

Aligning Indigenous Knowledge with Montana’s Middle School Physical Science Standards

Heidi Lyn Schuster

2026

Lesson Plan 4:

Heat, Shelter, and Balance – Understanding Thermal Energy

Date 6/29/26	Length of Lesson 13 days (50-minute class periods)
Course 8th Grade Physical Science	Unit/Theme Thermal Energy
Teacher Name Heidi Schuster	Standard(s) MS-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. MS-PS1-6 undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. MS-PS3-3 apply scientific principles to design, construct, and test a device that minimizes or maximizes thermal energy transfer.
Key Vocabulary Thermal Energy: total energy of moving particles in matter Temperature: measure of the average motion of particles. Heat Transfer: movement of thermal energy from warmer to cooler areas	Content Objective(s) • I can explain that thermal energy is related to particle motion. • I can describe how thermal energy moves through conduction, convection, and radiation. • I can compare how different shelters control heat transfer. • I can determine how Indigenous and natural structures manage thermal energy. • I can design, test, and improve a device that minimizes or maximizes heat transfer. • I can use evidence from investigations to explain the movement of heat.
	Essential Questions

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Conduction: transfer of heat through direct contact Convection: transfer of heat through moving liquids or gases Radiation: transfer of heat through electromagnetic waves Insulator: material that slows heat transfer Conductor: material that allows quick heat transfer. Particle Motion: movement of atoms and molecules Energy Transfer: movement of energy from one object or system to another. Thermal Balance: condition where temperatures become equal	● How does thermal energy move from one place to another? ● How do shelters help people control heat? ● Why are some structures better at retaining heat than others? ● How do animals and humans adapt to temperature changes? ● How can we design devices that control thermal energy transfer? Materials ● Images of: ○ Modern house ○ Traditional tipi ○ Sweat lodge ● Images of: ○ Beaver lodge ○ Prairie dog burrow ○ Bird nest ○ Bear den ● Poster board or cardstock ● Tape ● Scissors ● Ruler ● Thermometers ● Two identical containers with warm water (heat source) ● Stopwatch ● Dropper ● Popsicle sticks ● Wax paper ● Large index cards (5" × 8") ● Tape ● Tall, clear plastic cup
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Shelter: structure that protects people or animals from environmental conditions	• White sheet of paper • Food coloring (red, blue, or green) • Hot water (about 50 °C) in a beaker • Cold water in a beaker • Yellow food coloring in a small cup • Blue food coloring in a small cup • Magnifier • Ball and ring apparatus • Bunsen burner for heating the ball • Room temperature water • Basketball, very deflated • Scale that measures in grams • Pump • Can of compressed gas • clear plastic cups • 8-oz plastic bottle • Detergent solution in a cup • 4 teaspoons of dishwashing liquid • 4 teaspoons of sugar • Paper cups • Cardboard • Felt • Cotton balls • Aluminum foil • Fabric scraps • String
	Resources

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	● Comparing Heat Control in Tipis, Houses, and Sweat Lodges ● Articles ○ Lodges in Winter (Perryman, 2025) ○ Bears Make Their Beds for Winter (McCarthy McPhaul, 2017) ○ How Birds Build the Perfect "Warm but Breathable" Nest (SamheOutdoor, 2025) ○ Prairie Dogs (Hiller, 1990) ● Animal Shelter worksheet ● Molecules Matter ● Particles of a Liquid. ● Food Coloring in Water ● Water balloon ● Molecules in Motion ● Heating and Cooling a Liquid ● The Ups and Downs of Thermometers ● Heating and Cooling a Thermometer ● Particles of a Solid ● Comparing Solid and Liquid ● Heating and Cooling a Metal Ball ● Heating and Cooling a Solid ● Air, It's Really There ● Air Has Mass - Basketball ● Air Has Mass - Can ● Particles of a Gas ● Heating and Cooling Gas in a Bottle ● Comparing Solids, Liquids, and Gases ● Molecules of a Gas
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	• How Does Shape of a Structure Affect Heat Retention • Indigenous Engineering and Thermal Energy • Design Challenge • Claims, Evidence, Reasoning
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Day	Lesson Sequence	Notes
Day 1 25 min	Engage (Phenomenon) Students compare a modern house, a tipi, and a sweat lodge to question how different structures control heat. Procedure - Display images of: - A modern house - A traditional tipi - A sweat lodge - Create a class chart <i>How do shelters control the movement of thermal energy?</i> - Indigenous people developed shelter designs that respond to: - Climate - available materials - need for ventilation and heat control - Tipis are designed for: - airflow and smoke ventilation - heat circulation - Sweat lodges use: - heated rocks to release stored thermal energy - Ask students: <i>Which structure would stay warmest during winter?</i>	Resources: Comparing Heat Control in Tipis, Houses, and Sweat Lodges Modification suggestion: Sweat lodges are still used by the Crow Tribe today. Tipis were the predominant shelter for the Crow. If sweat lodges or tipis are not used in the specific community, use examples of traditional shelters.

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	○ Which structure might stay coolest during summer? ○ How do these structures manage heat?	
Day 2 1 day	Elder An Elder shares knowledge about tipis and how they respond to outdoor temperature. 1. Invite the Elder to discuss: ○ Traditional tipi construction ○ Materials used ○ Seasonal adjustments ○ Ventilation systems ○ How tipis respond to weather conditions 2. Guiding questions for class discussion: ● Why was a tipi shaped this way? ● How did people stay warm in winter? ● How was excess heat removed in summer? ● What materials provided insulation?	Modification suggestion: Have an Elder discuss how their traditional shelters were heated.
Day 3 25 min	Environment Students discuss animal homes to consider how heat is managed in their environment. Procedure 1. Jigsaw: a. Place students in groups of 4 b. Assign one article to each student i. Lodges in Winter ii. Bears Make Their Beds for Winter iii. How Birds Build the Perfect "Warm but Breathable" Nest	Resources: Articles Lodges in Winter (Perryman, 2025) Bears Make Their Beds for Winter (McCarthy McPhaul, 2017) How Birds Build the Perfect "Warm but Breathable" Nest

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	iv. Prairie Dogs 2. Display images of animal homes. 3. Students work in groups to analyze how animal homes are similar to human homes. 4. Students record their reflection on the Animal Shelter worksheet.	(SamheOutdoor, 2025) Prairie Dogs (Hiller, 1990) Animal Shelter worksheet Modification suggestion: If the animals selected for this activity are not indigenous to the area, find articles about animals that are.
Day 4-6 3 days	Explore Students investigate the difference in heat retention between a tipi and a home. Question: How does the shape of a structure affect heat retention? Independent Variable ● Shape of the structure (tipi vs. house) Dependent Variable ● Temperature inside the structure over time Controlled Variables ● Construction material (both made from the same poster board or cardstock) ● Thickness of material ● Size/volume of structure ● Heat source	Materials Poster board or cardstock Tape Scissors Ruler Thermometers Two identical containers with warm water (heat source) Stopwatch Resources: How Does Shape of a Structure Affect Heat Retention

