weather clip>

EXAMPLE

LESSON 0 - LABEL

Meteorology is the study of the atmosphere and all its processes, especially phenomena related to weather.

There are many types of careers in meteorology, not just the people you see on TV.





LESSON 0 - DEMONSTRATE

Let's explore some different careers in meteorology.

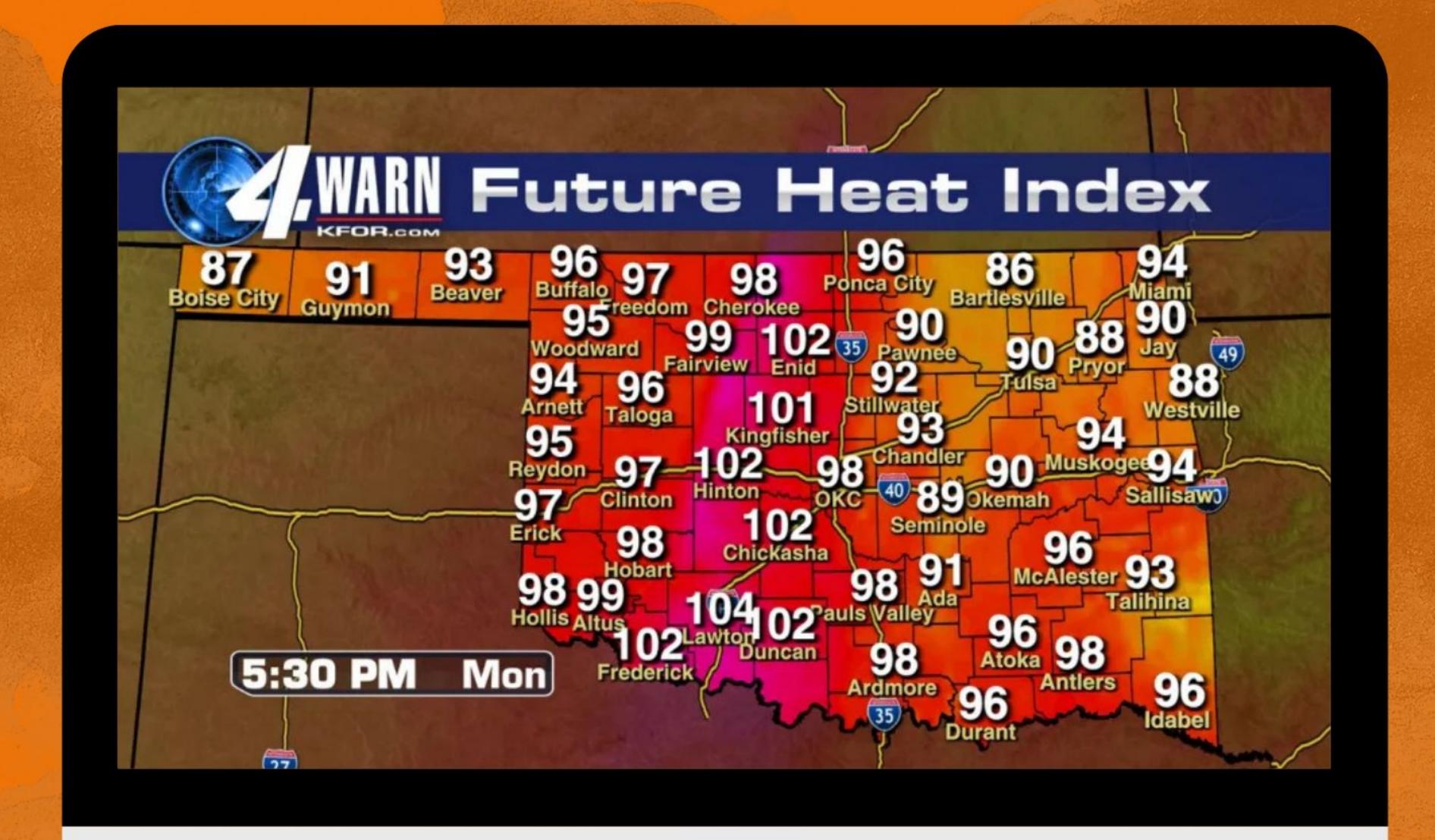
What do you find most interesting?

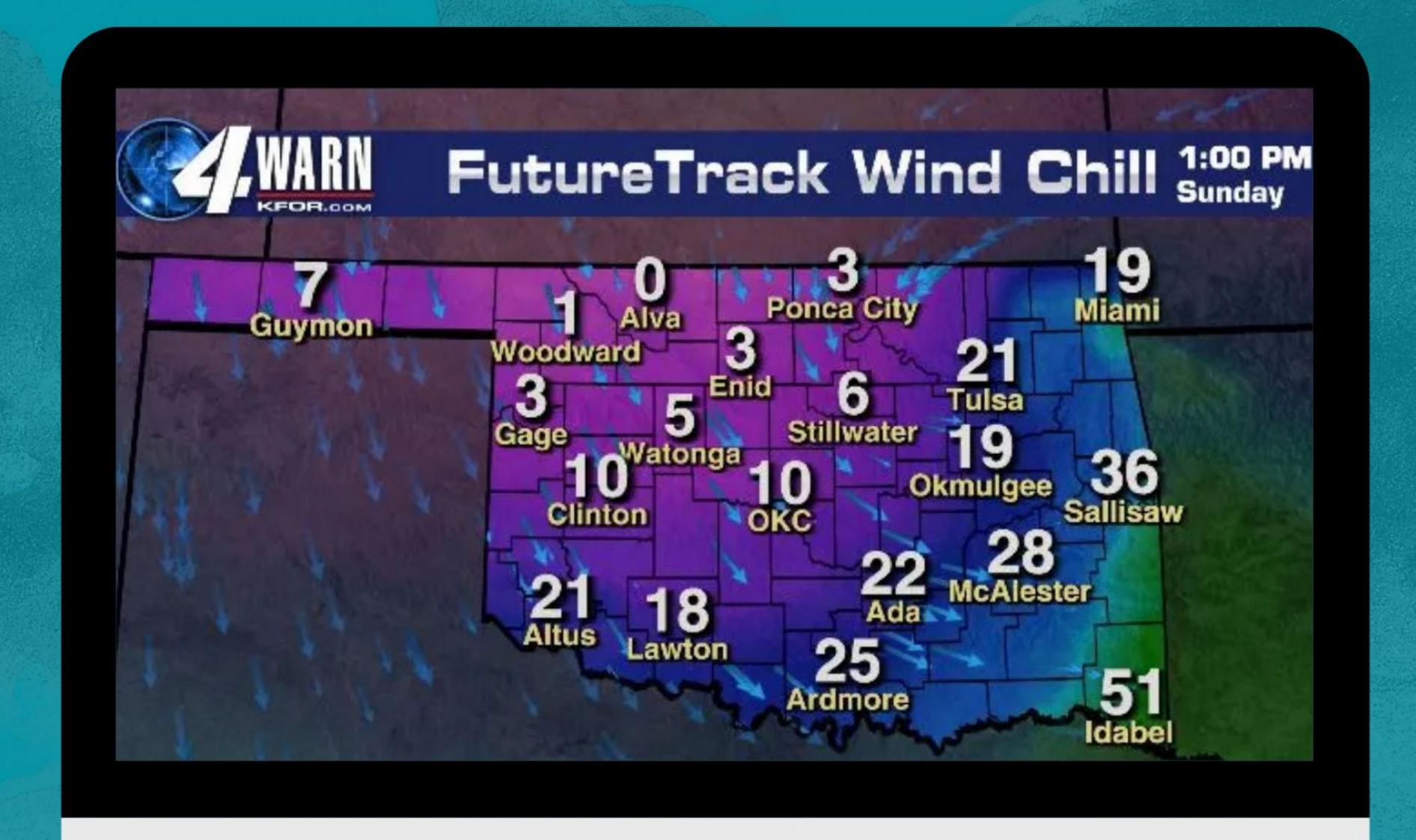
What is most surprising?











LESSON 1.1 - EXPERIENCE

How do we measure temperature?

Where should we measure temperature?



What is the temperature of this room?



<temp in F°>



<temp in C°>

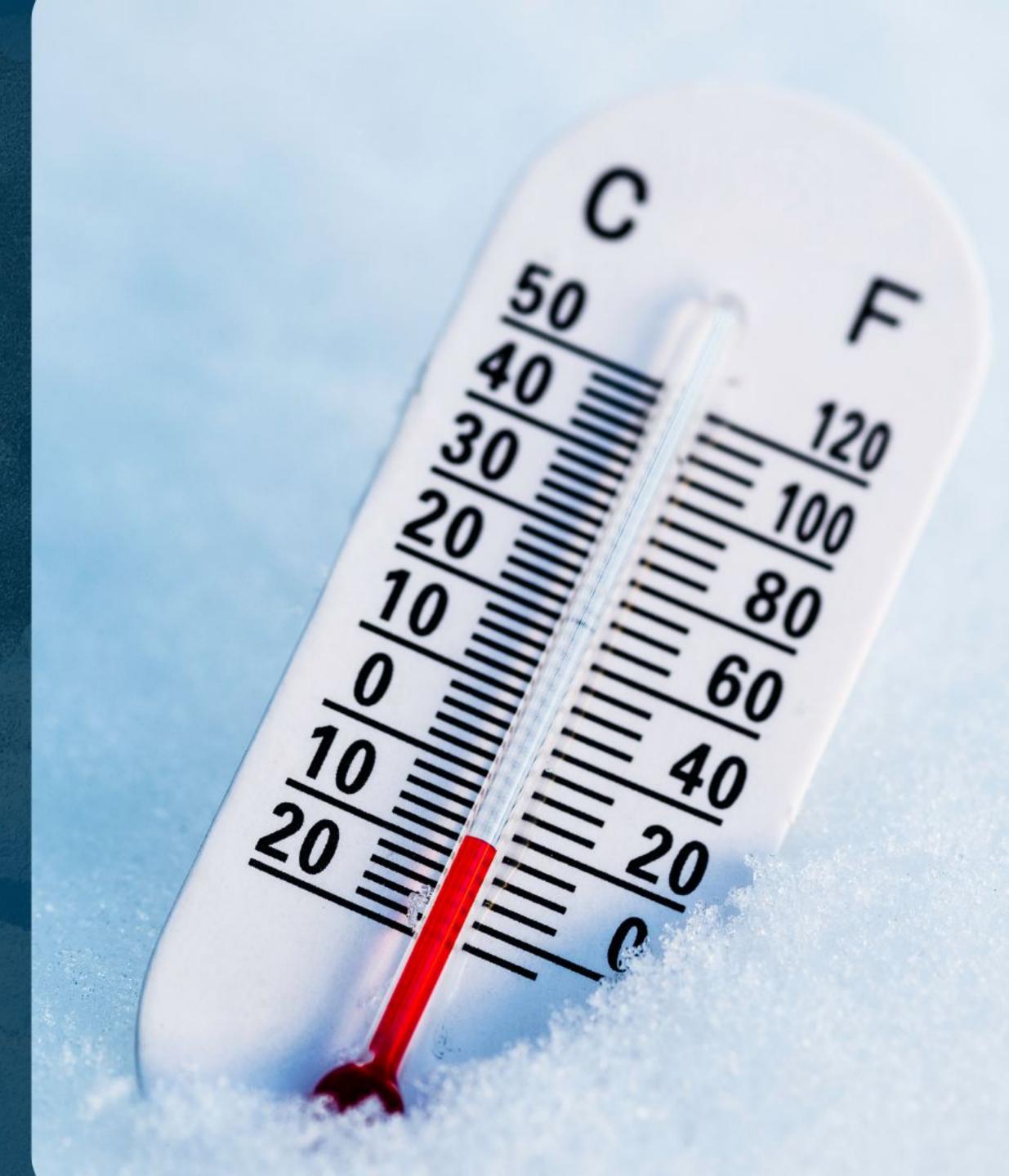


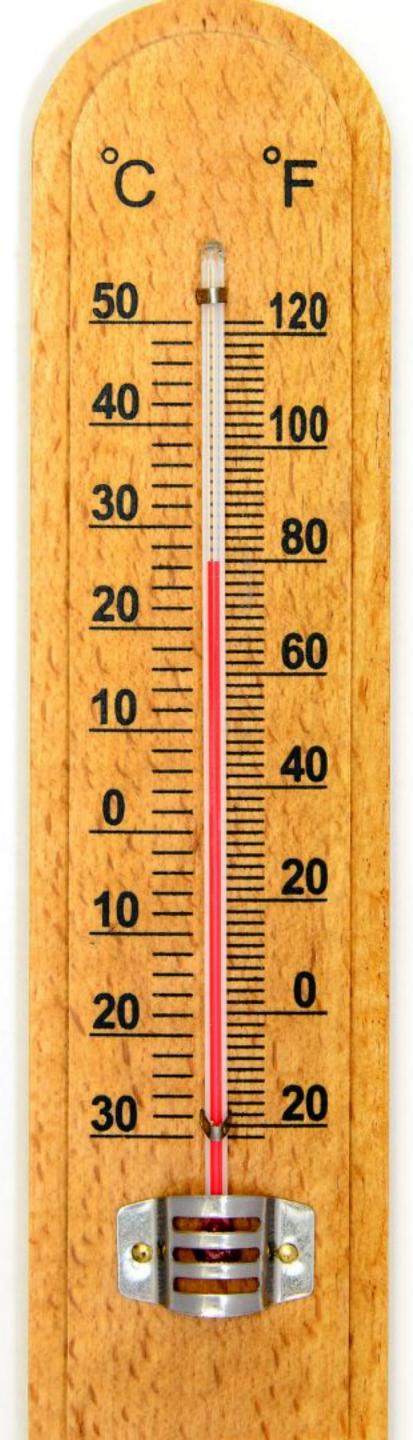
Turn and Talk!

- How can the room be two different temperatures at the same time?
- Be prepared to share your ideas with the class.

Celsius and Fahrenheit use different scales

Celsius is used for scientific purposes and in most countries around the world





How is this thermometer like a number line?

- Larger numbers on the thermometer represent higher temperatures
- Notice that zero is not at the bottom
 - 0°C is the temperature at which water freezes
 - In the Kelvin scale for temperature, zero (also known as absolute zero) is the lowest temperature possible

 ■ absolute zero (0K) has never been
 - reached

LESSON 1.1 - DEMONSTRATE

Let's practice reading a thermometer!

Complete page 1 of your Taking Temperatures handout.

LESSON 1.1 - DEMONSTRATE

Now that you're more familiar with Celsius and Fahrenheit temperatures, let's try collecting some data.

Complete page 2 of Taking Temperatures.

LESSON 1.1 - REVIEW

Now you know how to collect temperature data, just like a real meteorologist!

You'll get more practice later in this lesson. But for now, it's time to reflect on what you've learned. Record your ideas on your What I Know handout.







LESSON 1.2 - ENROLL

Does it matter where we collect temperature data outdoors?

Think about how temperatures might be different in the sun and in the shade.

Create an initial model to explain how you think temperatures might be different.

LESSON 1.2 - EXPERIENCE

Time to collect some data!

Record the temperature of 6 different samples. Some will be in the sun, some will be in the sun, some

Remember that scientists use Celsius!

LESSON 1.2 - EXPERIENCE

On your *Heat Absorption* handout, analyze your data to determine patterns and formulate an explanation.

THINK LIKE THE PROS!

Professionals use spreadsheets to analyze and graph their data. Practice your career-readiness skills by putting your data into Excel or Google Sheets.



Air, water, and soil absorb heat differently - why?

- The molecules in solids, liquids, and gases are moving at different speeds because they have different amounts of energy.
- Temperature can be described as the average kinetic energy (energy of motion) of the molecules in a substance.



Air, water, and soil absorb heat differently - why?

- As molecules of air, water, or soil heat up (absorb energy) they start to move faster (increase in temperature).
- Water and soil have more molecules than air does in the same amount of space, so it takes more energy to change the temperature of water or soil than air.

Gases absorb energy most quickly, so air will heat up and cool down the fastest.

Soil will heat up and cool down slower than air, but faster than water.

Is this what your results showed?



LESSON 1.2 - DEMONSTRATE

Now that you've analyzed your data, think back to the initial model you created about how temperatures might be different in the sun vs. in the shade.

