15. Bark and Soil: Nature's Insulators

Lesson Overview: This activity explores the use of insulation to slow the transfer of heat through materials. Bark (on stems of trees and shrubs) and soil are two kinds of materials that insulate living things from the heat of fires.

The trunk has only 1 set of materials for this experiment, so you can do it either as a <u>demonstration</u> or a <u>station</u> where students will work in groups of 2-4.

Subjects: Science, Mathematics

Duration: Two half-hour sessions <u>or</u> one half-hour session for demonstration, then 15-minute sessions for teams

Group size: Whole class for demonstration, teams of 3-4 for followup

Setting: Indoors

New FireWorks vocabulary: *insulation*

Lesson Goal: Increase students' understanding of heat transfer and the usefulness of insulation to slow the process of heat transfer.

Objectives:

- Students can describe how insulation affects the flow of heat through a substance.
- Students can explain how tree bark and soil can protect living tissues from the heat of fires.

ABOUT STUDENT PRESENTATIONS: If you did **Activity M11. Who Lives Here? Adopting a Plant, Animal, or Fungus**, this would be a great time for student presentations on all of the tree species. That way they can connect the concept of bark thickness to traits of particular species that they've been studying.

Standards:		6th	7th	8th
CCSS--ELA	Writing	4,7,10	4,7,10	4,7,10
	Speaking and Listening	1,4,6	1,4,6	1,4,6
	Language	1,2,3,6	1,2,3,6	1,2,3,6
	Writing: Science and Technology	4,7,10	4,7,10	4,7,10
CCSS--Math	Geometry	6.G		
NGSS	Structures/Properties of Matter	PS3.A		
	Energy	PS3.B		
	Engineering Design	ETS1.A,B,C		
	Natural Selection and Adaptation	LS4.C		
EEEGL	Strand 1	A,C,E,F,G		

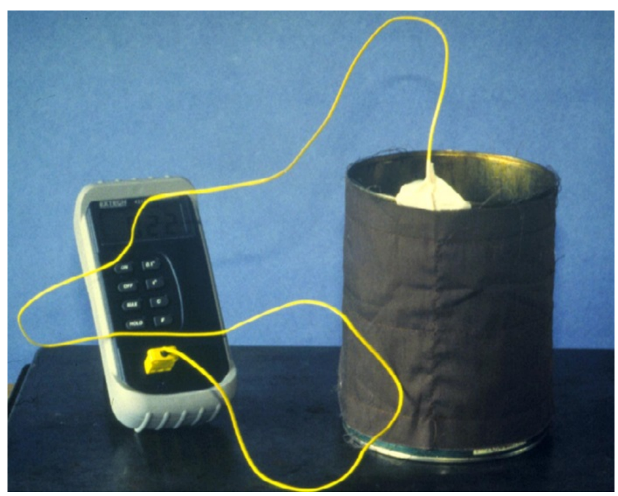
Teacher Background: This activity shows how insulation slows the transfer of heat through materials. The insulation in a home keeps it from heating up rapidly on a hot summer day and from cooling off rapidly on a cold winter night. Insulation may also slow the house's cooling *after* a hot summer day, which is why we might open the windows and use fans to bring more cool air inside.

Nature has ways to insulate living things from the heat of wildland fires. Many trees have thick bark, which slows the transfer of heat from fire to the crucial cambium cells beneath the bark; these are the living cells that make new cells. Soil is another of nature's insulators. Soil protects small animals that stay in their underground burrows during fires. It also protects roots, buried seeds, and other underground plant parts.

In this activity, we assume that bark and soil will not burn. That assumption is not completely accurate, though. Bark <u>can</u> burn if it gets dried out and is exposed to enough heat. Some materials in the soil can burn, too. Soil is composed of tiny particles of rock (minerals), which are <u>not</u> burnable, and partly decomposed particles of vegetation and animal matter, which <u>are</u> burnable. When the dead, rotting organic matter is in a distinct layer on top of the mineral soil, we call it duff. Also see **Activity M10. Fire, Soil, and Water Interactions**, which explores the effects of fire on soils.