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	• Starting temperature • Distance from windows, vents, and other heat sources • Length of investigation • Thermometer placement Procedure Build the Models 1. Construct a conical tipi model and a rectangular house model using the same type of poster board. 2. Make both structures approximately the same height and volume. 3. Create a small opening for inserting a thermometer. Set Up the Investigation 1. Fill two identical containers with the same amount of warm water. 2. Record the temperature of the water in each container. 3. Place one container inside the tipi and one inside the house. 4. Insert thermometers into both structures. Collect Data 1. Record the starting temperature inside each structure on the data sheet. 2. Measure and record the temperature every minute for 15 minutes. 3. Observe any visible airflow or condensation. 4. Graph the change in temperature over time for each shelter 5. Analyze the data to determine which shelter retained the most heat.	Modification suggestion: If tipis are not used in the specific community, build models of traditional shelters.
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Day 7-9 3 days	Explain Students learn how thermal energy affects particle motion. This lesson was developed from the American Chemical Society - Middle School Chemistry. (American Chemical Society, 2025) Molecules Matter Discussion <i>What is Chemistry?</i> - Chemistry is the study of matter and what matter does. <i>What is Matter?</i> - Anything that has mass and takes up space - The three common types of matter on Earth are solid, liquid, and gas. <i>What are some examples of matter?</i> <i>Does water have mass, and does it take up space?</i> - A bucket of water is pretty heavy to lift. It definitely has mass. It also takes up space in the bucket. Since it has mass and takes up space, water is matter. Question: Does water hold together well or come apart easily? Procedure - Use the dropper to gently squeeze out a drop of water, but try not to let the drop fall completely out of the dropper. See how far you can make the drop hang off the end of the dropper without the drop falling. - Place 4 or 5 drops of water together on a piece of wax paper to make one medium-sized drop.	Molecules Matter: Resources Molecules Matter Particles of a Liquid. Food Coloring in Water Water balloon video Molecules Matter: Materials Water in small cup Dropper Popsicle sticks Wax paper Large index cards (5" × 8") Tape Tall, clear plastic cup Water (room temperature) White sheet of paper Food coloring (red, blue, or green)
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	3. Gently tilt the wax paper in different directions so that the drop moves. 4. Use a popsicle stick to slowly drag the drop around the wax paper a bit. Try using your popsicle stick to separate your drop into two. 5. Use your popsicle stick to move the drops near each other. Then move one drop so that the two drops touch. 6. Discuss and record observations on the Molecules Matter worksheet. Demonstration 1. Add water to the cup until it is about $\frac{3}{4}$ filled. 2. Ask students to watch closely as you add one or two drops of food coloring to the water. Do not stir. Instead, allow the color to slowly mix into the water on its own. 3. Hold the cup up with a sheet of white paper behind it so it is easier for students to see the color moving and mixing in the water. The drops of food coloring will slowly move and mix into the water. Eventually all the water in the cup will be evenly colored. Explain 1. Show the molecular model animation Particles of a Liquid. 2. Show the molecular model animation Food Coloring in Water 3. Have students draw their own model of water on the molecular level and complete the activity sheet Students' drawings should show that the molecules are: a. Randomly arranged b. Close together	Molecules Matter: Teacher Preparation Cover a large index card with a piece of wax paper so that the wax paper completely covers the card. Tape the wax paper in place. Prepare one card for each student.
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	c. Moving - Show a video of a water balloon popping in slow motion so that students can see an example that water molecules are attracted to one another. <i>Why do you think the water keeps its shape the moment the balloon is popped?</i> Molecules in Motion Question: Is the speed of water molecules different in hot and cold water? Procedure - In groups of 2, students use droppers to carefully place 1 drop of yellow and 1 drop of blue food coloring into the hot and cold water at the same time. - Students allow the colors to mix on their own, observing them for a couple of minutes. - Record and discuss observations on the Molecules in Motion worksheet. - Show the molecular model animation, Heating and Cooling a Liquid. - Point out to students that molecules of hot water are moving faster and are slightly further apart. The molecules of cold water are moving more slowly and are a little closer together. - Have students answer questions about the animation and draw a model of water molecules on their activity sheet. - Have students refer to the drawing of room temperature water on their activity sheet and discuss how they should represent the molecules in cold and hot water. Question	Molecules in Motion: Resources Molecules in Motion Heating and Cooling a Liquid Molecules in Motion: Materials Hot water (about 50 °C) in a beaker Cold water in a beaker Yellow food coloring in a small cup Blue food coloring in a small cup 4 droppers
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	8. <i>Let's say that you measure exactly 100 milliliters of water in a graduated cylinder. You heat the water to 100 °C and notice that the volume increases to 104 milliliters. Using what you know about the attractions between water molecules and the way heating affects molecular motion, explain why the volume of water in the cylinder increases when it is heated.</i> <u>The Ups and Downs of Thermometers</u> Question: What makes the liquid in a thermometer go up and down? Procedure 1. Have students look closely at the parts of a thermometer with a hand lens and practice reading the temperature in °C. Have students put thumb or finger on the bulb and see if the red liquid moves in the thin tube. 2. Observe the red liquid in the thermometer when it is heated and cooled, measuring the temperature of hot and cold water. Record the temperature on The Ups and Downs of Thermometers worksheet. 3. Have students pick a temperature somewhere between the temperature of cold water and hot water and attempt to combine an amount of hot and cold water to achieve that temperature in one try. 4. Show the molecular model animation, Heating and Cooling a Thermometer. 5. Answer the reflective questions on the worksheet. 6. Have students draw a molecular model to represent the molecules of the liquid in a thermometer. <u>Moving Molecules in a Solid</u> Question: Do you think heating or cooling a solid affects the motion of the atoms? Procedure	The Ups and Downs of Thermometers: Resources The Ups and Downs of Thermometers Heating and Cooling a Thermometer The Ups and Downs of Thermometers: Materials Student thermometer Magnifier Cold water Hot water (about 50 °C)
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	1. Show the molecular model animation Particles of a Solid. 2. Point out the following about solids: a. The particles (atoms or molecules) are attracted to each other. b. The particles (atoms or molecules) vibrate but do not move past one another. c. The solid retains its shape. 3. Show the molecular model animation Comparing Solid and Liquid. Demonstration 1. Use ball and ring apparatus to show the expansion of a metal when heated. (If you do not have this equipment, you can show students a video of this demonstration titled Heating and Cooling a Metal Ball.) 2. Show the molecular model animation Heating and Cooling a Solid. 3. Have students complete the questions and drawings on the Moving Molecules in a Solid activity sheet about heating and cooling the metal ball. 4. Have students apply what they have learned about heating and cooling solids to explain why bridges have flexible connections. Air, It's Really There Question: Is gas matter? Demonstration 1. Basketball a. Place the deflated ball on the scale to get the initial mass.	Moving Molecules in a Solid: Resources Particles of a Solid Comparing Solid and Liquid Heating and Cooling a Metal Ball Heating and Cooling a Solid Moving Molecules in a Solid: Materials Ball and ring apparatus Bunsen burner for heating the ball Room temperature water Air, It's Really There: Resources
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	b. Ask students if they think the ball will weigh more or less after you pump air into it. c. Pump as much air into the basketball as you can and then put it back on the balance. d. If you don't have the materials for this demonstration, watch the video Air Has Mass - Basketball	Air, It's Really There Air Has Mass - Basketball Air Has Mass - Can Particles of a Gas Heating and Cooling Gas in a Bottle Comparing Solids, Liquids, and Gases Molecules of a Gas
	2. Can of compressed gas a. Place a can of compressed gas on a scale and check its mass. b. Shoot gas out of the can for a few seconds and then place the can back on the scale. c. If you don't have the materials for this demonstration, watch the video Air Has Mass - Can	Air, It's Really There: Materials Basketball, very deflated Scale that measures in grams Pump Can of compressed gas
	3. Show the molecular model animation Particles of a Gas. a. Molecules of a gas have very little attraction for one another and barely interact with each other.	clear plastic cups 8-oz plastic bottle Detergent solution in a cup
	2. Discuss and record student observations on the Air, It's Really There worksheet. Question: How does heating and cooling affect a gas? Procedure 1. Warming the air inside the bottle a. Pour hot water into an empty cup until it is about ½-full. b. Turn the bottle over and dip the opening of the bottle into the detergent to get a film of detergent covering the rim. c. While holding the bottle, slowly push the bottom of the bottle down into the hot water.	Hot water (about 50 °C) Cold water Air, It's Really There: Teacher Preparation