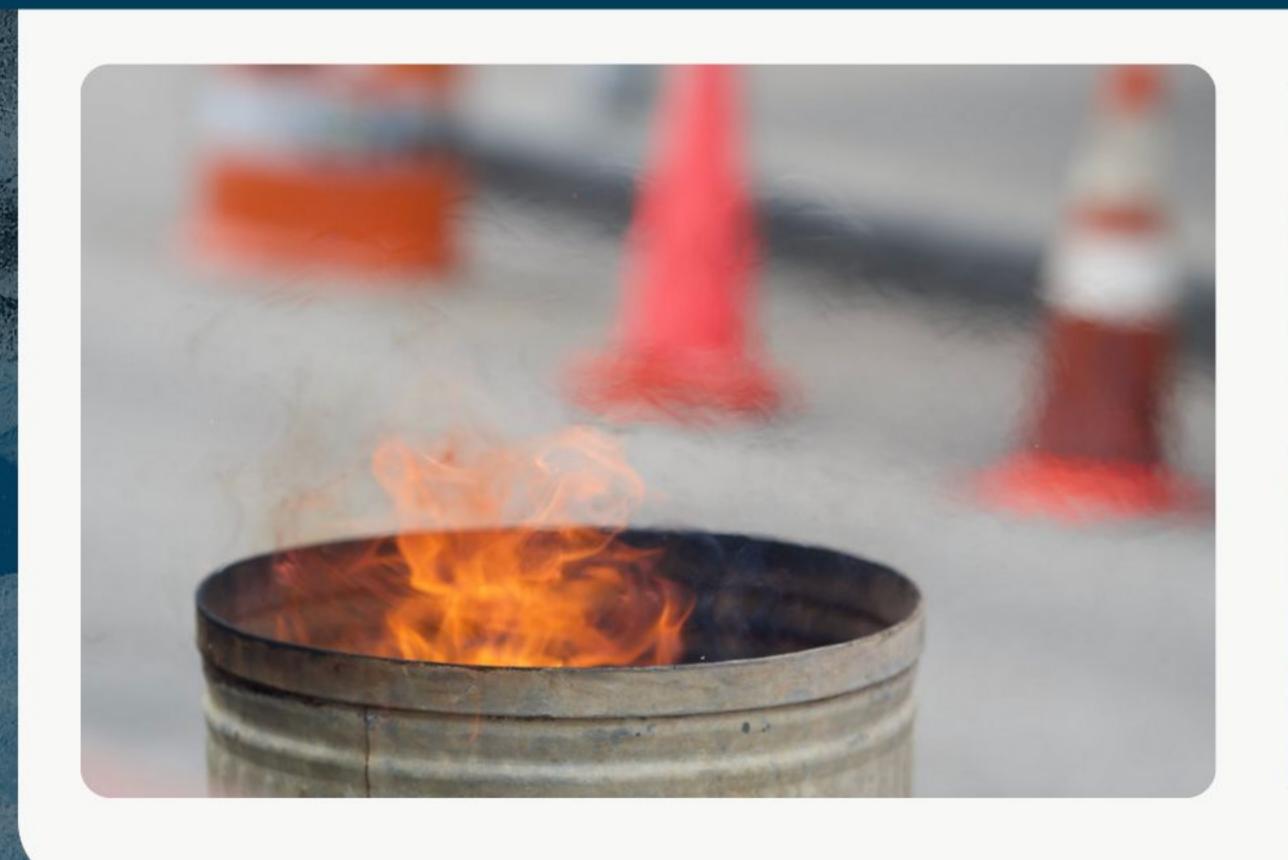
On your *Developing Ideas* handout, construct a new model to explain what you've learned.







WHAT IS GOING ON IN THESE IMAGES?

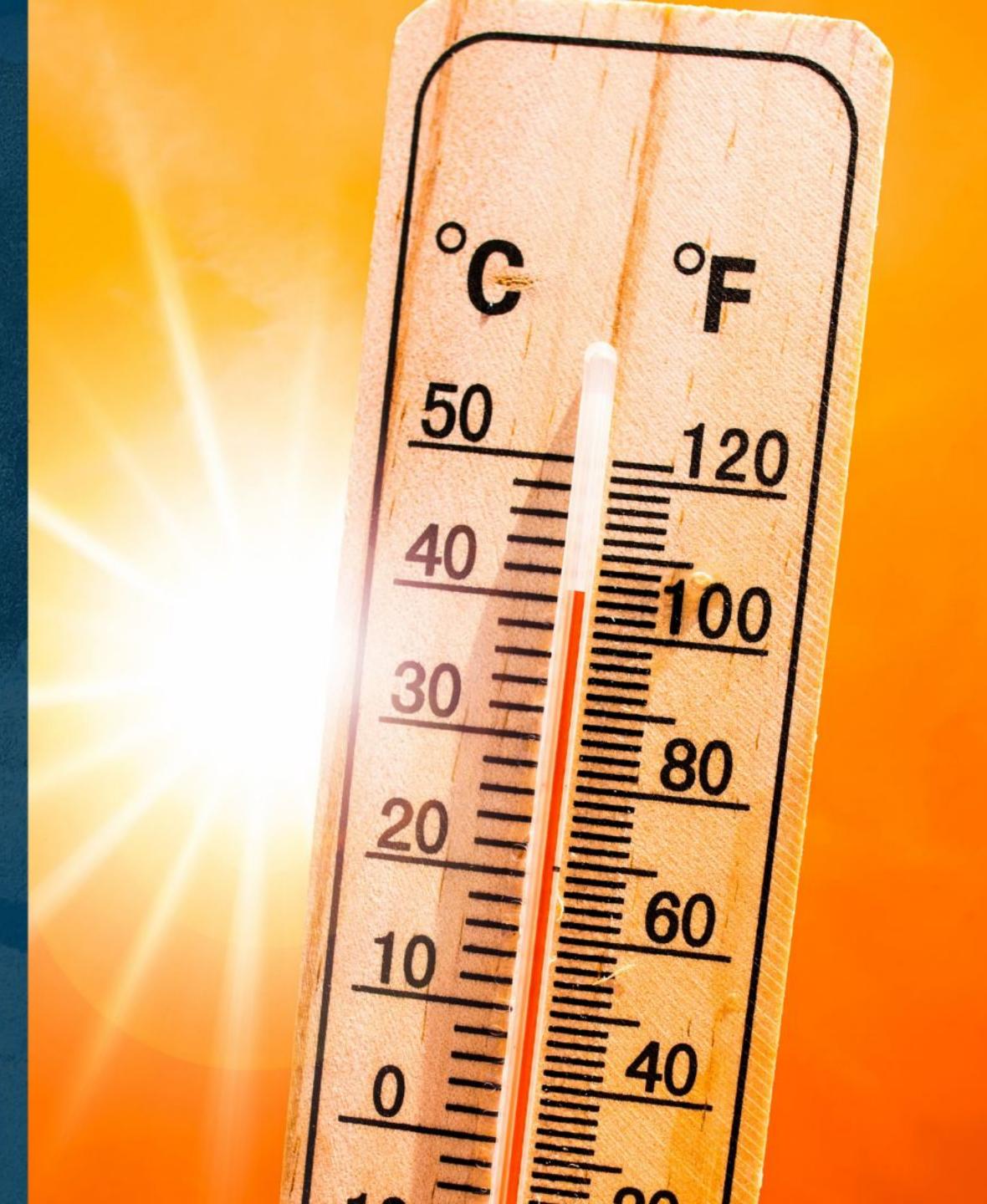




LESSON 2.1 - ENROLL

What else do we know about heat?

Think about things such as where heat comes from, how we know when something is hot, how objects heat up and cool down, etc.

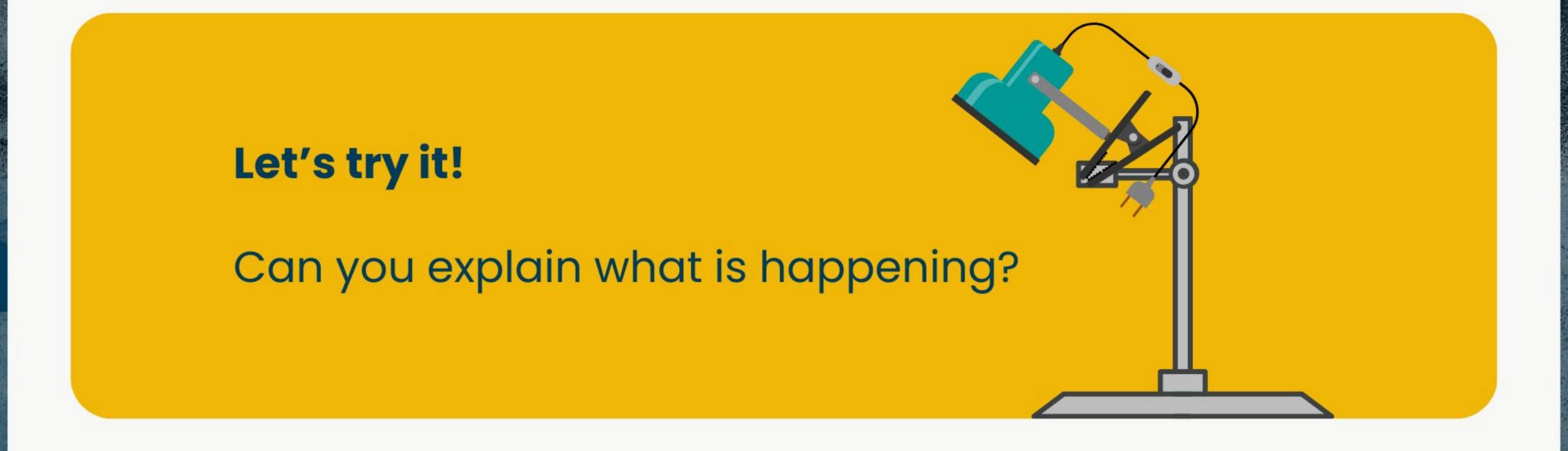




LESSON 2.1 - EXPERIENCE

Why can you feel heat when you're near a hot object if you're not touching it?

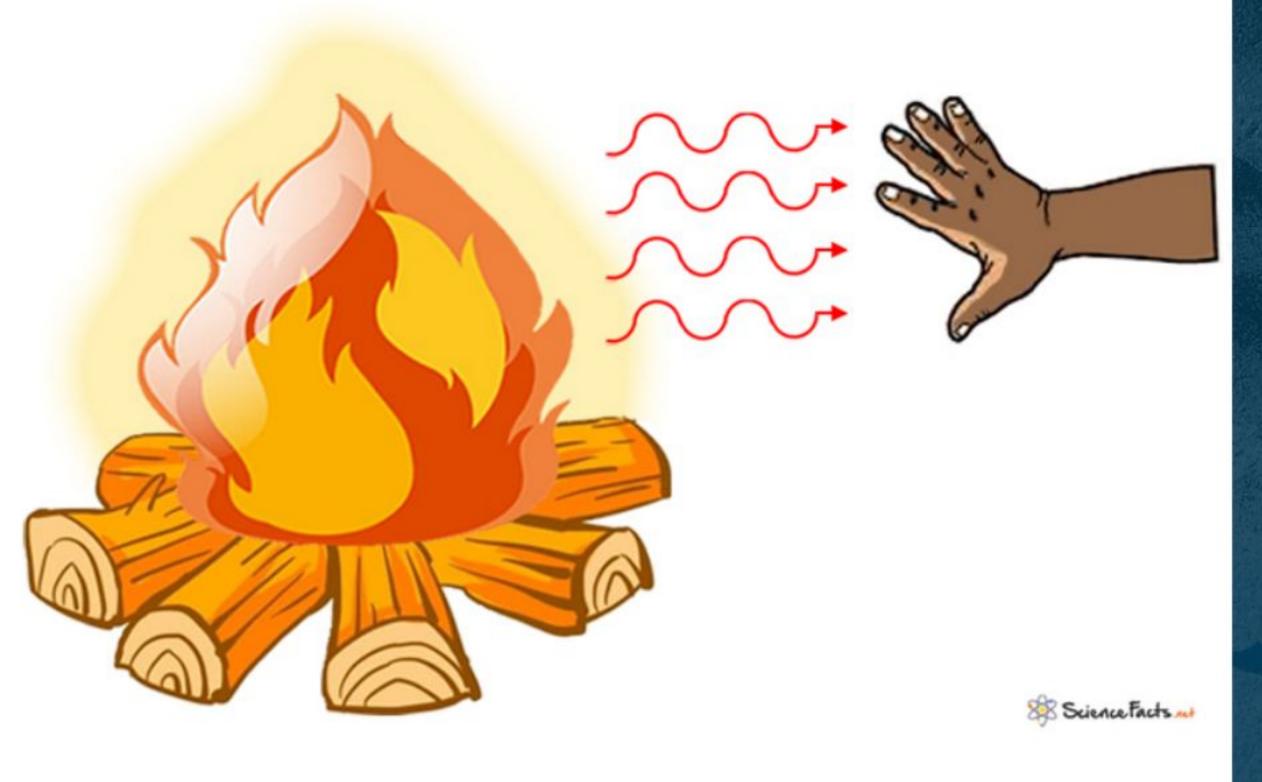
LESSON 2.1 - EXPERIENCE





Thermal Radiation

Campfire



LESSON 2.1 - LABEL

Radiation is the transfer of energy across space in the form of waves.

You can see radiation (in the form of heat) by using a thermal or infrared camera.

LESSON 2.1 - DEMONSTRATE

Remember our investigation of temperatures in the sun and shade?

How can we feel heat from the sun? Answer on page 2 of your *Heat Transfer* handout.

LESSON 2.1 - REVIEW

What other examples of radiation can you think of?





LESSON 2.2 - ENROLL

What do you observe in this video?

Can you explain what is happening?





LESSON 2.2 - EXPERIENCE

Observe how ice melts when placed on a heat source compared to when it is left at room temperature.

Use your Make it Melt handout.

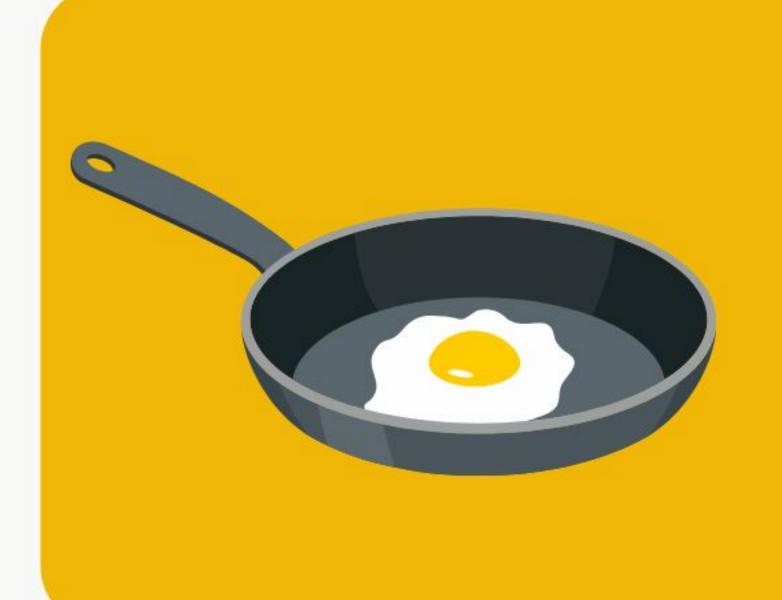
LESSON 2.2 - EXPERIENCE

Why does the ice on the hot plate melt faster?

What is the ice actually touching?



LESSON 2.2 - LABEL



Conduction is the transfer of heat from one object to another through direct contact.

Objects conducting heat can also radiate heat. More than one type of heat transfer often happens at the same time.

LESSON 2.2 - LABEL

How does conduction work?

- Molecules within a substance move faster or slower, depending on how much energy they have.
 - Solids have less energy and move slower, so the molecules are closer together
 - Gases have more energy and move faster, so the molecules are farther apart
- When heat is added, molecules move faster and bump into each other, transferring some energy to their neighbors
- As the hot plate heats up, it transfers energy to the molecules of the beaker, which then transfers energy to the molecules of the ice

LESSON 2.2 - DEMONSTRATE

Let's demonstrate conduction!

We are going to compare how heat is transferred in a solid and in a gas.

Each of you represents a molecule in either a solid or a gas. Your cup represents the amount of energy you contain.

As energy is added to the solid/gas in the form of heat, the way you are able to move will also change.

LESSON 2.2 - DEMONSTRATE

The amount of beads in your cup represents how much energy you have. The more energy you have, the faster you're able to move.

Move around the space according to how much "energy" you have. When you are close enough to high-five another person, give them a high-five. If you have more energy than they do, transfer some of your energy to their cup.

Keep moving until everyone has about the same amount of energy (the line on your cup).