In this activity, students "model" nature's insulation by covering a surface (a model tree or model soil) with quilting materials. They use a hair dryer to simulate the heat of a fire. They heat the surface for a short time and record the temperature pattern beneath the insulation as it heats up and cools off. They may be surprised to find that, while thick insulation prevents the temperature from rising rapidly, it also prolongs the heating process and slows the cooling process when compared with thin insulation.

Materials and preparation:



- **Decide** how to do the activity. The trunk has only 1 set of materials. Unless you have additional materials, you will need to do the experiment either as a <u>class demonstration</u> or as a <u>station</u> to be used by 2-4 students at a time. We describe the "station" approach in the steps below. We suggest that you do the first iteration (0 layers of insulation) as a demonstration, then have the student teams do the second (5 layers of insulation) and third (10 layers) iterations at the station.
- **Decide** whether to model the insulating properties of <u>tree bark</u> or those of <u>soil</u>. You can discuss which one to do with the class (Step 4 below). The only difference is where you place the insulation: around a coffee can ("model" of a tree trunk) or on a table ("model" of the soil surface). After you have studied heat transfer through one material (either bark or

soil), the students should be able to discuss heat transfer through the other material. This is the last question on the handout.

- **Decide** whether to have students graph their data by hand on page 2 of the handout or use computer software such as Excel. **Note** that they must sketch hypotheses as well as observations on the graph, and that complicates the use of a computer spreadsheet.

The photo above and the directions here explain how to do the tree bark model and demonstrate the first iteration of the experiment together with the class.

Set up a table so it can be used for demonstration. Use these materials from the trunk:

- Hair dryer
- Ruler
- Digital thermometer (make sure it has a working battery and you have a spare)
- 1.5-pound coffee can/paint can/round oatmeal box (if simulating tree bark). Cover the outside with newspaper. Tape the thermocouple to the outside of the paper, about a hand's width down from the top edge.
- 3 pieces of fabric (1 piece with no quilt batting, 1 with 5 layers of quilt batting, 1 with 10 layers of batting).

Provide these materials yourself:

- Masking tape to secure thermocouple to table or "tree".
- Masking tape or clothes line clips to secure fabric to "tree"
- Stopwatch or clock (must show seconds)
- 1 copy/student or team of **Handout M15-1: Insulating Power**. <u>Copy it 1-sided, if possible</u>, because students will graph the data from the first page onto the graph on the second page.

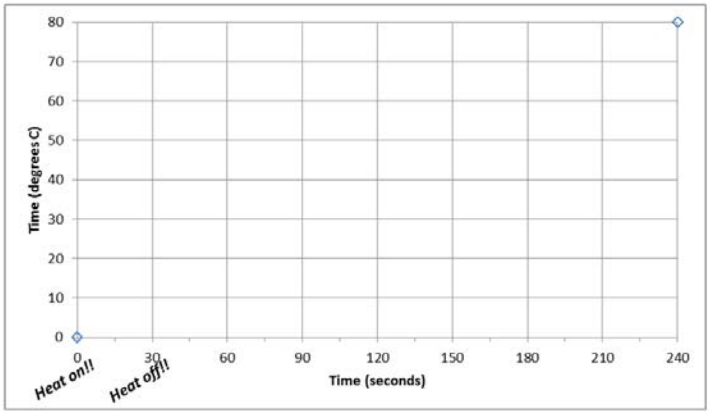
Sketch the graph for data on the board or butcher paper (**M15_EmptyGraph.pptx**).