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	2. Cooling the air inside the bottle a. Pour cold water into another cup until it is about $\frac{1}{2}$-full. b. If there is still a bubble on the bottle, slowly push the bottom of the bottle down into the cold water. c. If a bubble is not still on the bottle, make another bubble by dipping the opening into detergent and then pushing the bottom of the bottle into hot water again. d. While holding the bottle, slowly push the bottom of the bottle down into the cold water. 3. Discuss and record student observations on the Air, It's Really There worksheet. 4. Show the animation Heating and Cooling Gas in a Bottle. 5. Have students answer the questions about the growing and shrinking bubble on the activity sheet. 6. Show the molecular model animation Comparing Solids, Liquids, and Gases 7. Explain the following differences to students: a. Solid—Particles (atoms or molecules) are very attracted to one another. They vibrate but do not move past one another. The atoms or molecules stay in fixed positions because of their strong attractions for one another. A solid has a definite volume and a definite shape. b. Liquid—Particles (atoms or molecules) are attracted to one another. They vibrate but are also able to move past one another. A liquid	Detergent solution: 4 teaspoons of dishwashing liquid 4 teaspoons of sugar $\frac{1}{2}$ cup of water Gently stir until the detergent and sugar are dissolved. Place about 1 tablespoon of detergent solution in petri dish for each group of students
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	has a definite volume but does not have a definite shape. c. Gas—Particles (atoms or molecules) are not attracted to each other much at all and move freely. A gas does not have a definite shape or volume. The atoms or molecules of a gas will spread out evenly to fill any container. 8. Have students draw a model of solids, liquids, and gases on their activity sheet. 9. Have students apply what they have learned to explain why a balloon grows when it is heated. 10. Show the animation Heating Molecules of a Gas to give students a hint.	
Day 10-12 3 days	Elaborate Students design and test a device that controls heat, using data to improve their design. Indigenous Engineering Design Challenge Objective Students will design, build, test, and improve a container that minimizes thermal energy transfer by applying Indigenous knowledge used to keep people warm and protect food from temperature changes. Question: How have people used knowledge of materials, shelter design, and the environment to control thermal energy? Indigenous Knowledge Crow and Northern Cheyenne peoples carefully selected materials and designed structures that helped manage heat in extreme weather conditions. Tipis, buffalo-hide clothing, bedding, and food storage methods were designed through generations of observation and testing. These technologies	Resources Indigenous Engineering and Thermal Energy Design Challenge Materials Paper cups Cardboard Felt Cotton balls Aluminum foil Fabric scraps String Tape Thermometers

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	demonstrate sophisticated engineering and an understanding of thermal energy transfer. Before beginning the challenge, have students read in their groups Indigenous Engineering and Thermal Energy and show students photos of: ● Tipi liners and insulating air spaces ● Buffalo hides and fur as insulation ● Winter clothing made from animal hides ● Earth lodges and other Native shelters ● Traditional methods for keeping food warm or protecting it from freezing Design Challenge A family traveling across the Northern Plains needs a way to keep water warm during cold weather. Design a thermal container inspired by Indigenous engineering practices that keeps water warm for the longest amount of time. Criteria ● Must hold one cup of water. ● Must use only provided materials. ● Must be inspired by a Native technology, material, or design concept. ● Must minimize heat loss. ● Must include a labeled design sketch showing how Indigenous knowledge influenced the design. Procedure 1. Research or discuss one Indigenous technology that controls heat. 2. Sketch a container design inspired by that technology.	Hot water Modification suggestion: Describe local tribal insulation technologies for students to replicate.
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	3. Label features that reduce conduction, convection, or radiation. 4. Construct the first prototype. 5. Explain how the design reflects Indigenous engineering principles. 6. Pour warm water into the cup. 7. Record starting temperature. 8. Place the cup inside the device. 9. Record temperatures every 5 minutes for 20 minutes. 10. Students redesign based on their data and observations. 11. Students repeat the investigation and compare results. Analyze • Students calculate total temperature change • Students complete Reflection Questions	
Day 13 1 day	Evaluate Students demonstrate understanding of thermal energy transfer. Using the Claims, Evidence, Reasoning (CER) format, students explain how thermal energy moves from one object to another. 1. Give the students the following guiding question: <i>How does thermal energy move, and how can a design reduce heat transfer?</i> 2. Give the students the following statement to use as the Claim: <i>Thermal energy moves through conduction, convection, and radiation, and insulation can reduce heat transfer.</i>	Resources Claims, Evidence, Reasoning

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	3. Using all of the information gained from this lesson, students write a statement of Evidence. They may use the sketch part of the CER to illustrate their evidence. 4. Using all the information gained from this lesson and critical thinking, students will write their Reasoning, illustrating their ideas with a drawing.	
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Comparing Heat Control in Tipis, Houses, and Sweat Lodges



*Tipis, Crow Reservation,
Montana*

Photographer: J.J. Sloan
(Sloan, 1925)



Small House

Photographer: Olivia Barnes
(Barnes, 2025)



Crow Sweat Lodge

Photographer: Unknown
(Native American Culture—
Sweat lodges, n.d.)

Shelter	How Might It Control Heat?
Tipi	
House	
Sweat Lodge	

1. Which structure would stay warmest during winter? _____
Why? _____
2. Which structure might stay coolest during summer? _____
Why? _____
3. How do these structures manage heat? _____

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LODGES IN WINTER (Perryman, 2025)

By Heidi Perryman

January 27, 2025

People love to think about beavers in the wintertime. Probably because everything is frozen and out of their way. When things start to thaw and melt, we get much less interested.

Cool Critters: Beavers at home during winter – and maybe a muskrat or two. >



This time of year, it's hard to beat having a good meal inside a warm, rustic lodge with a waterfront view.

Just ask a beaver.

Beaver lodges aren't just by the water; they're below and above it. When temperatures drop, these furry, buck-toothed, flat-tailed animals hunker down in their multilevel dwellings that are warm, safe, and stocked with food.

You see, beavers don't hibernate during winter. Instead, they stay active inside their well-insulated lodges built of sticks, stones, and mud. Other than swimming through tunnels beneath the ice, "when ponds are iced over, beavers often spend almost all their time in the lodge," said Joe Mouser, communications manager for Beavers Northwest, a nonprofit organization based in Washington state.

These beavers are used to icy winters. Not all beavers. Surely our beavers in Martinez never had to endure freezing winters or create a food cache.

Yet this winter is different. Here it is, mid-January, and beavers can be seen skimming across water and waddling on adjacent land. They're still sleeping, grooming, and eating in their lodges, but they've increased their time outside. Why?

Probably because temperatures in the Inland Northwest have been so mild, said Mouser. Consequently, our ponds, lakes, and creeks remain largely unfrozen. In Western Washington, where the water seldom freezes, beavers spend plenty of time outside their lodges in winter, he said.

Whether a mild or frigid winter, beavers are at home this time of year. All the chewing, logging, and hauling they do during the warm season? It's not just about dams, said wetland wildlife species specialist Shawn Behling of the Washington Department of Fish and Wildlife.

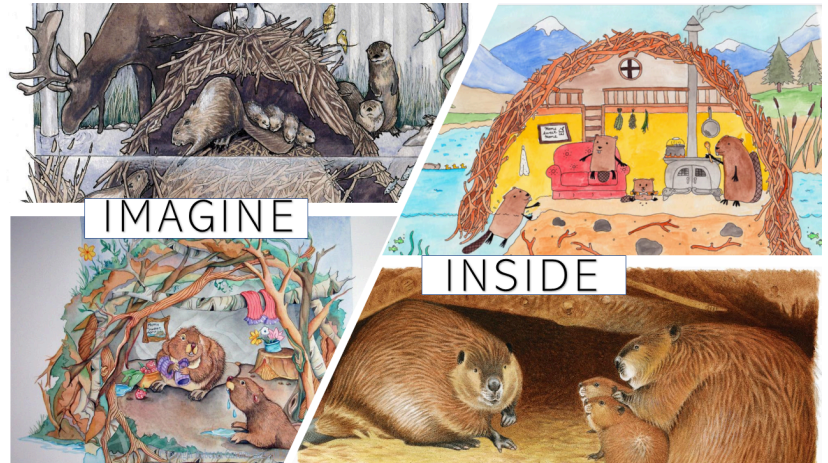
Washington knows its beavers so well they even know how the east and west differ!

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“They spend a good part of late summer and the fall building lodges or beefing up their existing ones,” she said, adding that the semiaquatic rodents are skilled construction workers and ecosystem engineers.

Their jagged, dome-shaped structures, typically 6 feet high and 15 feet in diameter, resemble a tangled heap of sticks. But don’t judge a lodge by its cover.



It is a sturdy network of whittled-smooth sticks, rocks, and aquatic vegetation – all sealed with a waterproof mud mixture that also provides insulation. The beavers’ living chambers are situated above the waterline, and two underwater entryways are located below. On the lodge’s roof is an opening that brings in fresh oxygen.