LESSON 2.2 - REVIEW



- As you read, highlight important points of information
- Summarize what you highlighted in 3-4 sentences.





LESSON 2.3 - ENROLL

What is happening in this video?



LESSON 2.3 - ENROLL

Quick review!

- We can feel heat when we are near a hot object because of radiation.
- Air that is near a hot object heats up because of conduction.

What happens to that air after it heats up?





LESSON 2.3 - EXPERIENCE

We're going to use water to simulate what happens when air heats up and cools down.

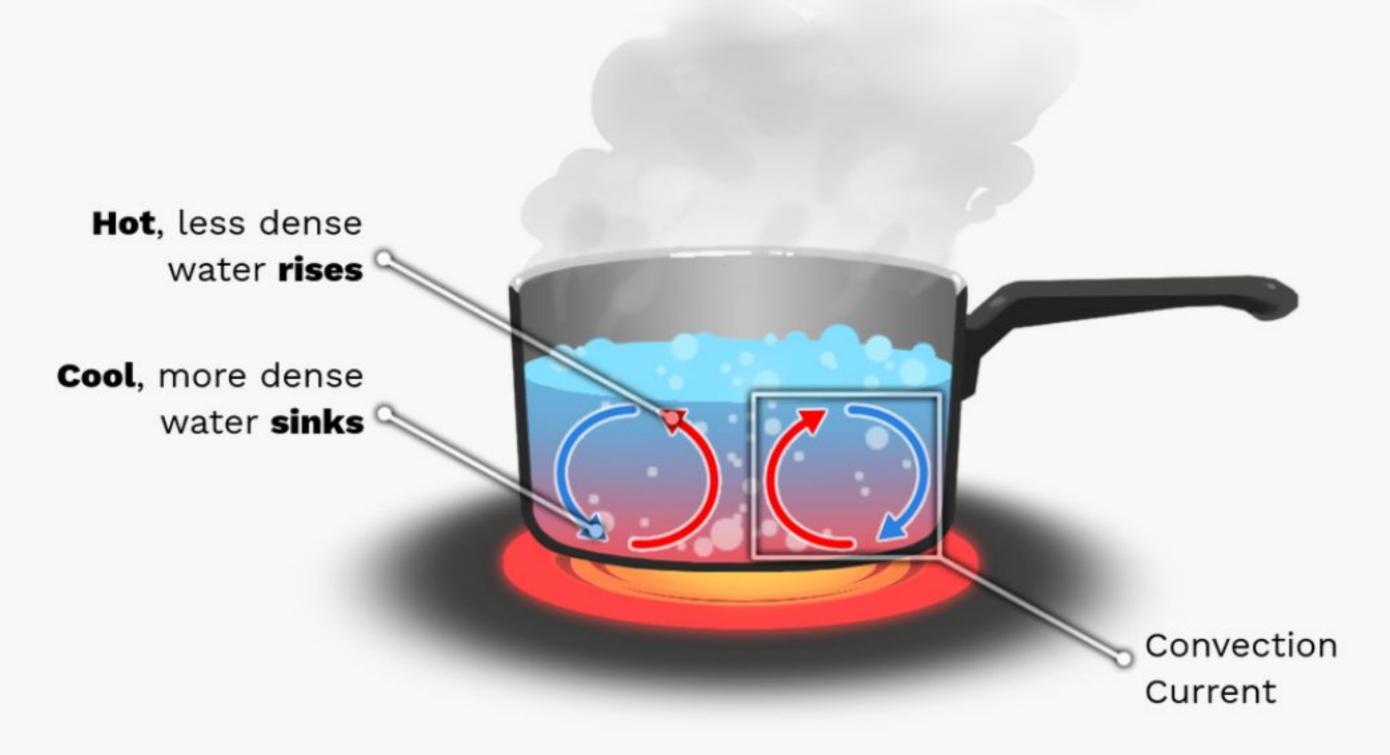
Why are we using water?

- Water is easier to see than air
- Both are fluids, so both behave in the same way.

LESSON 2.3 - LABEL

Convection is the transfer of heat by the movement of fluids (liquids and gases).

Warm fluids rise and cool fluids sink. This pattern creates a convection current.



LESSON 2.3 - LABEL

Why do warm fluids rise?

- Think about what happens to the molecules of a substance when it heats up.
 - o They move faster!
 - As the molecules start to move faster, they spread out, making the warm fluid lighter (less dense) so it floats up (rises).



LESSON 2.3 - LABEL

Using what you know about warm fluids, why do you think cold fluids sink?

- When a substance is cool, its molecules move slower. Because the molecules are moving slower, they get closer together (condense).
- This makes the fluid heavier (more dense), causing the cold fluid to sink.

Convection currents in the air can create large masses of warm or cold air that we call warm fronts and cold fronts.

LESSON 2.3 - DEMONSTRATE

Can you predict what will happen in this video?



LESSON 2.3 - REVIEW

Read this <u>article</u> on heat transfer from NOAA.

Update your What I Know handout with what you've learned about heat transfer.





LESSON 2.4 - ENROLL

What is happening in this video?

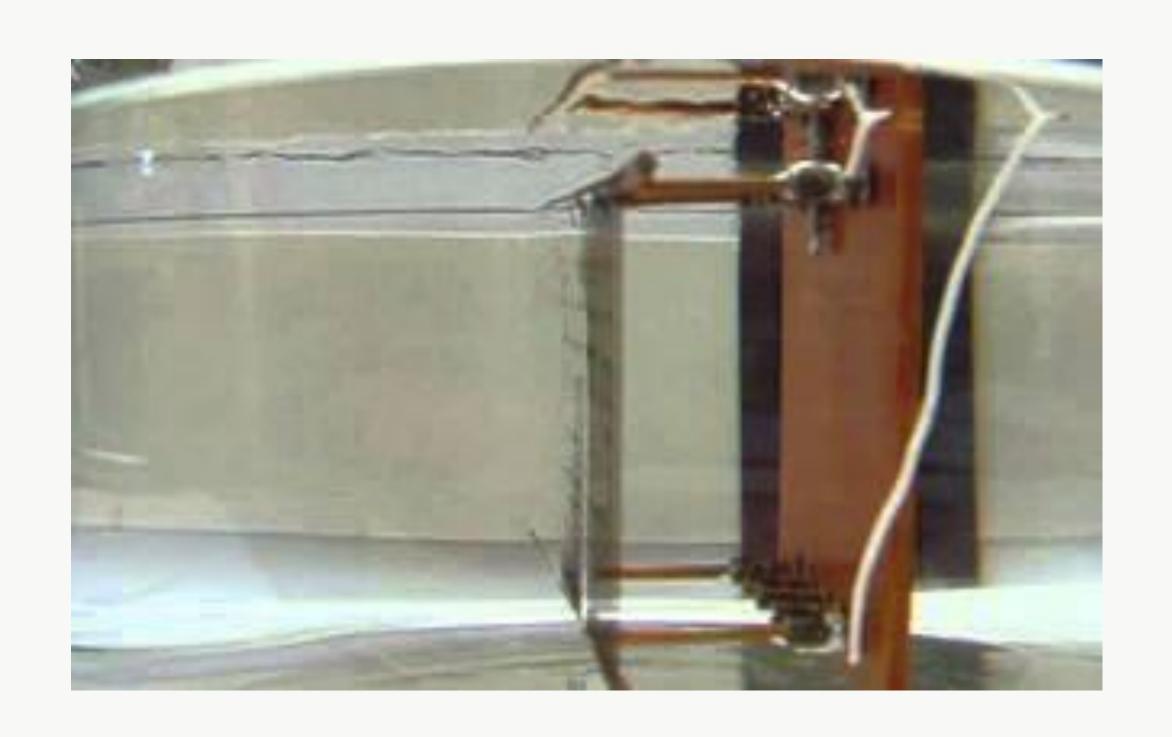


LESSON 2.4 - EXPERIENCE

Watch the video and record your observations.

What do you notice? What do you wonder?

What do you think is happening?

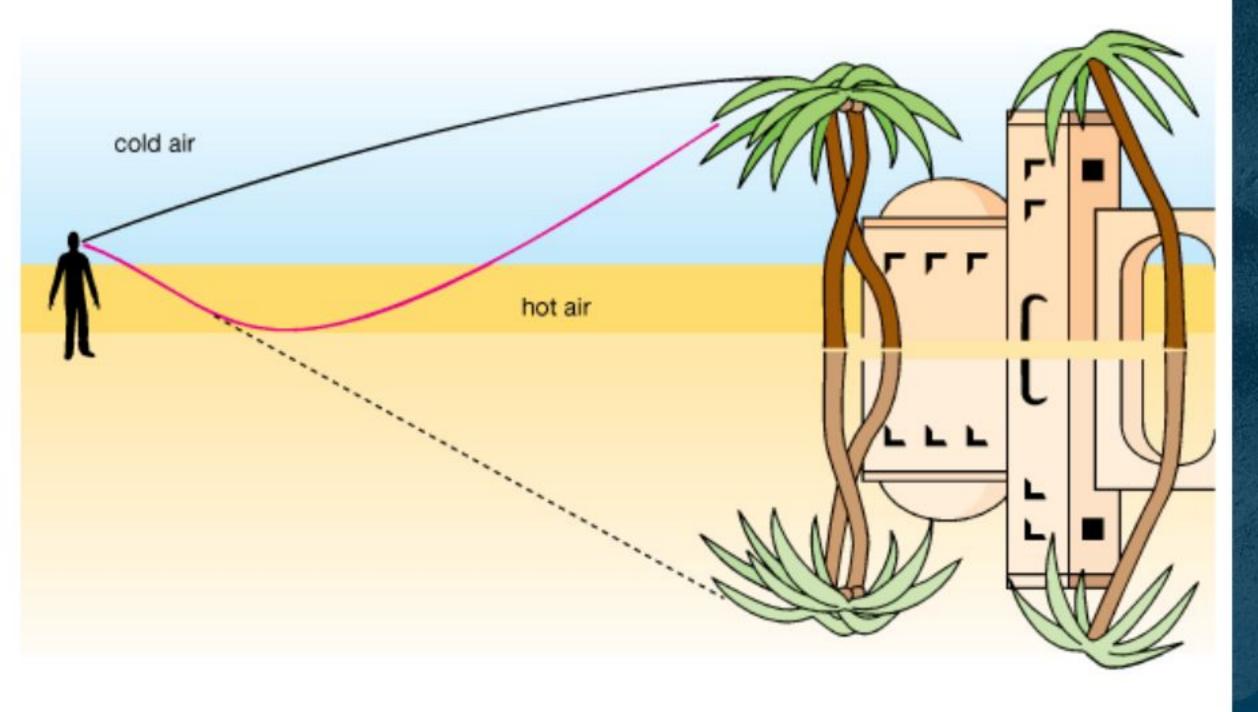


LESSON 2.4 - LABEL

Read this article about the device you just witnessed.

Update your Are Invisibility Cloaks Real handout.

Formation of an inferior image



© 2010 Encyclopædia Britannica , Inc.

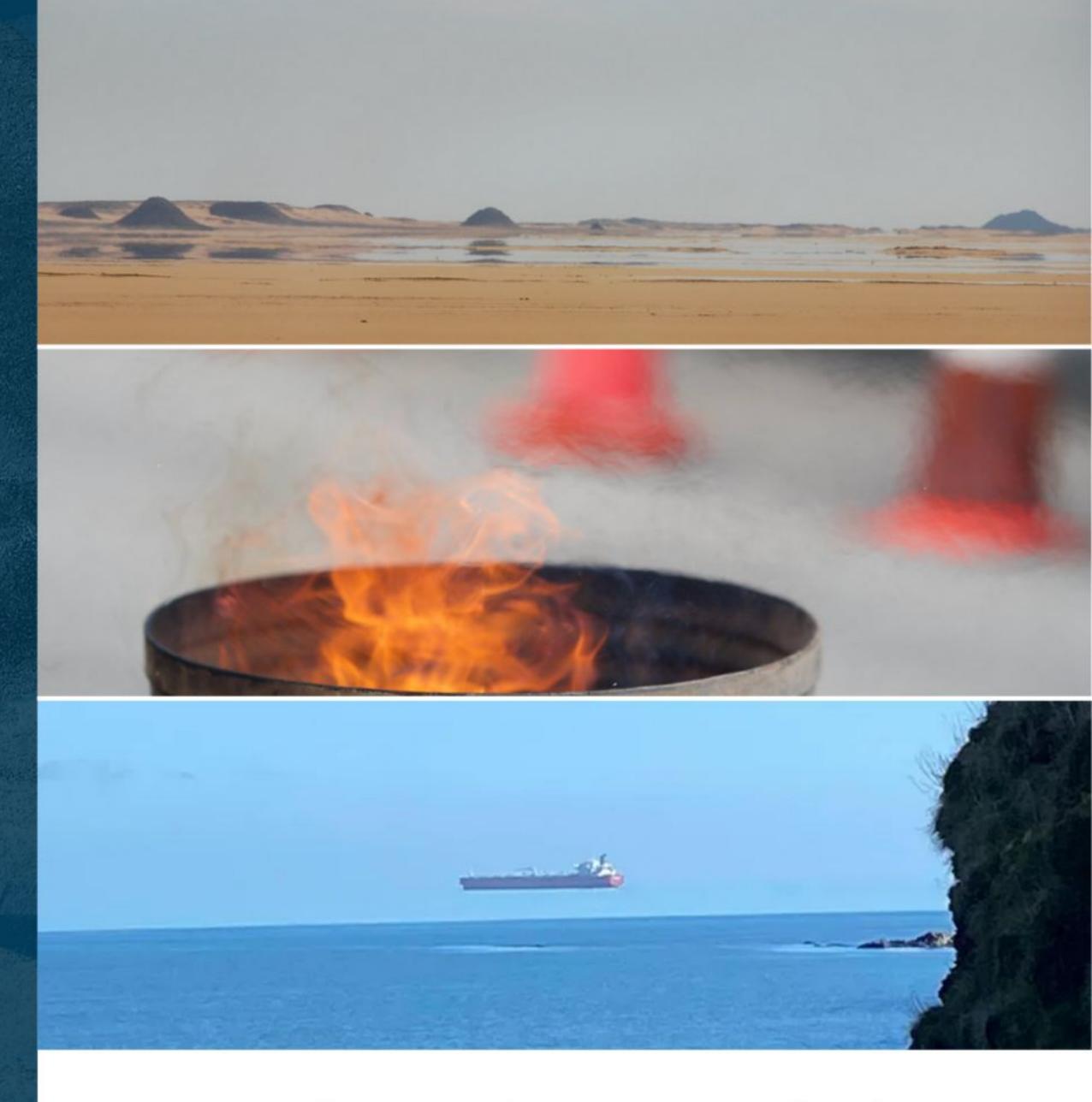
LESSON 2.4 - LABEL

A mirage is an optical illusion that causes us to see images that aren't really there.

A mirage happens when a very hot surface (such as a roadway) conducts a lot of heat to the air directly above the surface.

LESSON 2.4 - LABEL

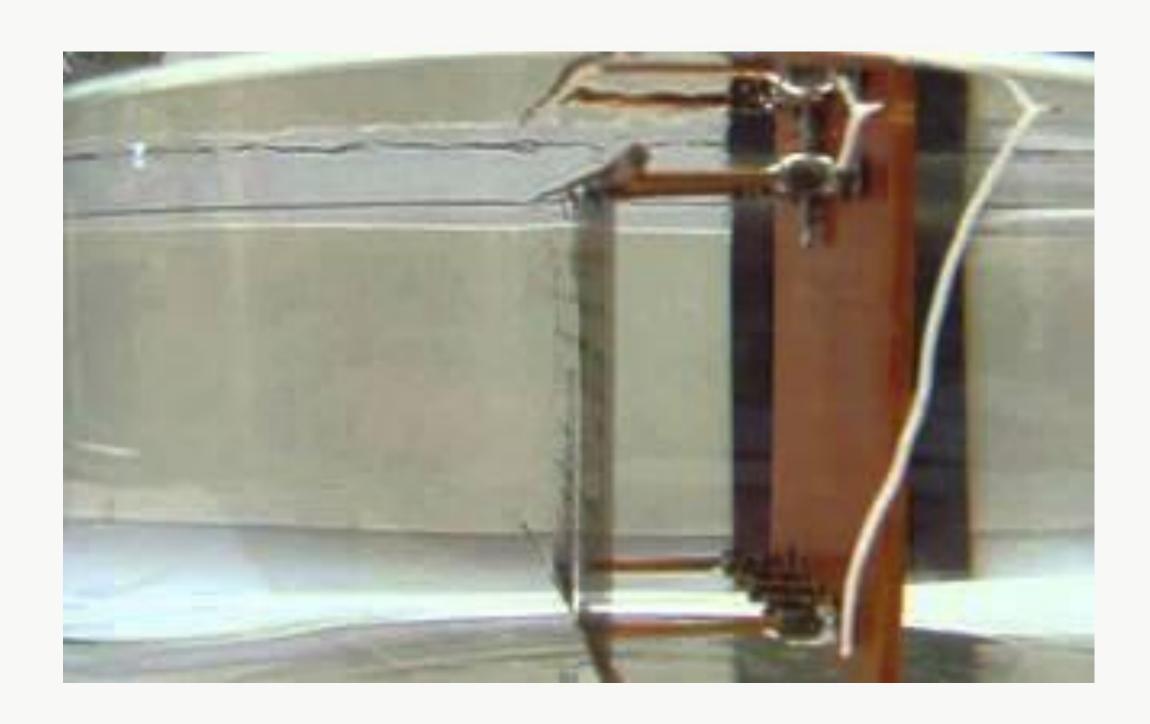
- The air near the surface is much hotter than the air above it.
- Light moves differently through the two layers of drastically different air temperatures.
- This causes us to see reflections of images or the sky (when it looks there's water on the ground).
- A mirage can also hide part of the surface, making it appear is though things are floating in the air



Heat shimmer is a type of mirage.

LESSON 2.4 - REVIEW

Why does the device become invisible?



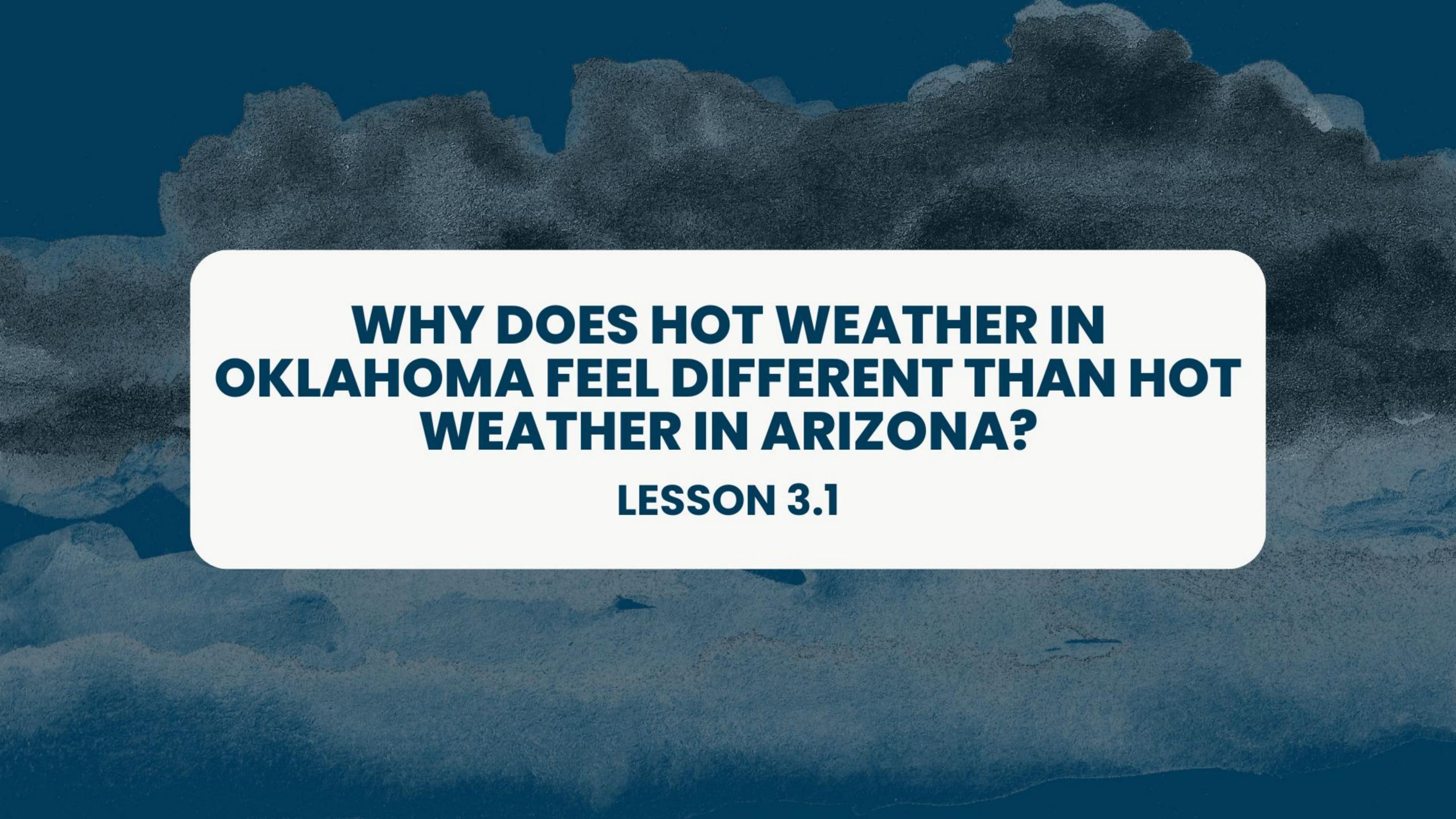
LESSON 2.4 - DEMONSTRATE

Use what you've learned to create a model that answers the question, "What happens after air heats up?"

Complete your Putting It All Together handout.





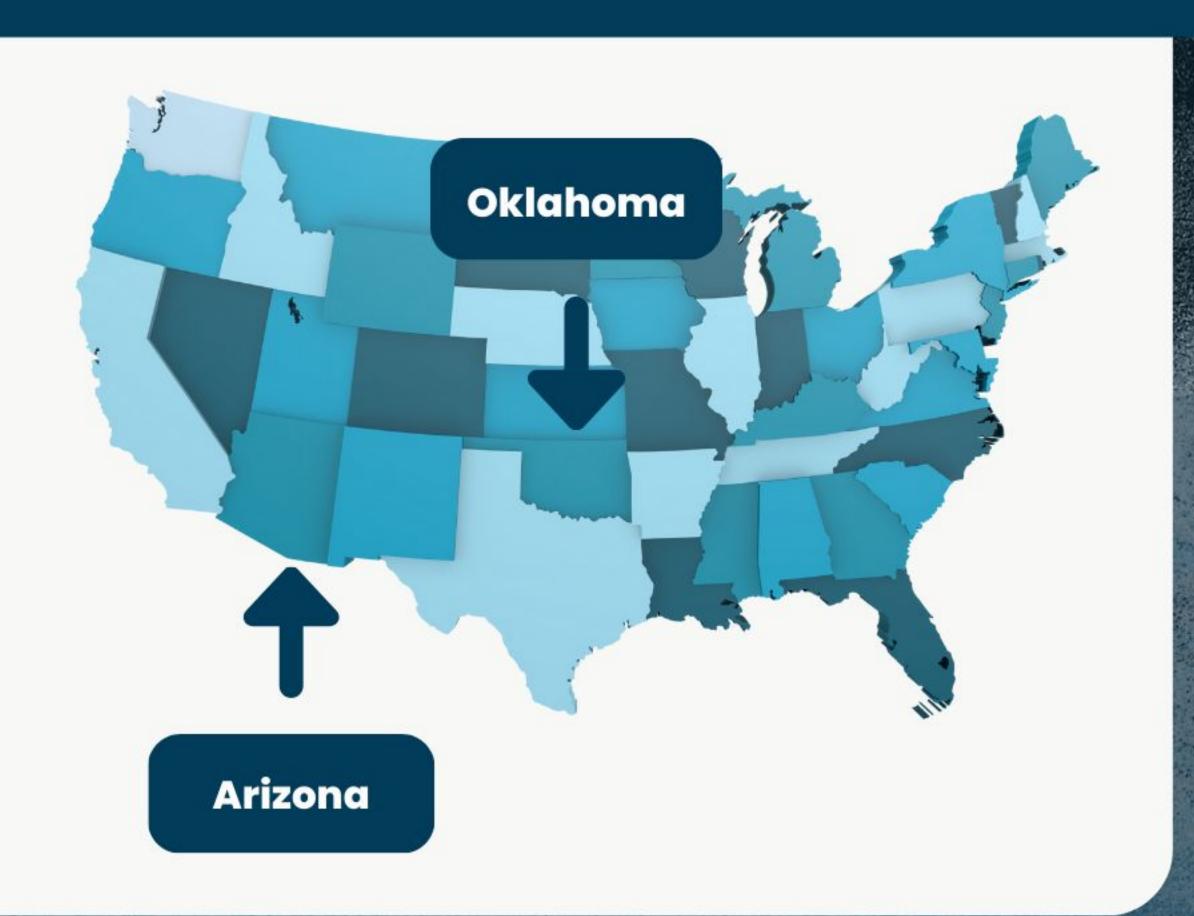


LESSON 3.1 - ENROLL

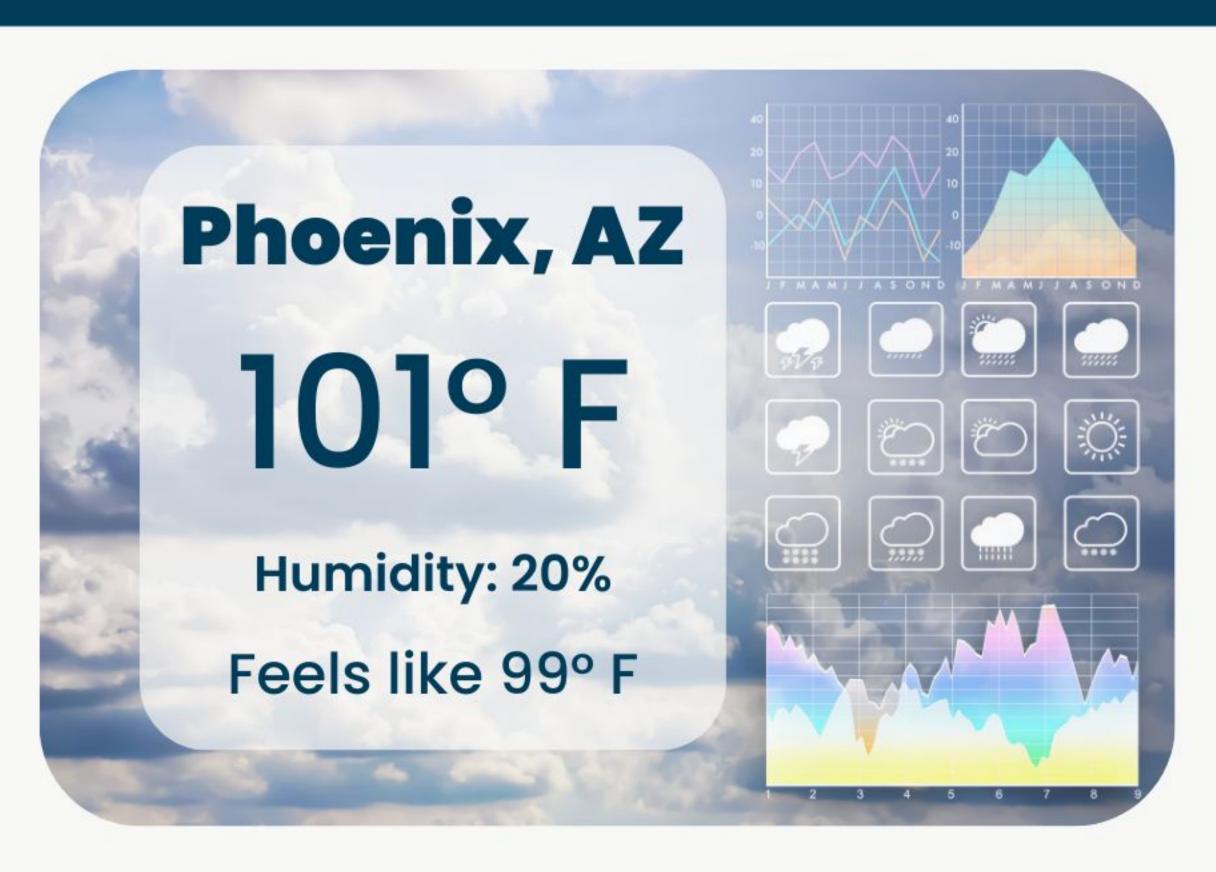
What do you know about Arizona and Oklahoma?

Have you ever been there?

What do you think it is like there?



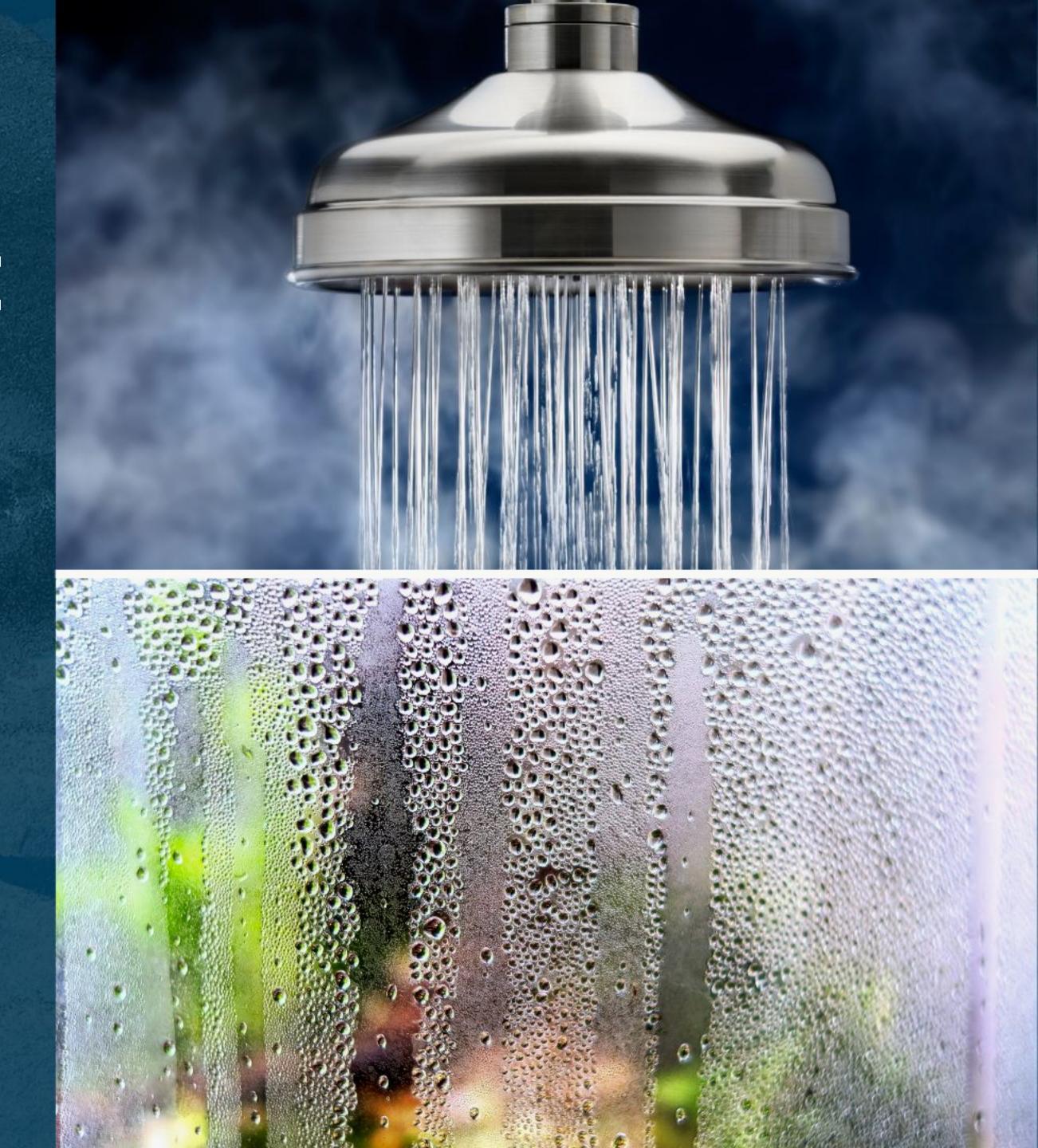
WHY DOES HOT WEATHER IN OKLAHOMA FEEL DIFFERENT THAN HOT WEATHER IN ARIZONA?