“On very cold days, warmth generated by the beavers’ bodies can cause steam to rise from the ventilation opening – as if their lodge has a chimney,” Behling said.

Who lives inside? A family of beavers – usually the parents, along with one to three yearlings and one to three kits born the previous spring. The animals’ radiant heat, combined with their homemade insulation, keeps the lodge relatively warm. One Canadian study found that when the outside temperature dropped to minus-6 degrees, the inside of an occupied beaver lodge hovered at 32 degrees.

Video cameras placed inside lodges by researchers have revealed that it’s not unusual for one or two muskrats to move in with a beaver family during winter. Even though both rodent species swim, they’re only distantly related. Also, beavers are considerably larger than muskrats and have paddle-shaped tails, while muskrats have skinny, rat-like tails.

Why do beavers tolerate muskrat freeloaders? It’s possible they recognize that the muskrats’ body heat makes the lodge warmer, according to one theory. To make it through winter, one rodent species moves into another rodent species’ lodge, and they become companions.

Sounds like a good plot for an animated Disney film. Naw, that would never happen. Beavers aren’t cool enough for Disney or Pixar. Only otters are that cool.

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Bears make their beds for winter (McCarthy McPhaul, 2017)

The Outside Story, sponsored by the Wellborn Ecology Fund, explains how black bears go to bed fat and strong and wake up skinny and strong'

By Meghan McCarthy McPhaul, The Outside Story | October 27, 2017

The fields around our home are something of a bear buffet from mid-summer through fall: wild blueberries in July, followed by blackberries, then apples come September, with beechnuts falling from the trees skirting the mown area. In our 13 years here, we've seen a mother bear noshing on fallen apples while her cubs scampered around in the tree above her, heard bears climbing and snapping the occasional apple branch while we lay in tents 20 yards away during a backyard campout, and even witnessed two cubs playing in our kids' sandbox.

I've often wondered where the neighborhood bruins — otherwise known as American black bears (*Ursus americanus*) — den up for the winter. How do they decide where — and when — to hunker down for the cold season?

"It varies by the individual bear and by the individual year," explained bear biologist Ben Kilham, author of several books on bear behavior, most recently *In the Company of Bears*. He has reinstated some 150 bears, mostly orphaned cubs, to the wild during his nearly three decades as a bear rehabilitator. "They may investigate denning sites as they travel throughout the year."

Bears will remain out and about as long as good food sources remain available. But once cold weather settles in and snow blankets the ground — or there's simply nothing left to eat — they take to dens they've already prepared for the winter.

When choosing a den, "security is the most important thing," said Kilham. "It has nothing to do with warmth. They carry their warmth with them."

Favored denning sites include hollow trees, if a bear can find one big enough — about three feet in diameter. Bears will also excavate dens under tree stumps, below the root mass of a blown-over tree, and beneath brush piles. Sometimes they use rock dens, typically along the base of a ledge. Some bears simply create ground nests, usually in areas of dense softwood, where there is some shelter from falling snow.

In poor food years, female bears may travel outside of their home range, which Kilham said is generally between 3 and 15 square miles, to find nourishment before winter. But they always return to their home area to den. Pregnant females and mothers of young cubs (which stay with their mothers until they are about 18 months old) use leaves, grass, moss, ferns, and softwood boughs to create nests within their dens.

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Pregnant bears are the first to den up, usually starting in early October. These mothers-to-be add 50 percent or more of body weight in the fall, stores they'll need to nourish cubs in utero and nurse them once they're born, as tiny as chipmunks, in January or February.

Black Bear den. Illustration by Adelaide Tyrol. >



Females with cubs are next to retreat to their dens, curling up with their young to share warmth. These mothers don't manage to store away as much fat as pregnant bears because they exert so much energy tending to their cubs.

Last to go are males, which stay active as long as they can find food. Since the largest males are the ones that breed, there is often a trade-off in staying out later into the fall or even into winter.

"If there's food accessible, they'll stay out," Kilham said. "Their goal in life is to get big enough to breed. There's been evidence of male bears that wake up in a warm spell in winter, hit a bird feeder, and then go back to den."

Which brings up the argument about whether or not bears hibernate. Their body temperature drops a few degrees below normal, and their metabolism slows considerably, but not to the extent to qualify bears as "true hibernators." They do not defecate or urinate while they are in their dens. By twitching their muscles through the winter, bears maintain strength, and they're able to transform fat and urea to protein. Their fat cells also release leptin, a hormone that prevents loss of bone mass.

"Hibernation is a nice word. It describes what they do. If you get technical about it, you can't have a word for how every animal spends the winter, because you'd have to have a different word for every animal," said Kilham. "Bears go to bed fat and strong and wake up skinny and strong."

Denning up, hibernating — whatever you choose to call it — allows bears to conserve energy during the long, cold months when there is little to eat. This year, with an extended warm spell following a summer of plentiful berries and an autumn abundant with apples, beech nuts, acorns, and mountain ash berries, the bears should be fat and happy as they withdraw from the buffet and nestle down for that long winter's rest.

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How Birds Build the Perfect "Warm but Breathable" Nest (SamheOutdoor, 2025)

October 10, 2025

When we think about bird nests, it's easy to imagine a simple bowl of twigs. But for the birds who build them, nests are more like tiny climate-controlled homes — designed to keep eggs warm, dry, and well-ventilated.

That balance — staying warm without overheating, and dry without suffocating — is what scientists call nest thermoregulation. It's one of the most fascinating (and overlooked) examples of natural engineering. And if you're a backyard birder, understanding it can help you support nesting birds more effectively, especially during early spring and cold snaps.

Why Temperature Control Matters

Bird eggs and hatchlings can only survive within a narrow temperature range — usually between 98°F and 104°F (37°C–40°C). Too cold, and embryos stop developing. Too hot, and they overheat within minutes.

According to research from *The Auk: Ornithological Advances* (Mainwaring et al., 2014), small fluctuations of even 2–3°F can determine hatching success. That's why birds don't just build nests — they build microclimates.

The Hidden Science Behind a "Smart Nest"

Each part of a bird's nest serves a thermoregulation purpose:



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Nest Feature	Function	Example in Nature
Outer shell	Structural support, shields from wind/rain	Robins use mud + grass to create a semi-waterproof wall
Insulating layer	Maintains stable heat inside	Chickadees add moss, fur, and feathers
Lining	Cushions eggs and regulates humidity	Finches use plant down or soft grass
Nest opening/ orientation	Prevents overheating or drafts	Tree swallows face their entrance slightly away from direct sun

Birds instinctively understand that heat retention and airflow are equally important — a nest that traps too much warmth can become just as deadly as one that's too cold.

Material Matters: Warmth Without Suffocation

Different birds choose different nesting materials depending on their environment — not just for availability, but for thermal performance.

A study in *Journal of Avian Biology* (Heenan & Seymour, 2012) found that materials like moss and fur can retain up to 40% more heat than dry grass, while still allowing humidity to escape.

Nest Placement and Microclimate Control

Even the location of a nest can change its temperature by several degrees. A 2019 *Frontiers in Ecology and Evolution* study showed that nests placed in partial shade retained more stable internal temperatures than those in full sun or deep cover.

Balancing Warmth and Dryness

It's not just temperature — moisture control plays a big role in chick survival.

Wet nests lose their insulating power quickly. That's why many birds choose materials that shed water or dry fast — like bark strips, pine needles, or mud walls reinforced with grass.

Final Takeaway

Birds are more than builders — they're thermal engineers. Every twig, feather, and fiber they use is a calculated choice to balance warmth, ventilation, and protection.

So next time you see a chickadee carrying moss or a wren fussing over twigs, remember — they're not just decorating; they're designing for survival.