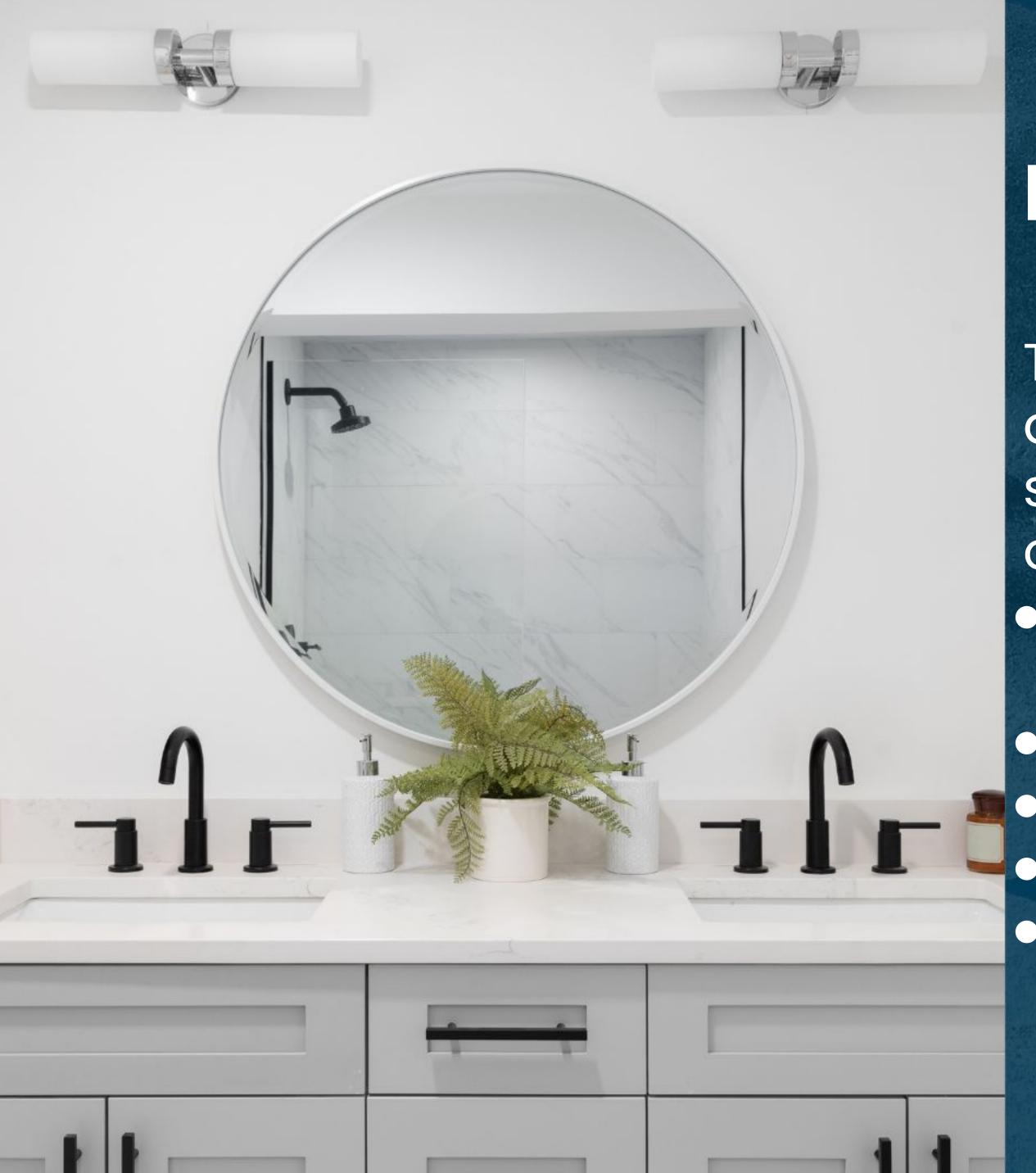


Tulsa, OK 96° F **Humidity: 67%** Feels like 120° F

Think about a time when you've taken a shower and the bathroom had a lot of steam afterwards.

- Could you see the steam?
- Was the mirror or other surfaces foggy and damp?
- How did the air feel?
- Did you cool off quickly?
- Was it easy to dry off?





Think about a time when you've taken a shower and the bathroom wasn't steamy afterwards, and the mirror and other surfaces weren't foggy or damp.

- How does it compare to the steamy bathroom?
- How did the air feel?
- Did you cool off quickly?
 - Was it easy to dry off?
 - Why would the air feel different if everything else is the same?

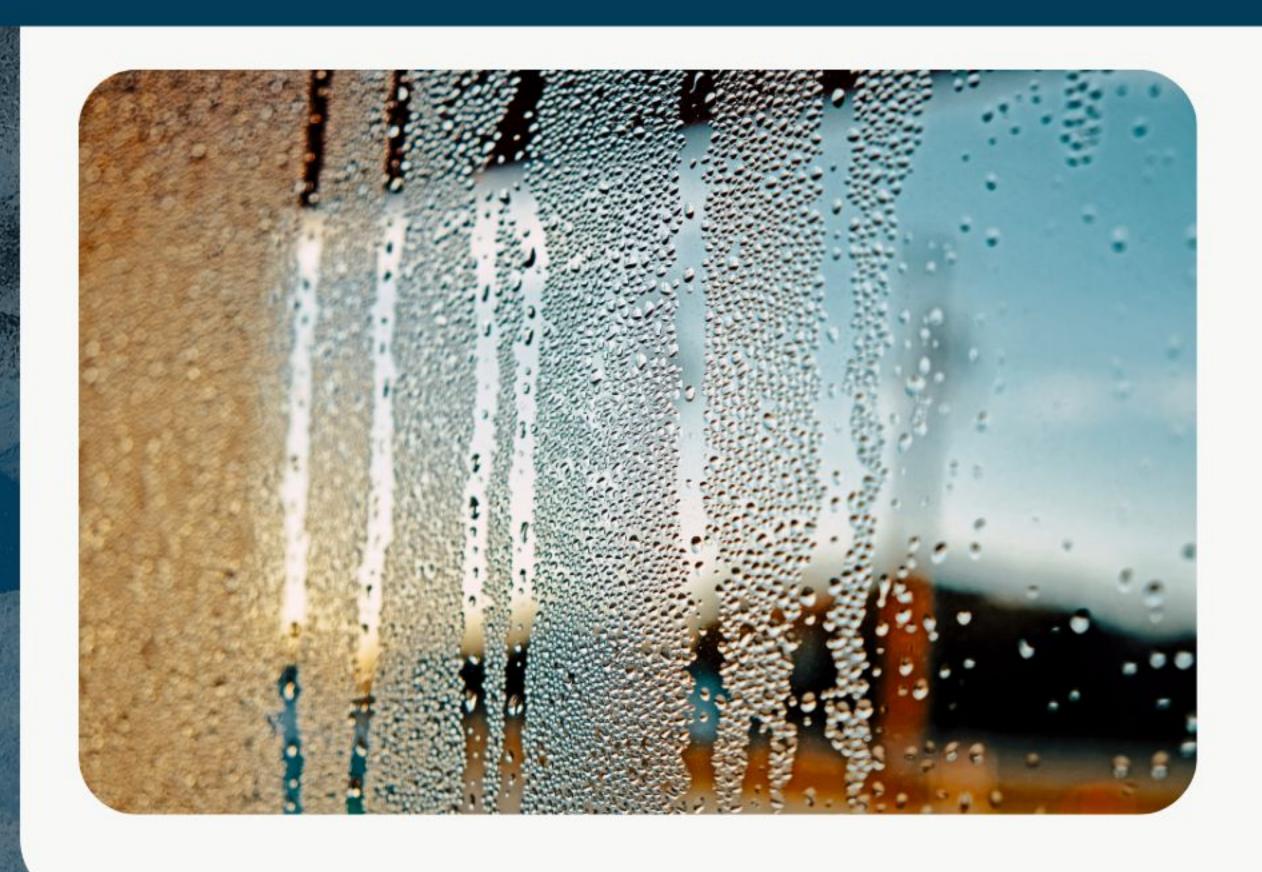
LESSON 3.1 - LABEL

Humidity is the amount of water in the air. (AKA absolute humidity)

- This is often referred to as "moisture" in the air, but this is a misleading description
- Remember the states of matter?
- What state of matter would water vapor be?
- Water in the air is not liquid, it's a gas!
- Water is still water whether it's solid (ice), liquid, or a gas

Water vapor in the air can't be seen, no matter how much is present.

When you see condensation like this, it is not water vapor, it's liquid (in the form of tiny droplets).





Have you ever heard the phrase, "It's not the heat, it's the humidity"?

Is there a limit to how humid the air can be?

Let's investigate! Use your ...It's the Humidity handout.

LESSON 3.1 - LABEL

Is there a limit to how humid the air can be?

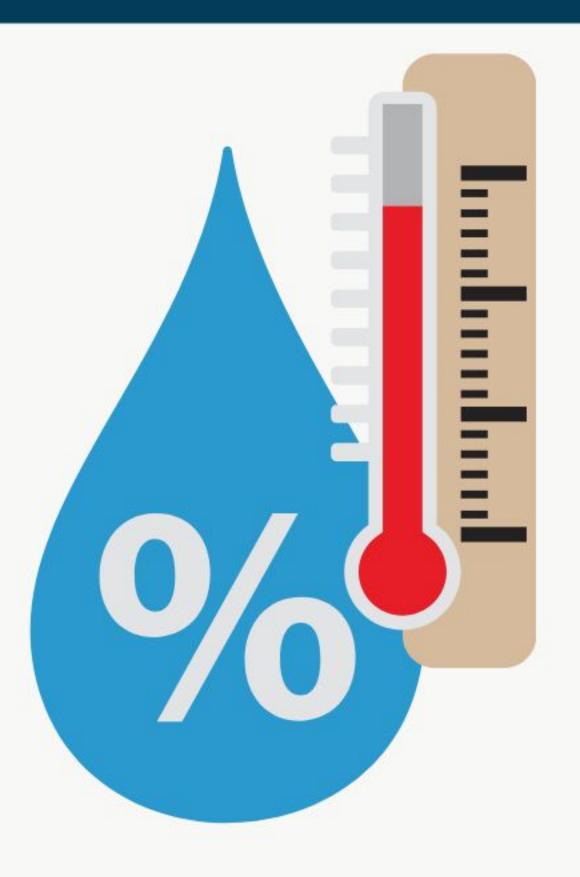
- It depends on temperature
 - Warm air can have more water vapor molecules than cold air
 - The amount of water vapor present compared to how much could be present at that temperature is called relative humidity.
 - This is expressed as a percent
 - For example, 70% humidity means the air contains 70% of the total water vapor that could be present at that temperature



LESSON 3.1 - LABEL

When 100% humidity is reached, the air is completely saturated.

- This does not mean that it will rain
- Fully saturated air may result in fog or clouds if some of the water vapor collect together to form tiny liquid droplets
- In order for complete saturation to cause rain, the air would first need to cool
 - A lower temperature means not as much water vapor can be present



LESSON 3.1 - DEMONSTRATE

Let's analyze how % saturation can change with the presence of more or less water.

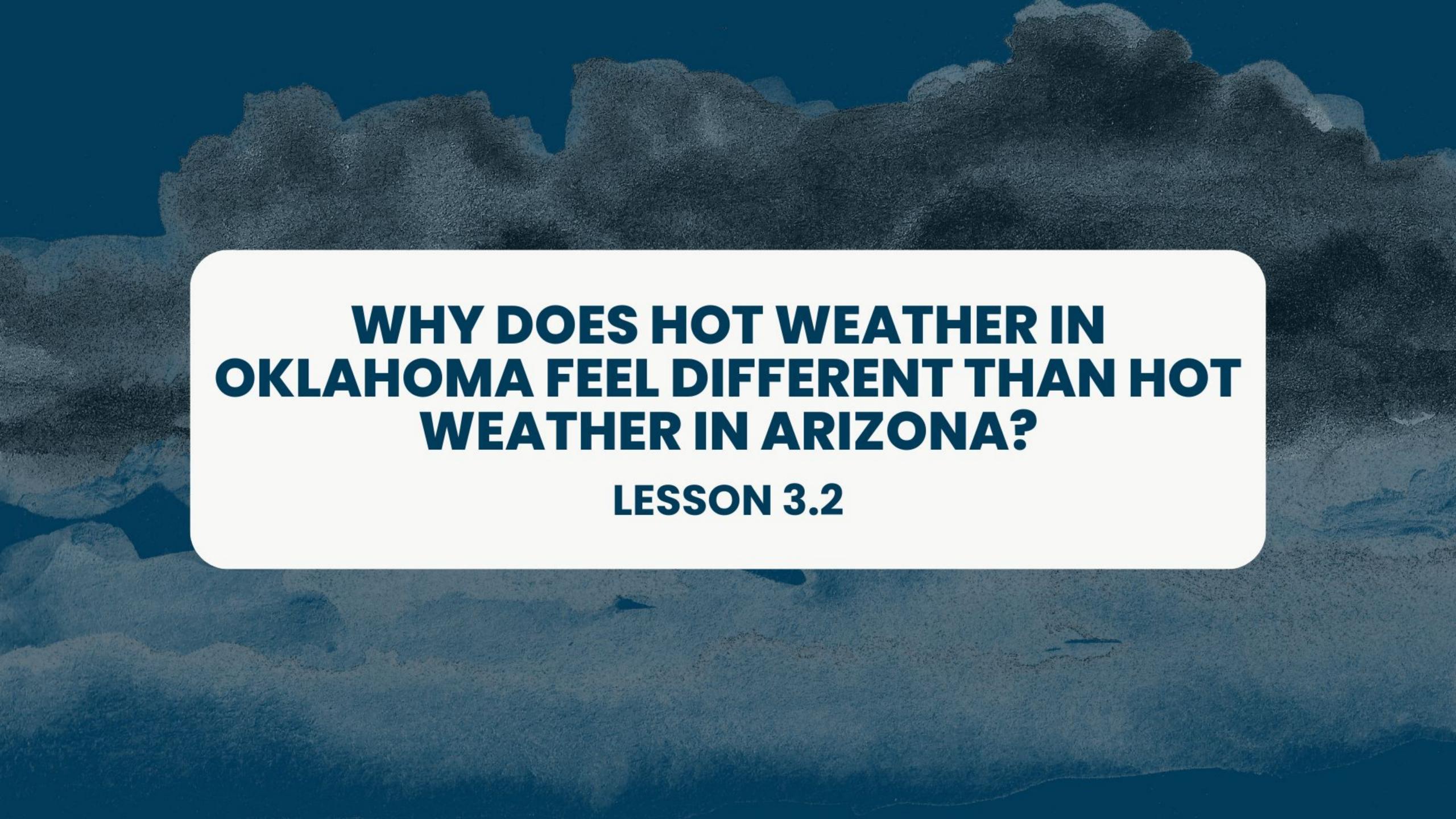
Use your Studying Saturation handout.

LESSON 3.1 - REVIEW

Let's take a moment to review what you've learned so far.