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Prairie Dogs (Hiller, 1990)

Prairie dogs sit up frequently, on the lookout for any danger. >

Mornings are a busy time in a prairie dog town as the residents come out to eat the grasses and weeds growing near their burrow entrances. These chubby members of the ground squirrel family seem to lead relaxed, sociable, uncomplicated lives as they wander about eating, visiting with their neighbors, or indulging in playful antics. However, they are constantly alert to danger, sitting up frequently to observe their surroundings. Their black-tipped tails are rarely still, swishing back and forth at a rate dependent upon their degree of excitement or fear. And although their bodies may be roly-poly, they are capable of making lightning-quick moves and split-second dives into the safety of their burrows. Before they leave their burrows, their heads pop up to scan the horizon in all directions.



The tunnels in the burrow system may range in length from twelve feet to more than a hundred feet. The main entrance tunnel goes straight down for twelve to fourteen feet, with a listening-post chamber close enough to the surface to hear, but deep enough to protect the listener. One or more passages run horizontally from the main tunnel and lead to chambers for food and refuse. There is also a grass-lined chamber for rearing the young. Lateral passages form pockets that help trap air when other portions of the burrow might be flooded. The tunnel system connects with at least two holes above the ground to provide ventilation and escape routes.

The mother prairie dog takes grass down into the burrow to build a nest for the young, which are born in litters of four or five during March or April. >



When the temperature range above ground is 77 to 99 degrees Fahrenheit, temperatures inside the burrow are more moderate, ranging from 80 to 89 degrees. When winter temperatures range from 25 to 44 degrees Fahrenheit, burrow temperatures will be 42 to 48 degrees. During the hottest hours of a summer day, the prairie dogs retire to their cooler burrows to nap or carry out other underground activities. But when evening comes, they once again return to the surface to eat. In winter, prairie dogs venture above ground to feed while the sun's rays are the warmest. During really bad weather, they sleep (but do not hibernate), living off body fat when there are no stored food supplies.

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Communication is an integral part of the prairie dog's daily life. The animals are quite vocal and have a variety of shrill whistles and barks for different situations. During their above-ground activities, one or more of the animals are on sentry duty, sitting atop their mounds ready to sound a warning to the entire community. At the first sign of danger, the sentry makes a sharp, warning bark. The other prairie dogs race to their burrows, sit up, and join in with the warning cry to spread the word. If the situation warrants it, each family member, one by one, dives into the security of the burrow, leaving a deserted-looking town for the intruder. When danger is past, the sentry gives a songlike all-clear bark and the others again join in to spread the word. Another interesting vocalization is the territorial call. To make this call, the prairie dog thrusts its body upward full-length, points its nose in the air, and stretches out its forelegs. Since this is a quick, powerful movement, the first few times a young prairie dog attempts the territorial call, it often tumbles over backwards.

To make the territorial call, the prairie dog quickly thrusts its body upward full length, nose in the air, and forelegs outstretched. >



A prairie dog's home territory is determined by the coterie (KOTE-uh-ree) to which it belongs. Just as a city is divided into neighborhoods, the prairie dog town is divided into coteries. Each coterie, which usually contains one male, several females, and six or more young (not necessarily related), has its own territory to defend and has the use of the burrow system within this territory. Although there is communication between coteries, members do not invade each other's territories. Every member of the coterie knows every other member. They keep in touch and reinforce recognition by frequently grooming each other and "kissing" (touching noses and teeth). They have a greeting kiss and recognition embrace. It is not unusual to see a pair sitting side by side with the arm of one over the shoulder of the other. When two prairie dogs meet, they touch their bared teeth together. If one is not a fellow coterie member, the intruder is sent on its way. Coterie members turn the touched bared teeth into a sort of kissing action and then may wrestle each other playfully. Their nuzzling, wrestling, and grooming antics are what make the prairie dogs such entertaining creatures to watch.

Prairie dogs are sociable creatures, and their nuzzling and grooming antics make them entertaining to watch. Their "kissing" behavior (touching of noses with bared teeth) is the way they identify members of their own coterie. >



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Young prairie dogs are born in March and April. They first appear above ground when they are about six weeks old. They are weaned shortly after, and by the time they are three months old, the family ties are broken. They become sexually mature in the second year. At one time, prairie dog towns were enormous – one in Texas is reported to have covered twenty-five thousand square miles and housed some 400 million prairie dogs. Sharing their burrow system (not necessarily as invited or welcomed guests) were a number of other animals. However, the three most common intruders were the black-footed ferret, the burrowing owl, and the rattlesnake.

The black-footed ferret's long, weasel-like body was perfect for entering and exploring the complex maze of burrows in search of its prey – prairie dogs. Its range, of course, was the same as that of the prairie dog. Unfortunately, when ranchers declared war on the prairie dog because its burrow holes were a menace to livestock and it competed with cattle for vegetation, the ranchers also inadvertently attacked the ferret. They not only destroyed its food source, but the poison and gas that were used to kill the prairie dogs also killed the ferrets. At this time, the black-footed ferret is considered the rarest mammal in North America and appears on both state and federal endangered species lists. It is doubtful if a single one can be found in Texas.

The burrowing owl was not hurt as badly by the extermination of so many prairie dogs as the ferret. The owls lost a few eggs and chicks to the resident prairie dogs, and the owls ate a few young prairie dogs. However, young prairie dogs were not the owl's main food, and it could dig its own burrow with its sharp talons and long legs. It just found the ready-made burrows less work than digging its own. Rattlesnakes were even less dependent on the prairie dogs for survival. The burrows were a cool place for the snakes to go to get out of the hot sun, and they also provided den sites, where rattlesnakes could gather and hibernate until spring. Of course, the snakes probably ate a share of the young prairie dogs and the burrowing owl chicks and eggs. Heat-sensitive facial pits made it possible for the rattlesnake to find its prey in even the darkest tunnel system. However, when the prairie dogs discovered a snake's presence, they escaped through the emergency exit, circled back to the hole where the snake entered, and, with the help of their prairie dog neighbors, filled in the hole, burying the snake alive. Other predators that include prairie dogs on their menu are eagles, hawks, coyotes, bobcats, and badgers.

Vast prairie dog towns with millions of inhabitants are a thing of the past, but a few preserved colonies, such as the one at Mackenzie State Park *[in Texas]*, ensure that we will be able to watch the prairie dog and enjoy its antics into the future.

Lesson Plan 4:

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Animal Shelters

Beaver Lodge	How does this shelter control heat?
	How do these shelters reduce heat loss?
	How are they similar to human shelters?
Bear Den	How does this shelter control heat?
	How do these shelters reduce heat loss?
	How are they similar to human shelters?
Bird Nest	How does this shelter control heat?
	How do these shelters reduce heat loss?
	How are they similar to human shelters?
Prairie Dog Burrow	How does this shelter control heat?
	How do these shelters reduce heat loss?
	How are they similar to human shelters?

Lesson Plan 4:

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How Does Shape of a Structure Affect Heat Retention