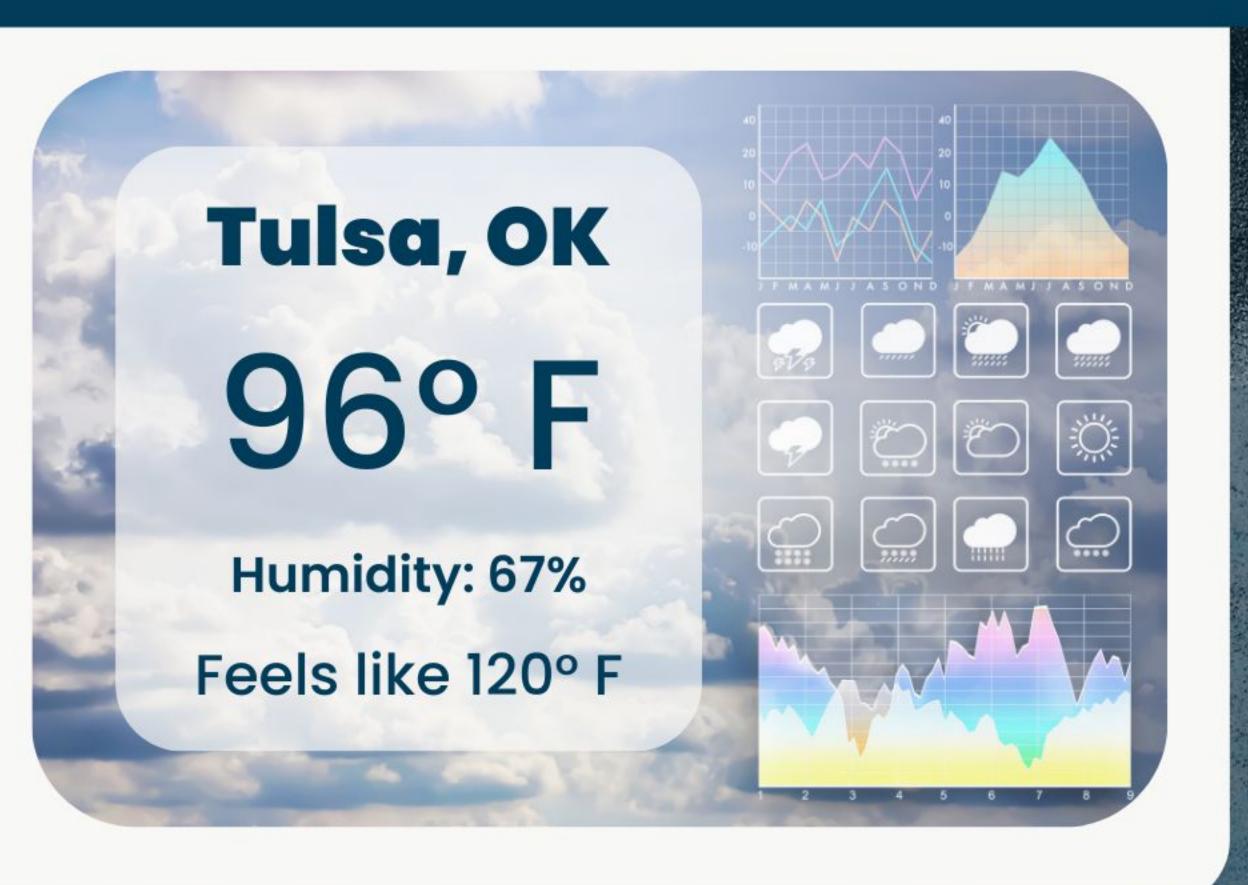
Use your Module 1 - What I Know handout.





WHY DOES HOT WEATHER IN OKLAHOMA FEEL DIFFERENT THAN HOT WEATHER IN ARIZONA?





Let's take a closer look at the relationship between temperature and relative humidity.

Use your It's All Relative (Humidity) handout.



Humidity doesn't affect the temperature outside, but temperature does affect the relative humidity.

Why does it feel hotter when it's more humid?

Imagine you are playing outside in Arizona in August. Think about what your surroundings look like.

- What does it feel like outside?
- Is there a breeze?
- Is it hot?
- How does the air feel?
- Is it raining, sunny, cloudy?





Now imagine you are playing outside in Oklahoma in August. Think about what your surroundings look like.

- What does it feel like outside?
- Is there a breeze?
- Is it hot?
- How does the air feel?
- Is it raining, sunny, cloudy?

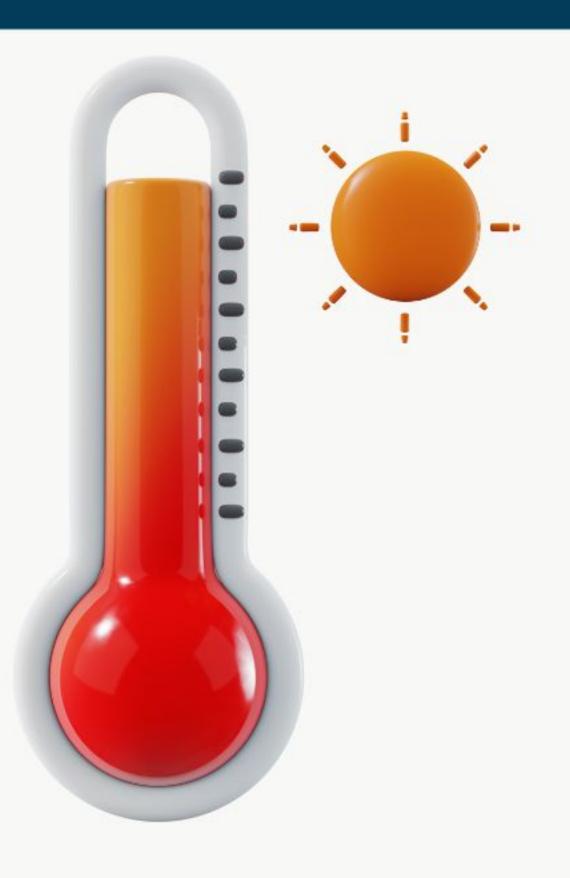
Let's say you've been outside playing soccer for a while. Would you be sweating if you were in Arizona? What about in Oklahoma?

- What does sweat do for your body?
- If Oklahoma feels hotter than Arizona, is sweat cooling you off the same in both places?
- Why do you cool off easier in Arizona than in Oklahoma?

LESSON 3.2 - LABEL

- As sweat evaporates from your body, it helps cool you off.
- When the humidity is high, this evaporation doesn't happen as easily.
 - When humidity is high, the air is more saturated with water vapor, which means less water vapor is able to enter the air.
- Since your body can't cool as well, you perceive the air as being hotter than it actually is.

This is called the **Heat Index**.



LESSON 3.2 - LABEL

Heat Index is calculated by comparing the relative humidity with air temperature in the shade.

The chart on the following slide is then used to determine the heat index.

Heat index can be used to determine outdoor safety during hot weather.

LESSON 3.2 - LABEL

	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
	81	84	86	89	93	97	101	106	112	117	124	130	137			
60 65 70	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
7,00	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
75 80 85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131								no	AA
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										HE STATE OF THE PARTY OF THE PA
		Like	lihood	of He	at Dis	orders	s with	Prolo	nged E	xposı	ire or	Strenu	ious A	ctivity	,	

As you read a heat index chart, notice that it sometimes it feels cooler outside than the actual air temperature.

LESSON 3.2 - DEMONSTRATE

Let's find out what the heat index is today using your *Think Like a Meteorologist* handout.

We will first need to measure the temperature and relative humidity.

Field meteorologists that collect weather data use a device called a sling psychrometer to measure relative humidity. These can easily be made at home.

LESSON 3.2 - REVIEW

Do we now have enough information to answer the question, "Why does hot weather in Oklahoma feel different than hot weather in Arizona?"

Consider all the data you have collected, models you have drawn, charts you have analyzed, etc.

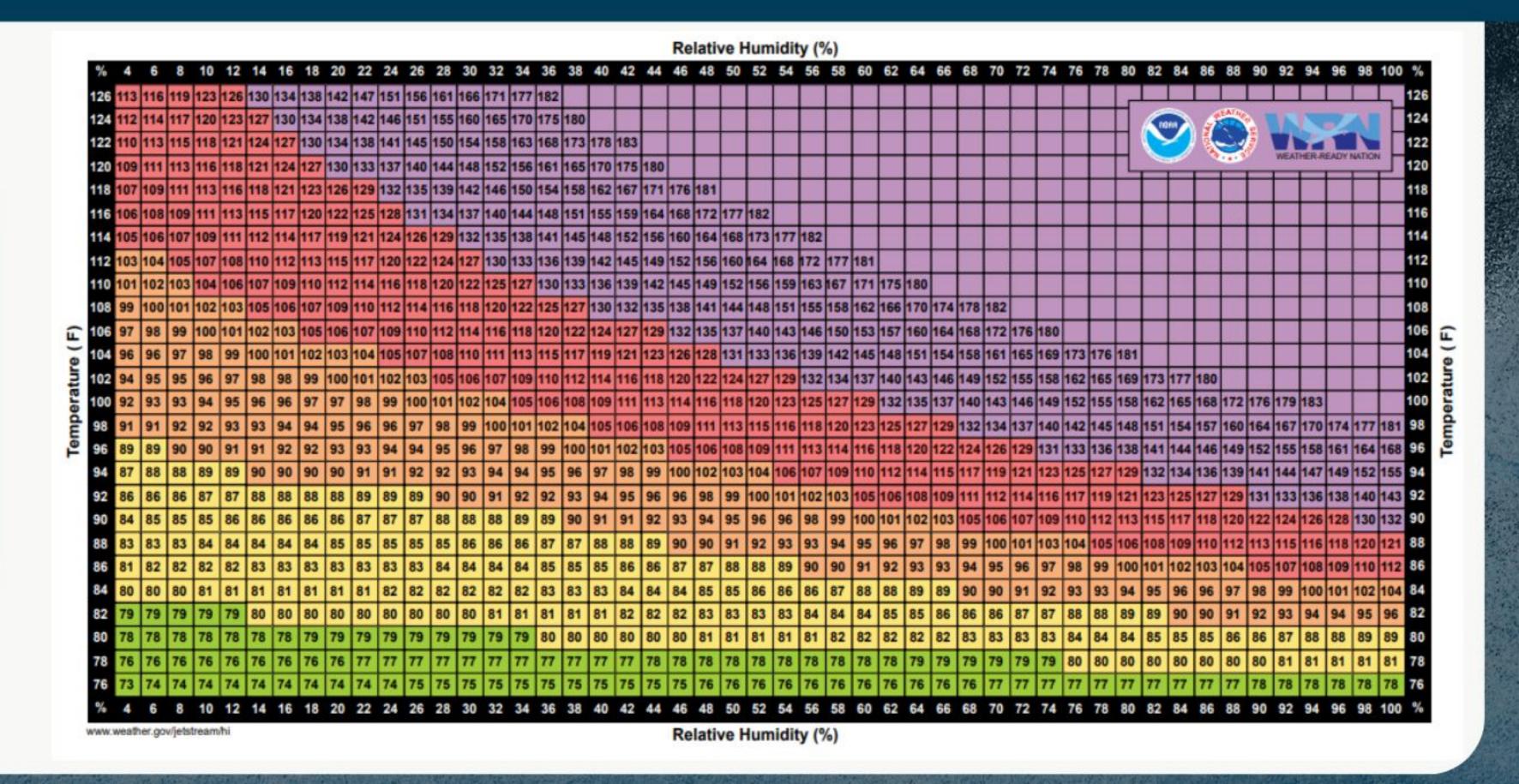




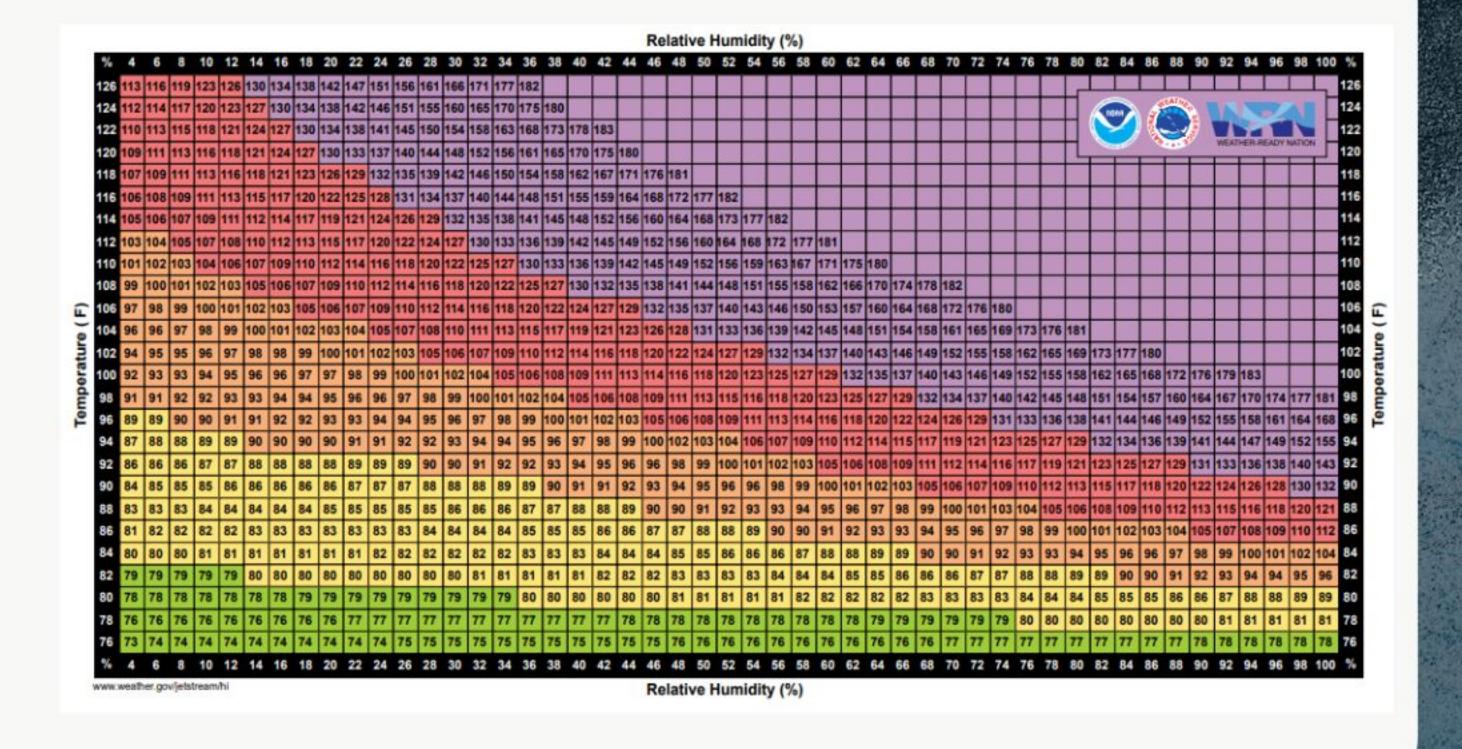


LESSON 4 - ENROLL

Does heat index work the same in winter?



- Have you ever seen a weather report for a cold day that included a heat index?
- Why do you think that is?
- Look at the heat index table.
 Why do you think there aren't any temperatures listed below 76° F?
- Let's figure it out!





LESSON 4 - Label

At cooler temperatures, humidity no longer causes the air to feel warmer than it really is, because evaporation of sweat is no longer an issue.

However, our bodies may still lose heat due to other atmospheric conditions like wind.

 Wind blows our body heat away, making us feel colder.

Wind chill is what the air feels like to humans due to wind blowing on exposed skin.

- The higher the wind speeds, the colder it will feel
- Wind chill does not affect things that are not alive

LESSON 4 - DEMONSTRATE

How does wind make it feel colder than it really is?

How much can wind affect the temperature?

Fill out your Chilling with Wind Chill handout.

LESSON 4 - REVIEW

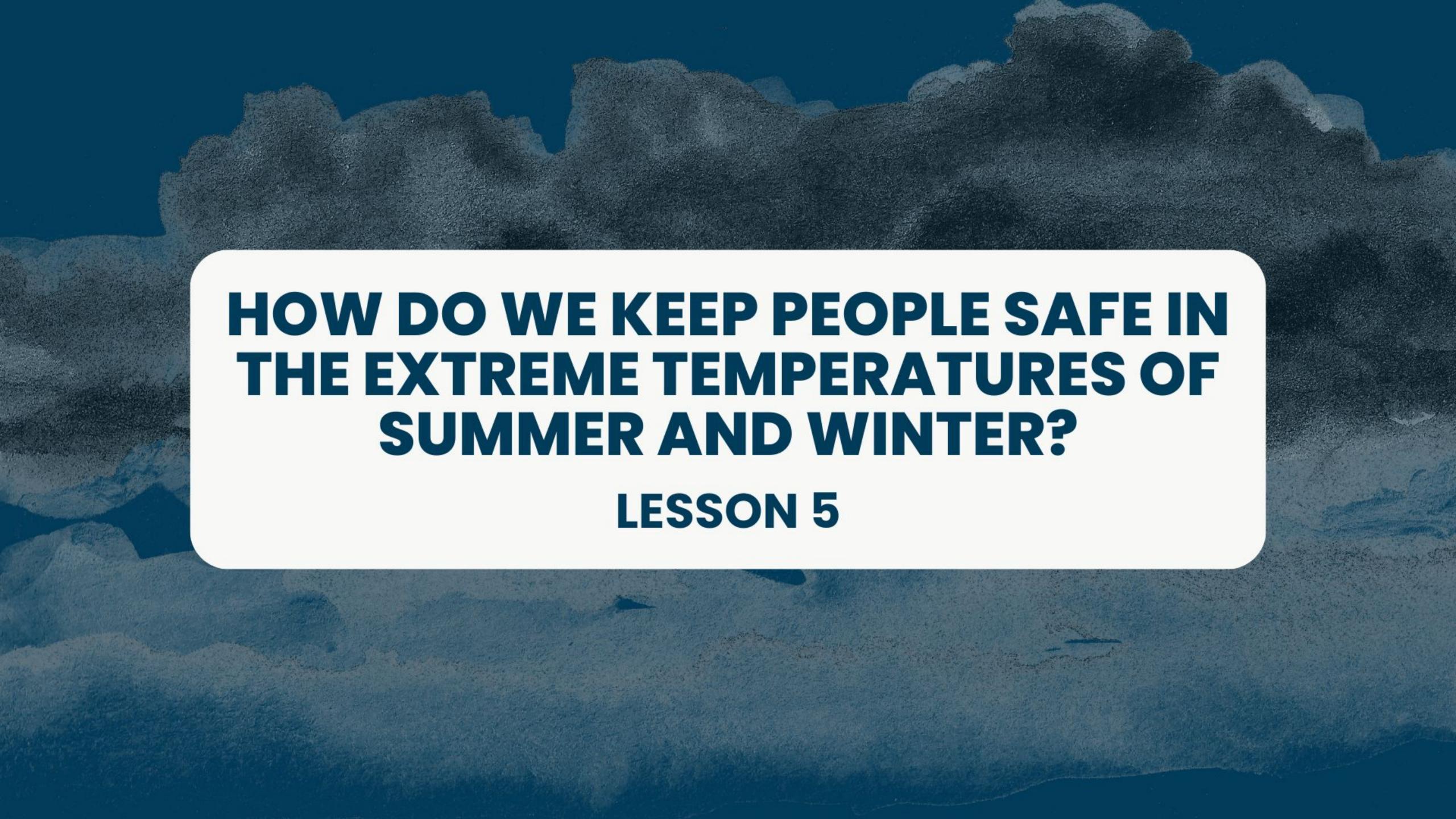
- You've learned a lot about temperature, heat transfer, and how our bodies perceive temperature.
- Use your Putting It All Together handout to explain why we sometimes perceive the temperature to be hotter or colder than it really is.







Lesson 5 - Temperature Advisory Alerts



LESSON 5 - ENROLL

- Have you seen the words watch, warning, or advisory on weather alerts?
- Have you ever seen a temperature advisory alert?
- Where or when have you seen one?
- How do you usually receive a warning about extreme temperatures?





What do temperature advisory warnings have in common?

When and how are they issued?

Search the internet to find some examples of temperature advisory warnings and share your discoveries with others.

Complete your *Investigating Weather Warnings* handout.

LESSON 5 - LABEL

- Issued in advance for those who need extra time to prepare for extreme conditions:
 - Excessive Heat Outlook excessive heat possible in the next 3-7 days
 - Excessive Heat Watch excessive heat is likely in the next 24 to 72 hours
- Issued within 12 hours of the onset of extremely dangerous heat conditions:
 - Heat Advisory When max heat index is 100° or higher for at least 2 days
 - Excessive Heat Warning When max heat index is 105° or higher for at least 2 days

LESSON 5 - LABEL

Wind Chill Watch

there is potential for very cold air and strong winds to create dangerously low wind chill values

Wind Chill Advisory

low wind chill temperatures are expected but will not reach local "warning" criteria

Wind Chill Warning*

very cold air and strong winds will create dangerously low wind chill values

*These levels will result in frostbite and hypothermia if precautions are not taken

LESSON 5 - LABEL

Heat Exhaustion

a serious condition in which the body overheats

Can lead to heat stroke if untreated

Heat Stroke

the body can no longer control its temperature and is unable to cool down

Can result in brain damage, organ failure, coma, and death

Hypothermia

when the body loses heat faster than it can produce heat

Can cause organ failure and death

LESSON 5 - ENROLL

Is the difference between these words obvious to you?

- Watch
- Warning
- Advisory

What past experience helps you understand these words?

If you didn't have that past experience, do you think the words would have the same meaning for you?

If your primary language was a language other than English, do you think the words would have the same meaning for you?



LESSON 5 - DEMONSTRATE

How can we keep people safe?

Choose either extreme heat or extreme cold and make a temperature advisory that will help keep people safe.

Use your Creating a Temperature Advisory Notice handout.





LESSON 5 - REVIEW

Use the *Peer Evaluation Form* to review the advisory notices of other students and provide them with feedback.

What suggestions do you have for how they can improve their design?





STUDENT HANDOUTS





Name		
NULLIE		

Date

How's the Weather?

- 1. What is the weather like today? Imagine you are describing today's weather to someone who doesn't live here. Be as descriptive as possible. You don't have to look anything up, just describe it in your own way.
- 2. What was the weather like yesterday?
- 3. What about 3 months ago?
- 4. Share your descriptions with a partner or group. What do your descriptions have in common? What patterns do you notice in how you describe the weather?

What do meteorologists do?

5. Watch a clip of your local weather forecast. What do you notice about the weather report? What do you wonder?

I Notice	I Wonder

Careers in Meteorology

- 6. There are many types of careers in meteorology. Explore the following websites to discover different careers in meteorology. What careers are the most interesting to you?
 - https://www.indeed.com/career-advice/finding-a-job/jobs-in-meteorology
 - <a href="https://www.ametsoc.org/index.cfm/ams/education-careers/car

7.	What do you find most surprising about the different types of careers?

Taking Temperatures

 Compare the Celsius temperature scale with the Fahrenheit temperature scale.
 What do you notice?

What do you notice?

BOILING
100°C OF W

80
70
60
50
40
30
20
10
FREEZIN
0 O°C -OF W

(°)	C	BOILING POINT	۱ ۱	F	
	100	— 100°C 212°F —	220		
	90	OF WATER	200 190		
	80		180 170		
	70		160 150		
	60		140		
	50		120		
	40		110 100		
	30		90		
=	20		70 60		
=	10	FREEZING POINT	50 40		
=	0	— 0°C 32°F —	30		
=	10	OF WATER	20 10		
=	20		0 10		
=	30		20	-	
CELS	SIUS	FA	HRE	NHE	ΙT

1

- 3. Choose 3 different temperatures in Fahrenheit and determine what the equivalent temperature would be in Celsius.
 - ____°F = ____°C
 - ____°F = ____°C
 - ____°F = ____°C
- 4. Which scale do you feel would be easier to use? Why?

Let's Try It!

5. Your teacher has set up two different water samples for you to measure.

Practice using a thermometer by recording the temperature of each sample in Celsius.

• Sample 1: ____°C

• Sample 2: ____°C

6. Use your measurements in Celsius to estimate the temperature of each sample in Fahrenheit.

• Sample 1: ____°F

• Sample 2: ____°F

7. Compare your estimates with a partner. Now measure the actual temperature in Fahrenheit. Who estimated closest to the actual temperature?

	My Estimated Temp in °F	My Partner's Estimated Temp in °F	Actual Temp in °F	Who is closest?
Sample 1				
Sample 2				

Name		
MATT		
NULLIC		

Date_____

Module 1 - What I Know

Lesson 1

What weather is
Components that can be used to describe weather
How to use a thermometer
How temperature is different in the sun and in the shade
How different substances absorb heat differently

What I Know

How I Know, I Know It

Name	Date

Heat Absorption

1. Predict what will happen if we measure temperatures of the same substances in the sun and in the shade. Use words and/or pictures to explain what you think will happen and why.

In the sun	In the shade

Data Collection

2. Collect temperature readings of the substances indicated by your teacher. You should record temperatures for the same substances in the sun and in the shade. Record temperatures in degrees Celsius.

Substance	°C in the Sun	°C in the Shade

Data Analysis

- 3. Input your data in a spreadsheet such as Excel or Google Sheets. Remember to label the columns and rows.
- 4. How does the temperature of each substance compare in the sun and in the shade? Use the formula functions in the spreadsheet to calculate the difference between the sun and shade in degrees Celsius. You may want to add a column to the table in your spreadsheet.
- 5. Use the formula functions to calculate the mean (average) temperature difference between the sun and shade.
- 6. Use the graphing functions in the spreadsheet to produce a graph of the temperature difference between each substance in the sun and in the shade.

7.	Analyze the mean temperature difference and the graph of your data. What do these things tell us about energy transfer in the sun versus in the shade? (Remember that energy can be in the form of heat.)
8.	Based on your data, make a claim about the differences in how air, water, and soil absorb heat from the sun.

Developing Ideas

1. Review your initial model about temperature. Revise your initial thinking to explain why temperatures in the sun and shade are different for different substances. Why do you think air, soil, and water would absorb heat differently? Consider how the molecules are arranged and move in a solid, liquid, and gas. Use words and/or pictures to explain your ideas.

In the sun In the shade

2. Discuss your model with a partner. Did you have similar ideas? Make any necessary adjustments to your model based on your conversation with your partner.

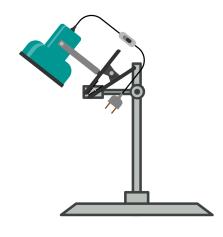
Heat Transfer

 Set up a heat station by attaching a heat lamp to the top of a ring stand.



Caution! Heat lamps get HOT! Be sure not to touch the bulb or lamp shade while in use. Keep all other objects clear from the lamp, as they may catch fire!

2. Before turning on your lamp, place your hand about 12 inches in front of the bulb. Do you feel any heat?



3. Turn on the lamp and place your hand in the same position, 12 inches in front of the bulb. Does it feel different?

Do not move your hand closer than 12 inches to the bulb. Remember that heat lamps get hot!

- 4. Turn off the lamp and allow it to cool completely before disassembling the ring stand.
- 5. Draw a model that explains why you can feel heat if you're not touching the lamp. Where is the heat coming from? Use words and pictures to show what you think is happening. Remember to include labels.

Putting It All Together

6.	Revisit your model from Lesson 1 about why temperatures might be different in the shade. Draw a new model that explains how shade might		
	affect how we feel the radiation from the sun. Be sure to include the term		
	radiation and label all parts of your mo	del.	
		T	
	In the Sun	In the Shade	
7.	What other examples of radiation can y	ou think of?	
8.	Share your list with a partner. What ideas did they come up with?		

Name	Date

Make it Melt!

Investigate how and why some objects melt by setting up a heat station.

Materials:

- Hot plate
- 2 aluminum foil pans or 2 glass beakers
- Ice
- Stopwatch

Procedure:

- 1. Place an aluminum foil pan or glass beaker on top of the hotplate.
- 2. Place the second foil pan or glass beaker on the table top next to the hotplate.
- Add one ice cube to both containers. Make sure the ice cubes are about the same size.
- 4. Turn on the hotplate to medium-high temperature
- 5. Start the stopwatch and wait for the ice to melt.
- 6. Record the time at which each ice cube is fully melted.
- 7. Turn off the hotplate when the ice has melted.



Caution! Hotplates get HOT! **Do not touch** the surface of the hotplate. Objects placed on top of the hotplate will also be hot! Allow the foil pans or beakers to **cool completely** before touching them. Keep all flammable objects like paper clear, as they may catch fire!

I.	I. Predict which ice cube will melt first. Why	do you think so?

2. Record your data and observations below.

	On Hotplate	On Table
Time to fully melt (min : sec)		
Observations		

3.	. Which ice cube melted faster? Why do you think that is?		
4.	What is causing one ice cube to melt faster than the other? Use words and pictures to create a model that explains what is happening. Remember to include labels.		

Name	Date
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Make it Melt (Again)!

Investigate how and why some objects melt by setting up a heat station.

Materials:

- Hot plate
- 1 aluminum foil pan or glass beaker
- Several stainless steel washers or hex nuts
- Ice
- Stopwatch

Procedure:

- 1. Use 3-4 stainless steel hex nuts or several stainless steel washers stacked on top of each other to create a platform on top of the hotplate.
- 2. Place an aluminum foil pan or glass beaker on top of the hex nuts so that there is about 0.5-1 cm of air between the hotplate surface and the container.
- 3. Add an ice cube to the container.
- 4. Turn on the hotplate to medium-high temperature
- 5. Start the stopwatch and wait for the ice to melt.
- 6. Record the time at which the ice cube is fully melted.
- 7. Turn off the hotplate when the ice has melted.



Caution! Hotplates get HOT! Do not touch the surface of the hotplate.

Objects placed on top of the hotplate will also be hot! Allow the foil pans, beakers, and hex nuts to **cool completely** before touching them. Keep all flammable objects like paper clear, as they may catch fire!

 Do you think the ice cube with air beneath it will melt faster or slower than when its container was placed directly on the hotplate in the previous activity?
 Why do you think so? 2. Record your data and observations below. Compare these results to the results of the previous activity.

	Hovering Above Hotplate	Directly on Hotplate	On Table
Time to fully melt (min : sec)			
Observations			

3.	Which ice cube melted faster? Why do you think that is?

4.	Why is the ice cube that is hovering above the hotplate still able to melt?	Use
	words and pictures to create a model that explains what is happening.	
	Remember to include labels.	



Date	

Module 1 - What I Know

Lesson 2

What radiation is
What conduction is
What convection is
How radiation, conduction, and convection result in heat transfer between
Earth's surface and the atmosphere
How mirages are formed

What I Know

How I Know, I Know It

Name	Date
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Simulating Air Movements

We will be using water to simulate how air moves when it heats up and cools down.

Materials

- Colored hot water
- Colored cold water
- Room temperature water

- 1 Large container
- 2 Small cups or beakers
- 2 Pipettes

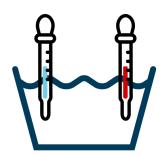
Predictions

Predict what you think will happen to both hot water and cold water when it is added to room temperature water.

Procedure

- Fill the large container with room temperature water and place it on the table where it will not be disturbed.
- 2. Fill one small cup with colored hot water and one with colored cold water.

 Remember that hot water is **hot**! Use caution when handling hot water!
- 3. Fill one pipette with hot water while someone else fills the other pipette with the cold water. Remember to use proper pipetting technique.
- Insert both pipette tips into the large container of room temperature water. The pipettes should be on opposite sides of the container.
- 5. When the pipette tip is about midway to the bottom of the container, slowly squeeze the bulb to release the colored water. Be sure not to create bubbles or to suck water back up into the pipette! This will create mixing which may make results difficult to see.



- 6. Slowly pull the pipette back out of the container, being careful not to mix the water.
- 7. Observe how the hot and cold water move within the container. Record your observations.

Observations

1. Use words and pictures to record your observations about how the colored water moved.

Hot Water	Cold Water

2.	How do your results compare to your predictions?			

Notice & Wonder Chart

1. Watch the video of carbon nanotubes and record your observations. Use words and/or pictures to record your observations of what you see and hear. What questions do you have?

l Notice	l Wonder

- 2. What do you think might be happening in this video?
- 3. How is this carbon nanotube phenomenon similar or different from the heat shimmer effect in the desert?

Name	Date

Are Invisibility Cloaks Real?

Read the following Science Daily article. As you read, decide if you agree or disagree with the statements below. Provide evidence from the article to support your stance or explain your reasoning.

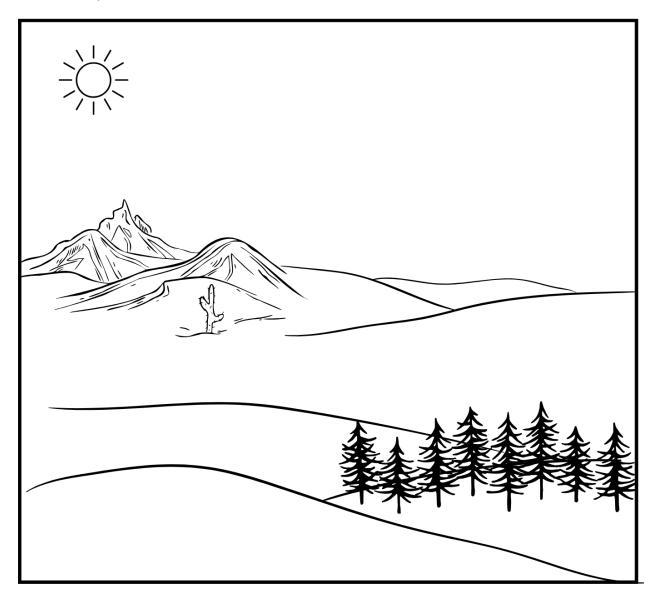
'Mirage Effect' Helps Researchers Hide Objects

On the	Page - Thin	k of these as true or false statements that can be found in the article.
Agree	Disagree	
		1. Mirages are most likely seen in hot areas.
		2. Mirages occur because of a layer of hot air that is above a layer of cool air.
		3. Mirages occur because of how light travels through air at different temperatures.
		- These statements are alluded to in the article, but aren't directly d to "read between the lines" to decide if you agree or disagree.
		4. A mirage is evidence of heat transfer.
		5. There is only one type of mirage phenomenon.
•		- These statements are not necessarily referenced in the article at all. n an opinion based on what you've read.
Agree	Disagree	
		7. The "mirage effect" produced by the cloaking device would work better for a submarine than an airplane.
		8. A mirage can't occur in low-light conditions.