Data

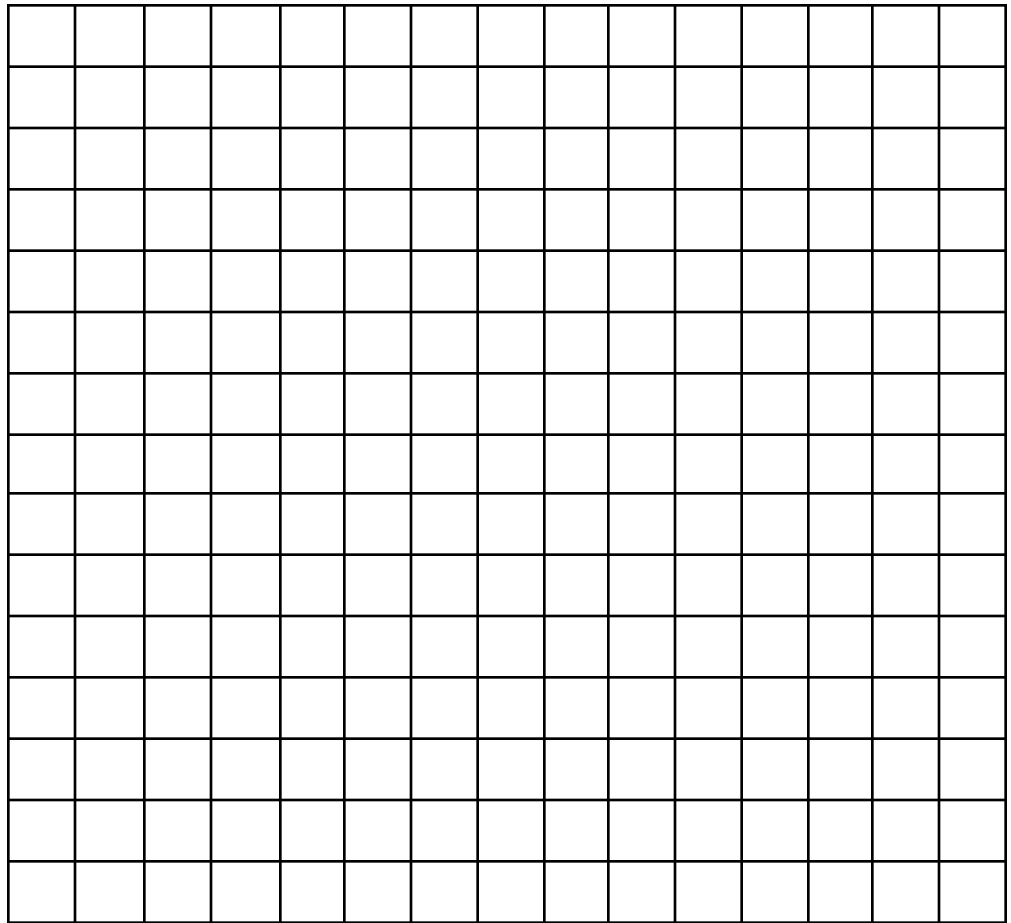
Time (min)	Tipi Temperature (°C)	House Temperature (°C)	Observations
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

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Graph

Temperature



Time

Tipi Data Analysis

1. Total temperature change: _____
2. Average temperature decrease per minute: _____

House Data Analysis

3. Total temperature change: _____
4. Average temperature decrease per minute: _____

Lesson Plan 4:

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5. Which structure warmed faster? _____

6. Which retained heat longer? _____

7. How does the shape of a structure affect heat retention? _____

8. Why? _____

Lesson Plan 4:

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Molecules Matter (American Chemical Society, 2025)

Purpose

In the activity below, you will investigate some of the characteristics of water. You will also model and explain, on the molecular level, why water acts the way it does.

Question

Does water hold together well or come apart easily?

Materials

- Water in small cup
- 2 popsicle sticks cut in half
- Dropper
- 2 cards covered with wax paper

Procedure

1. Use a dropper to gently squeeze out one drop of water but try not to let the drop fall completely out of the dropper. See how far you can make the drop hang off the end of the dropper without the drop falling.
2. Place 4 or 5 drops of water together on the wax paper to make a larger drop.
3. Gently tilt the wax paper in different directions so that the drop moves.
4. Use a popsicle stick to slowly move your drop around the wax paper. Try using your popsicle stick to separate your drop into two.
5. Use your popsicle stick to move the two drops near each other. Then move one drop so that the two drops touch.

Analysis

1. When you squeezed the drop of water out of the dropper, did the water break apart or did it hold together?

2. When you were pulling the drop around the wax paper, did the water seem to hold together or come apart easily?

3. When you tried to split your drop, did the drop separate easily? _____
4. Was it easy or difficult to make the drops come together? _____

Lesson Plan 4:

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Demonstration

5. Your teacher placed a drop of food coloring in a cup of water. The color slowly mixed into the water without being stirred. What does this tell you about water molecules?

Explain

You saw an animated molecular model of water. Now draw your own molecular model.

6. Using circles and motion lines to represent water molecules, draw a model of water on the molecular level. Be sure to show that water molecules are:

- Randomly arranged.
- Close together because they attract each other.
- Moving



7. What is it about water molecules that helps explain why the water drops were difficult to split apart but easy to join together?

Lesson Plan 4:

Heat, Shelter, and Balance – Understanding Thermal Energy - Resources

Molecules in Motion (American Chemical Society, 2025)

Question: Is the speed of water molecules different in hot and cold water?

Materials

- Hot water in a clear plastic cup
- Cold water in a clear plastic cup
- Food coloring (yellow and blue)
- 4 droppers

Procedure

1. With the help of your partners, use droppers to carefully place 1 drop of yellow and 1 drop of blue food coloring into the hot and cold water at the same time.
2. Allow the colors to mix on their own as you watch them for a couple of minutes.

Analysis

1. Describe the colors and how they moved and mixed in cold water.

2. Describe the colors and how they moved and mixed in hot water.

3. What does the speed of the mixing colors tell you about the speed of the molecules in hot and cold water? _____

Explain

You saw an animation of water molecules being heated and cooled. Now you can draw your own molecular model.

4. Based on your observations and the animations, fill in the blanks with the words "*increases*" or "*decreases*".

5. Heating a substance _____ molecular motion.

Cooling a substance _____ molecular motion.

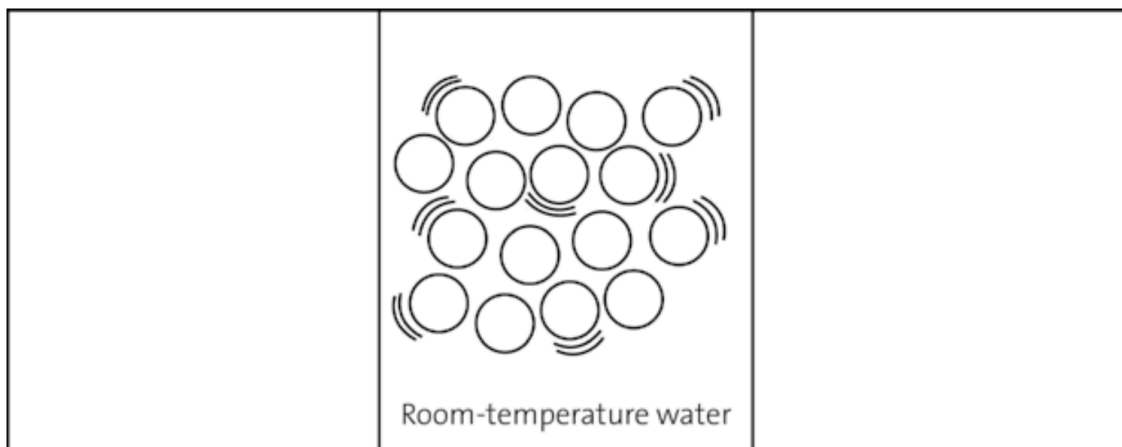
As molecular motion increases, the space between molecules _____.

As molecular motion decreases, the space between molecules _____.

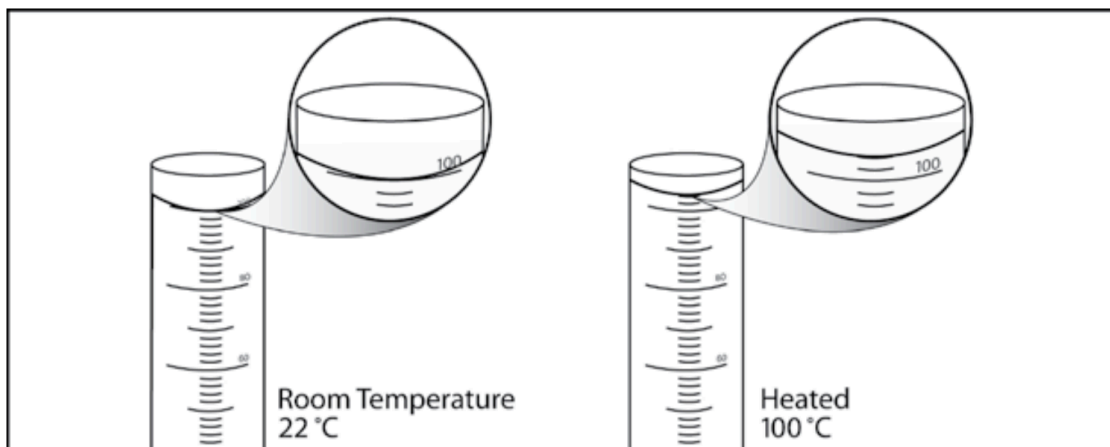
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6. Using circles to represent water molecules, draw a model of the molecules in cold and hot water.
- Use motion lines to show the speed of the molecules.
 - Consider the space between molecules in each temperature of water.



Let's say that you measure exactly 100 milliliters of water in a graduated cylinder. You heat the water to 100 °C and notice that the volume increases to 104 milliliters.



7. Using what you know about the attractions between water molecules and the way heat affects molecular motion, explain why the volume of water in the cylinder increases when it is heated.

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The Ups and Downs of Thermometers (American Chemical Society, 2025)

Question: What makes the liquid in a thermometer go up and down?

Materials

- Student thermometer
- Cold water
- Magnifier
- Hot water (about 50

Procedure

1. Look closely at your thermometer. The liquid inside is probably a type of alcohol that's been dyed red.
2. Read the temperature in °C by having your eye on the same level as the top of the red liquid. What is the temperature?
3. Use a magnifier to look closely at the thermometer from the front and from the side. Look at the bulb and the thin tube that contains the red liquid.
4. Put your thumb on the red bulb and see if the red liquid moves in the thin tube.
5. Observe the red liquid in the thermometer when it is heated and cooled.
 - a. Place the thermometer in hot water and watch the red liquid until it stops moving.

Record the temperature in °C. _____
 - b. Now put the thermometer in cold water. Keep it in the cold water until the liquid stops moving.

Record the temperature in °C. _____

Observations

1. Based on what you know about the way molecules move in hot liquids, explain why the liquid in the thermometer goes up when heated.

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2. Based on what you know about the way molecules move in cold liquids, explain why the liquid in the thermometer goes down when cooled.

3. Why do you think the tube that contains the red liquid is so thin?

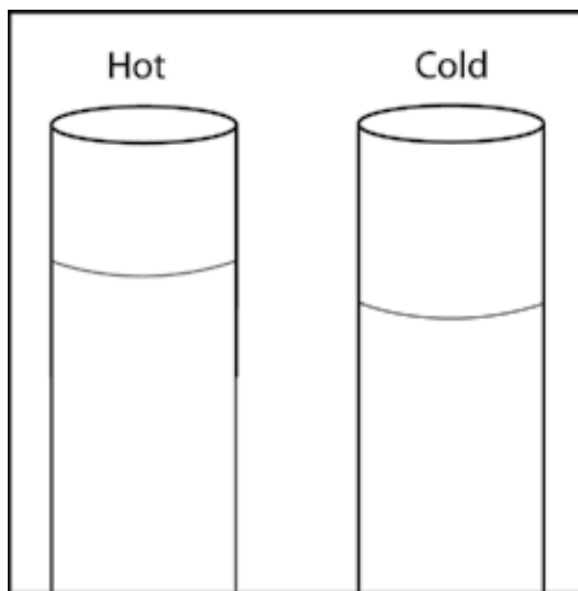
4. What do you think is the purpose of the larger outer tube?

Explain

You saw an animated molecular model of a thermometer at different temperatures. Now you will draw your own model.

The drawing shows two close-ups of a thin tube in a thermometer like the one you used. One picture represents the thermometer in hot water, while the other is the thermometer in cold water.

5. Based on what you know about the motion of molecules in a liquid and what you saw in the animations, draw circles to represent alcohol molecules in the liquid in the thermometer. Try to show the difference in distance between the molecules when the liquid is hot and cold. Use motion lines to represent their movement (fast or slow).



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Movement of Particles in a Solid (American Chemical Society, 2025)

Explain

After you watch the molecular model animations of liquids and solids, answer the questions below.

1. How is the motion of the atoms in solid metal different from the motion of the molecules in liquid water?

2. What is it about atoms and molecules in liquids and solids that keep them close to one another even though they are moving?

Demonstrate

After watching the video demonstration of a metal ball fitting in a ring, answer the following questions.

3. At room-temperature the metal ball fit through the ring. What happened when they tried to push the heated ball through the ring?

4. What happened to the atoms in the heated metal ball so that it didn't fit through the ring?

5. After the ball was cooled by putting it in the water, why do you think it fit through the ring again?

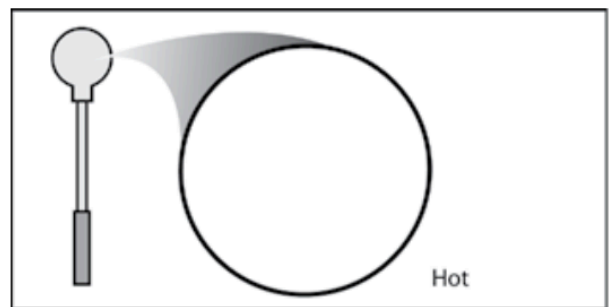
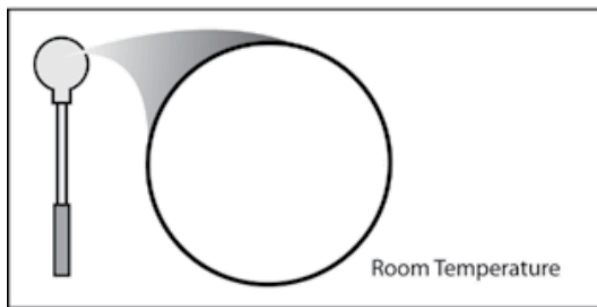
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Model

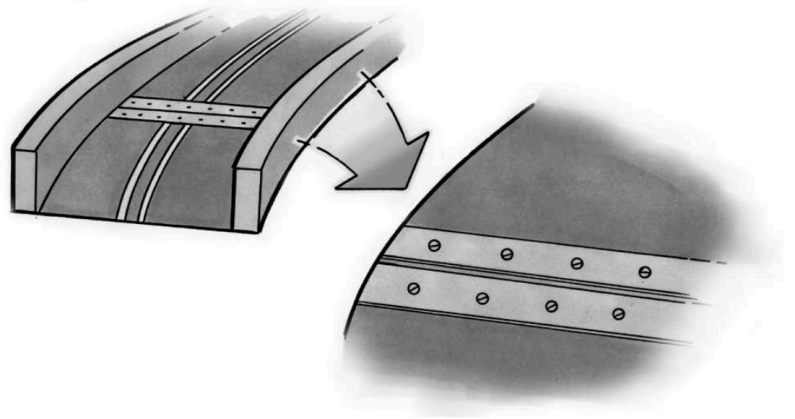
You saw in the animation that atoms in a solid move faster and get slightly further apart when heated. You also saw that they slow down and get slightly closer together when cooled. Use this information to make your own drawing on the molecular level of the metal ball.

6. Draw a model of the atoms in the metal ball at room-temperature and after it has been heated. Use circles and motion lines to show the speed and spacing of the atoms in the room-temperature ball. Include captions like “atoms faster and further apart” or “atoms slower and closer together” to describe your drawings



Explain

Look at the picture of the road of a bridge. The road on a bridge gets colder in the winter and hotter in the summer than the road leading to it and away from it. Many bridges have a flexible connection like the one shown in the picture.



7. Knowing what you do about how solids act when they are heated and cooled, why do you think they put flexible connections in the road on a bridge?

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Air, It's Really There (American Chemical Society, 2025)

Demonstrate

The demonstrations with the basketball and the can of compressed air were meant to show something about gases and matter. Matter is anything that has mass and takes up space.

1. Think about the demonstration with the deflated and inflated basketball. The basketball weighed more after it was inflated with air than when it was deflated. How does this show that gas is matter?

2. Think about the demonstration with the can of compressed gas. The can weighed less after some gas was shot out of the can. How does this show that gas is matter?

Explain

After watching the animation of gas molecules inside a balloon, answer the following.

3. What did you notice about the molecules of a gas?
 - a. Do the molecules of a gas have strong or weak attractions? _____
 - b. Are the molecules of a gas randomly or orderly arranged? _____
 - c. When molecules of gas hit, do they stick together or bounce off? _____

Question: How do heating and cooling affect a gas?