Putting It All Together

Can we answer the question, "What happens after air heats up?"

Use what you've learned about heat transfer to create a model that explains how the sun is responsible for the events and phenomena we've explored in this lesson. Start with what causes air to heat up, then include everything that happens after it heats up, such as how the air behaves or where the heat goes. Be sure to include the terms radiation, conduction, convection, convection current, warm front, cold front, less dense, more dense, and mirage. Feel free to add components to the landscape to illustrate your ideas.



It's Not The Heat...

What do you know about Arizona and Oklahoma? Use words and/or pictures
to record your thoughts about what it might be like to live there, what the
weather is like, what you might see, what kinds of plants or animals live there,
etc.

Arizona	Oklahoma

2. Look at the weather forecasts for Phoenix and for Tulsa. Use words and/or pictures to record what you see and what questions you have.

I Notice	l Wonder

3. Can you explain what might be going on to make Tulsa feel different than Phoenix?

What is "moisture"?

4. What do you know about the states of matter? Use words and pictures to record everything you know about the 3 states of matter. This may be something you have seen or experienced yourself, something you've learned previously, an analogy, or even a question you have or something you're not sure about.

State of Matter:		
My Ideas:		

5. Draw a model of water vapor in the air compared to steam. Imagine you can zoom in on the molecules using a microscope. How might air and steam look different?

Water Vapor in the Air	Steam

6.	Make a claim about the state of water in steam. What evidence supports this
	claim?

Name	Date

...It's The Humidity

We want to investigate how much water vapor can be in the air. There's only one problem - we can't see air or water vapor! Let's use other materials that we *can* see to simulate water vapor entering the air. Use the provided materials to design an investigation. Your design should provide data that allows you to answer the Investigation Question.

Materials

- Beaker
- Pipette
- Water
- Dry sponge

Investigation Question

We wish to investigate the question, "Is there a limit to how much water can be added to a substance?"

Brainstorming Space

Let's brainstorm some ideas for how we can design our investigation. What
can we use to represent the air? What can we use to represent water vapor in
the air? How can we measure how much water is held by our air-substitute?
How do we know when there's too much water? Draw or describe your ideas
below.

Investigation Design

2. After sharing your ideas with classmates, decide on a design for your investigation. 3. Describe how you will use the provided materials (What is the purpose of each?): a. Beaker b. Pipette c. Water d. Dry sponge 4. Keeping the purpose of our investigation in mind, what data will you collect to help you answer the investigation question? 5. When will you stop collecting data? In other words, how will you know if you have reached the limit to how much water can be added to the object/substance? 6. How will you represent the data? Will you use a chart, a table, a graph, etc.? 7. How will you share your results with classmates?

8.	Now think about your procedures. What steps will you follow during your
	investigation? Outline your procedure below. The procedure should be specific
	enough that anyone could follow your directions and do exactly what you did.
	You may include a materials list and diagrams if you wish.
	You can assume other scientists will know they should first gather their
	materials before using them, so do not include, "Gather your materials" as one
	of the steps. However, consider including directions for using specific
	materials such as size of beaker, temperature of water, type of sponge, etc.
Resu	ults
9.	Conduct your investigation. Record your data and observations using the
0.	format you determined in number 6. You may choose to record your data,
	observations, and analysis digitally for a more professional presentation.
	observations, and analysis digitally for a more professional presentation.

10.	Analyze your results. Use data you collected to answer the Investigation	
	Question. Use the template below as a guide to help you explain your res	ults.
	Feel free to expand upon the template below.	
	We investigated if	Our
	results showed that	
	Additionally, we observed	
	Therefore, we conclude that	

Name			
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Date	

Studying Saturation

Let's practice calculating percent saturation using the data from our ...It's The Humidity investigation.

Setting the Stage

1.	At what point was the sponge fully saturated? What does it mean for the
	sponge to be saturated? What did you observe? Include how much water or
	how many pipettes of water it took to saturate the sponge.
2.	When the sponge was fully saturated, what was the % saturation?
3.	Why do you say it was that % saturated? What does that mean to you?
4.	What is the highest possible % saturation? Why do you think so?

Let's Calculate!

5. Draw a model or chart of how you believe the saturation of the sponge changed throughout the investigation.

6.	We can calculate the % saturation of the sponge each time you added another pipette of water. This is the same process as calculating your grade percentage on an assignment or test. Let's say you scored a 9 out of 10 on an assignment. Describe how you would calculate your grade percentage. Use words to explain the process, then write a sample calculation.				
7.	Let's track how the % saturation of the sponge changed as you added more water. Calculate the % saturation for each time you added another pipette of water to the sponge. If you previously used number of pipettes for your data, use that unit of measurement here. If you previously used total milliliters, use that unit of measurement. Start with recording the total amount of water you added to reach 100% saturation.				
	100% saturation =(pipettes or mL)				
	Remember that to calculate % saturation, you will use the amount of water added at each step divided by the total amount of water added, times 100.				
	Amount of water added Total amount of water added X 100 = % Saturation				
	For example: 6 Pipettes 15 Pipettes 15 Pipettes				
	Create a table to track how the % saturation changes each time you added water to the sponge. This may be done on paper or using a spreadsheet.				
8.	Create a graph to represent how the % saturation changed over time. This				
	may be done on paper or using the chart functions in a spreadsheet.				
9.	Compare your data and graph with that of another group. You may have had				
	a different amount of water that you added to the sponge, but did the %				
	saturation change in a similar way? How do your graphs compare?				

Name			

Date	

Module 1 - What I Know

Lesson 3

What humidity is
How water vapor is similar to and different from other forms of water
What relative humidity is and how it is different than absolute humidity
What saturation is
The relationship between relative humidity and saturation
What heat index is
Why hot weather may feel different in different places

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How I Know, I Know It

Name			
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Date	

It's All Relative (Humidity)

Recall that relative humidity is the amount of water vapor present in the air compared to how much could be present at that temperature.

1. Draw a diagram or picture that helps you understand what relative humidity means.

- 2. Finish these sentences:
 - Warm air can contain_____water vapor than cold air.
 - As the temperature outside increases, _____water vapor is able to enter the air.
- 3. Let's say the temperature outside is 75 degrees with a relative humidity of 45%. The temperature then cools off to 60 degrees, but the amount of water vapor in the air stays the same. Would the new relative humidity be more or less than 45%? Why do you think so?

Draw a model that describes your thinking. How do the statements from #2 show up in your model?

75 degrees, 45% humidity	60 degrees, <u>?</u> % humidity

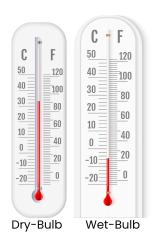
4.	Now that you've seen an example of how relative humidity can change with temperature, create a new model to revise your thinking. How easy would it be for more water vapor to enter the air at each temperature? Use words and pictures to express your reasoning.			
	75 degrees, 45% humidity	60 degrees, <u>?</u> % humidity		
5.	Why do you think sweat isn't as effective at cooling you off in Oklahoma? Think about the weather forecasts for each location. What might be preventing sweat from cooling you off? Look back at the model you drew in #4 for more inspiration. Use words and pictures to express your thinking.			
	Phoenix, Arizona Temp = 101°F	Tulsa, Oklahoma Temp = 96°F		

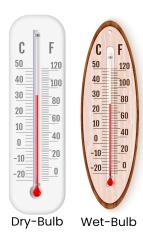
Think Like A Meteorologist

Heat index is how hot it feels outside when temperature and relative humidity are combined. If relative humidity and temperature are known, heat index can be determined using a standardized chart or heat index calculator.

Let's measure the heat index outside! We can use a regular thermometer to determine the temperature, but we will need to use a special tool called a sling psychrometer to measure the relative humidity. A sling psychrometer uses two thermometers to measure how much the temperature can be lowered through evaporation. One thermometer will measure the air temperature, while the other will measure the temperature when water is evaporating from its surface. These two values can be used to determine how much water vapor is already present in the surrounding air.

Look at the following sets of temperature readings from a psychrometer.
 Which one do you think represents higher humidity? Why do you think so? Use words and/or pictures to explain your reasoning.





Set 1

Set 2

Making The Psychrometer

Materials

- 2 thermometers
- Cardboard, plastic bottle, cup, or other sturdy material
- Cotton balls or gauze
- Strong twine
- Strong tape
- Rubber bands

Plan Your Design

Your sling psychrometer will need to have 2 thermometers firmly attached to a sturdy surface while still being able to read the thermometer. The bulbs of the thermometers will need to be completely exposed to air. One thermometer will be the dry-bulb that will measure actual air temperature while the other will be the wet-bulb that will measure temperature after evaporation. The wet-bulb thermometer needs to have wet cotton or gauze firmly wrapped around the bulb (this should not be added until you are outside). A long length of strong twine will need to be attached to the entire construction. This device is called a sling psychrometer because you are going to swing it around in the air. It is therefore very important that all parts of your device are securely attached!

Plan how you will design your sling psychrometer. Use words and pictures to describe your design below:

3.	Try your design to make sure it works by using a pencil or marker in place of
	the thermometer (we don't want to break the thermometers). After testing it
	out, describe any changes you'd like to make to your design.

- 4. After you are happy with your design, take your psychrometer outside:
 - Allow your thermometers to rest outside for at least 5 minutes before
 adding the wet cotton or gauze to your wet-bulb thermometer. Check
 the temperature of both thermometers to ensure they are the same.
 Now add the wet cotton or gauze.
 - Twirl the psychrometer in the air like a lasso for at least 2 minutes.
 Pause every 30 seconds to observe the temperatures of both thermometers.
 - Keep swinging your psychrometer until the wet-bulb thermometer seems to no longer be changing temperature.

•	Record the temperature	of both thermometers.	
	∘ Drv-bulb=	°F Wet-bulb=	°F

Analyze Your Results

5.	To analyze your results, you will first need to determine the difference in
	temperature between the dry-bulb and wet-bulb thermometers. Subtract the
	wet-bulb temperature from the dry-bulb temperature and record it below:
	Dry temp - wet temp =°F
6.	Use the Relative Humidity (%) table to determine the relative humidity by
	comparing the actual air temperature with the dry temp - wet temp you
	calculated in #5.
	Relative humidity =%
7.	Use the Heat Index table to determine the heat index outside.
	Actual temperature=°F
8.	Do you think it is safe to spend much time outside today?

Name			
Name			

|--|

How Low Can You Go?

1. Look at the heat index table. There aren't any temperatures listed below 76°F. Let's see if we can figure out why. What do you notice about the cooler temperatures compared with the warmer temperatures? Are there any patterns? What questions do you have?

l Notice	l Wonder

2. Is there anything going on in the air or with our bodies that might explain why temperatures below 76°F aren't included on the heat index table? Create a model using words and pictures that explains your ideas.

Above 76°F	Below 76°F

Let's Investigate

3.	Use a <u>heat index calculator</u> to investigate heat index values for temperatures below 76°F. Use a spreadsheet to track what data you put into the calculator
	and what the results are. Try at least 10 different temperature values with at
	least 5 different relative humidity percentages. First decide what values you
	will try. Why do you think those are good values to test?
	Temperatures and % Relative Humidity I will try:
	Why I think I should test those values:
4.	Enter your chosen temperature and % relative humidity values in the
	calculator and record the results.
5.	Try using a color coding system and/or graphs to help you make sense of the
	data. What patterns do you notice?
6.	Make a claim about why heat index values for temperatures below 76°F are
٠.	not included on the table. What evidence do you have that supports this
	claim? Gather additional evidence from other groups if needed.

Chilling with Wind Chill

1. Why does wind chill make you feel colder? What is it about wind blowing against your skin that cools you down? Use words and pictures to create an initial model that might explain why wind can make the air feel colder.

2. Let's test out some different types of wind to see if they have the same cooling effect. Stand in front of a fan, then in front of a hair dryer. Describe what you observe. Do both types of "wind" feel the same?

Fan	Hair Dryer

3. Think about the heat transfer that is happening when the fan and hair dryer are blowing on you. Why do they feel different? Create a model that explains the difference in how heat is being transferred.

Fan	Hair Dryer

Forecasting Wind Chill

4. Use a <u>Wind Chill Chart</u> to determine the wind chill values for the following weather conditions. Create a color coding system to indicate the safety of outdoor activity in those conditions. Be sure to include a key below the chart.

Temperature	Wind Speed	Wind Chill
35°F	40 mph	
10°F	5 mph	
6°F	30 mph	
-5°F	15 mph	
-10°F	25 mph	
-15°F	50 mph	

Key:

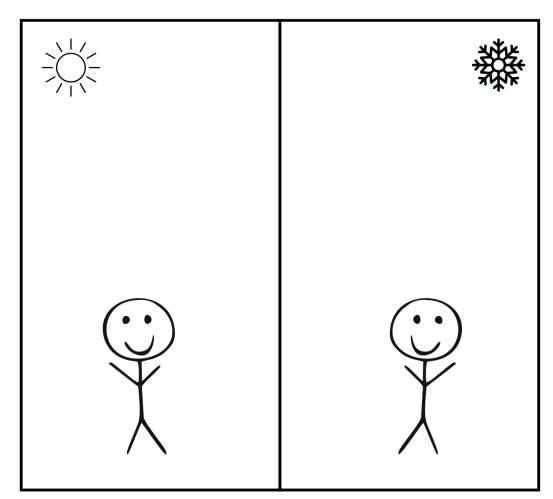
Date____

Putting It All Together

Think about what you've learned about temperature, air movement, heat transfer, relative humidity, heat index, and wind chill. Create a model using words and pictures to explain why summer and winter weather conditions cause us to feel hotter or colder than the actual air temperature.

Include in your model:

- Air temperature vs. what humans perceive
- Methods of heat transfer (such as radiation, conduction, convection)
 - o How these are involved in the heat index and the wind chill
- Movement of air molecules
- Our bodies' responses to heat and cold (such as sweating)
- Causes and process of the heat index
- Causes and process of wind chill



Marsa	Data
Name	Date

Investigating Weather Warnings

What do temperature advisory warnings have in common? Search the internet to find some examples of temperature advisory warnings and share your discoveries with others.

graphics, pictures, news clips, app updates, etc. What do you notice about what the advisory warnings have in common?
Is there any terminology or vocabulary used that might be confusing for people?
What else do you notice about these warnings? Think about how the warnings are accessed by people, what information is included, etc.

Name	Date
	<u> </u>

Meet a Professional

Have you ever tried learning another language? If so, you may have noticed that words or phrases don't always have a direct translation. For example, a heat watch and heat warning don't have separate meanings in every language. People whose primary language is something other than English may miss important weather safety information because of this.

Joseph Trujillo Falcón is a meteorologist in Oklahoma who is working to increase access to weather information for Spanish speakers. Read about his work here: https://ciwro.ou.edu/news-article-template?article_id=217&previous=1

I.	How is Joseph's research working to reduce barriers for Spanish speakers?		
2.	How can we use Joseph's work to make sure weather forecasts are more accessible for all?		
3.	If you could solve one problem relating to weather safety, what would it be?		

Creating a Temperature Advisory Notice

What can we do to help make sure people are prepared and protected during extreme temperatures of summer and winter?

 Decide if you would like to make a heat index or wind chill temperature advisory.

Make a Plan

2. What weather information do you want to include in your advisory notice?

3. What safety information do you want to include?

4. What kind of format will you use (how will people access it)? For example, will it be a radio announcement, a TV commercial, an app notification, etc.

5. How will you make sure it is accessible for all people? Who is the audience you are trying to reach?

Make a Prototype

6. Use the space below to sketch your plans. How do you want the advisory to look or sound? What will the design be? Do you need a script?

7. Make a prototype of your temperature advisory. This could be a video for a TV spot, a radio recording, a graphic for an app, etc.

Peer Evaluation Form

Content	Score	Comments
How well do you understand the advisory notice?	l'm confused It's totally clear 1 2 3 4 5	
How well do you think the public would understand the advisory notice?	Not well Really well 1 2 3 4 5	
How helpful is the information in the advisory?	Not very helpful Really helpful 1 2 3 4 5	
Is the advisory accessible for all people?	No Somewhat Yes 1 2 3 4 5	
What suggestions do you have for how to improve the advisory notice?		