Materials

- 2 clear plastic cups
- 8-oz plastic bottle
- Detergent solution in cup
- Hot water
- Cold water

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Procedure

Warming the air inside the bottle

1. Pour hot water into an empty cup until it is about $\frac{1}{2}$ -full.
2. Turn the bottle over and dip the opening of the bottle into the detergent to get a film of detergent covering the rim.
3. While holding the bottle, slowly push the bottom of the bottle down into the hot water.

Cooling the air inside the bottle

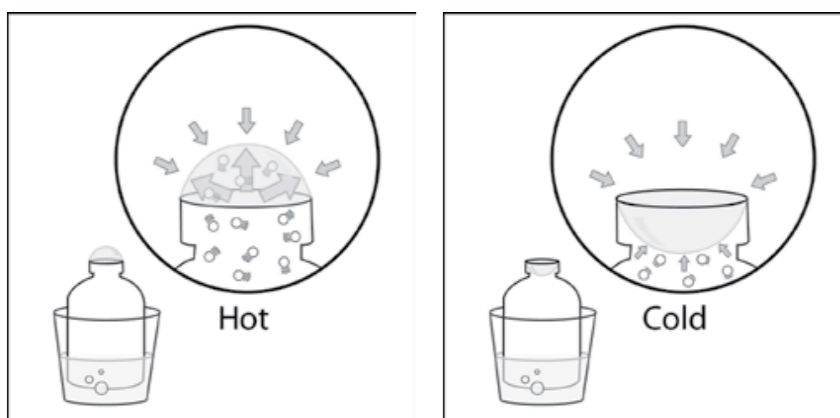
4. Pour cold water into another cup until it is about $\frac{1}{2}$ -full.
5. If there is still a bubble on the bottle, slowly push the bottom of the bottle down into the cold water.
6. If a bubble is not still on the bottle, make another bubble by dipping the opening into detergent and then pushing the bottom of the bottle into hot water again.
7. While holding the bottle, slowly push the bottom of the bottle down into the cold water.

Observations

4. What happened to the film of detergent solution when you placed the bottle in hot water? _____
5. What happened to the bubble when you placed the bottle in cold water? _____

Explain

You saw an animation showing the air molecules inside a bottle when it is placed in hot and cold water. Think of the animation and use the drawing below as a reference to answer the questions.



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6. What caused the bubble to form when you placed the bottle in hot water? Be sure to write about the speed of the molecules inside the bubble and the force on the bubble from the outside air.

7. Why did the bubble get smaller when you placed the bottle in cold water? Be sure to write about the speed of the molecules inside the bubble and the force on the bubble from the outside air. You saw an animation about the molecules in solids, liquids, and gases.

8. Draw circles to represent the molecules in a solid, liquid, and gas. Because all three different substances are all at the same temperature, draw the same number of motion lines near the circles for each substance. Under each box, write about the arrangement and motion of the molecules and the attractions the molecules have for one another.

Solid	Liquid	Gas
--------------	---------------	------------

9. Imagine that you work at a party store during the summer. You are going to ride home with the store owner whose car has been sitting in the hot sun all day. The owner tells you that you can take home a big bunch of balloons, but advises you not to blow them up all the way. Explain why the owner's advice is wise. Be sure to discuss how heating affects the motion of the molecules in a gas.

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Indigenous Engineering and Thermal Energy

How Did Indigenous People Stay Warm?

Long before modern insulation, heaters, and thermometers existed, Indigenous peoples developed technologies that helped them stay warm, protect food, and survive harsh winters. These solutions were based on careful observation of nature, experimentation, and generations of knowledge passed down through families and communities.

As you learn about thermal energy, consider how these traditional technologies controlled the movement of heat.

1. Tipi Liners and Insulating Air Spaces (Brink, 2008) (National Park Service, n.d.)

- a. A tipi was more than a portable shelter. It was carefully designed to manage heat and airflow.
 - i. An inner liner was attached inside the tipi walls.
 - ii. The liner created an air space between the outer covering and the living area.
- b. Thermal Energy concepts
 - i. Trapped air slows heat transfer and helps keep warm air inside the shelter.
 - ii. Adjustable smoke flaps controlled airflow and ventilation.
 - iii. The conical shape helped warm air circulate throughout the shelter.

2. Buffalo Hides and Fur as Insulation (Ewers, J. C., 2001) (Taylor, C., 1994)

- a. Buffalo provided food, tools, shelter materials, and clothing.
 - i. Buffalo robes were made with fur attached.
 - ii. Thick hides blocked the wind and protected against cold temperatures.
- b. Thermal Energy concepts
 - i. Air trapped in fur acts as an insulator, slowing the transfer of thermal energy away from the body.

3. Winter Clothing Made from Animal Hides (Gilman, R. I., Schneider, M. J., & Bradbury, P. J., 1987) (National Park Service, n.d.)

- a. Native peoples created clothing specifically designed for their environment.

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- i. Buffalo-hide robes, deer-hide leggings, fur-lined moccasins, hats and gloves
- b. Thermal Energy Concepts
 - i. Layers reduce heat transfer by trapping air and creating barriers between the body and the environment.
 - ii. Fur provided insulation.

4. Earth Lodges and Other Native Shelters

- a. Many Indigenous nations built shelters that matched their local climate.
 - i. Earth Lodges
 - 1. Constructed with wooden frames covered by soil.
 - 2. Thick earth walls provided natural insulation.
 - 3. Shelters remained warmer in winter and cooler in summer.
 - ii. Tipis on the Plains
 - iii. Plank houses in coastal regions
 - iv. Wigwams in forested areas
- b. Thermal Energy Concepts
 - i. Thick walls slow heat transfer between the inside and outside environment.

5. Traditional Food Storage (Nabhan, G. P., 1989) (National Museum of the American Indian, n.d.)

- a. Keeping food from spoiling was important throughout the year.
 - i. Food was dried and stored in protected containers.
 - ii. Underground storage pits helped maintain stable temperatures.
 - iii. Elevated storage platforms protected food from animals.
 - iv. Snow, ice, and cool earth were used to keep food cold.
- b. Thermal Energy Concepts
 - i. Underground temperatures change more slowly than air temperatures, helping food stay cool or protected from freezing.

Lesson Plan 4:

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Design Challenge

A family traveling across the Northern Plains needs a way to keep water warm during cold weather. Design a thermal container inspired by Indigenous engineering practices that keeps water warm for the longest amount of time.

Criteria

- Must hold one cup of water.
- Must use only provided materials.
- Must be inspired by a Native technology, material, or design concept.
- Must minimize heat loss.
- Must include a labeled design sketch showing how Indigenous knowledge influenced the design.

Materials

Paper cups	Cardboard	Felt	Cotton balls	Thermometers
Aluminum foil	Fabric scraps	String	Tape	Hot water

Procedure

1. Research or discuss one Indigenous technology that controls heat.
2. Sketch a container design inspired by that technology.
3. Label features that reduce conduction, convection, or radiation.
4. Construct the first prototype.
5. Explain how the design reflects Indigenous engineering principles.
6. Pour warm water into the cup.
7. Record starting temperature.
8. Place the cup inside the device.
9. Record temperatures every 5 minutes for 20 minutes.
10. Students redesign based on their data and observations.
11. Students repeat the investigation and compare results.

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1. Sketch a container design inspired by Indigenous technology. Label features that reduce conduction, convection, or radiation.

2. Explain how this design reflects Indigenous engineering principles.

Data

Time (min)	Temperature (°C) Device #1	Temperature (°C) Device #2
0		
5		
10		
15		
20		

Analyze

Explain how device #1 is different from device #2.

Total temperature change Device #1_____

Total temperature change Device #2_____

Which design features worked best?

Lesson Plan 4:

Heat, Shelter, and Balance – Understanding Thermal Energy - Resources

Reflection Questions

1. Which materials were the best insulators? _____

2. How did your design reduce heat loss? _____

3. What similarities exist between your design and Indigenous technologies? _____

4. How does Indigenous knowledge demonstrate engineering and scientific thinking? _____

5. Why were these thermal-energy technologies important for survival on the Northern Plains? _____

Lesson Plan 4:

Heat, Shelter, and Balance – Understanding Thermal Energy - Resources

Claims, Evidence, and Reasoning Graphic Organizer

[illegible]