Procedures:

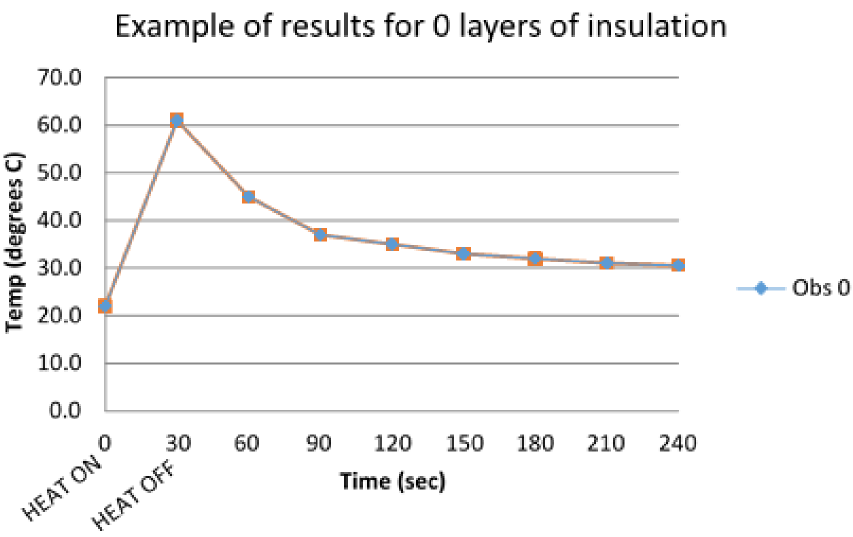
1. Ask: How do you protect yourself and your home from freezing in winter and from getting too hot in summer? We use insulation – as well as heat from wood, fossil fuels, and other sources of energy.
2. Ask: How do wildland animals, plants, and fungi protect themselves from freezing and over-heating? Their main mechanism is insulation – either something they grow themselves, like fur and tree bark, or something in the environment, like soil. If you have done **Activity M11. Who Lives Here? Adopting a Plant, Animal, or Fungus**, the students can refer to adaptations of specific organisms.
3. Explain: In this activity, we'll get a better understanding of how insulation works. What you learn here will apply to the insulation in your home just as much as to insulation of living things in wildlands.
4. Give each student or team a copy **Handout M15-1: Insulating Power.** Read the experimental questions together with the class. Decide – or tell them - which question to

investigate – the insulating effects of tree bark or soil. (Or split the class up and have different teams do the 2 different questions.)

5. **Demonstration:** Get a team of 3 or 4 students to take on the roles described in the handout. Have them practice the timing of "Heat on" and "Heat off" before actually collecting data.
6. Sketch the figure on the board (**M15_EmptyGraph.pptx**). Remind students that this is the same as what is on page 2 of their handouts. Go over the axes with the students.



7. Ask: Can they hypothesize – make a guess - at what the temperature pattern will be if they do the experiment with just a thin piece of cloth insulating the thermocouple from the heat of the hair dryer? Try to get 2-3 hypotheses and sketch them on the graph. Mark each one with "Hyp 0" for "hypothesized pattern with 0 layers of insulation." Be sure to tell them that there is ABSOLUTELY NOTHING WRONG IF YOUR HYPOTHESIS TURNS OUT TO BE INCORRECT. The point of the experiment is to learn stuff, not to prove ourselves right or wrong.
8. Set up the experiment and follow steps 1-7 on the handout. Have students record the data on their handouts under the "Obs 0" column (for "observed pattern with 0 layers of insulation").
9. Have your student helpers graph the data on the board, then have all the students graph it on their handouts. Be sure to label the line "Obs 0." It may look like the graph below.
10. Explain: Students will work at the station in teams to get the second and third hypotheses (steps 9 and 12) and sets of data (steps 10 and 13).
11. Arrange the teams and complete the experiment.



Assessment: Base assessment on completion of the handout. See the **Answer Key for Handout M15-1: Insulating Power.**

Evaluation:

	Excellent/Complete	Good	Fair	Poor/Incomplete
Question #11	-The student clearly compared/contrasted the observed and predicted results. -The student cited specific examples from the data.	-The student contrasted the observed and predicted results. -The student did not cite specific examples from the data.	-The student wrote that the predictions were (or were not) accurate. -The student did not explain why.	-The student did not address the question.
Question #14	-The student clearly compared/contrasted the observed and predicted results. -The student cited specific examples from the data.	-The student contrasted the observed and predicted results. -The student did not cite specific examples from the data.	-The student wrote that the predictions were (or were not) accurate. -The student did not explain why.	-The student did not address the question.
Question #15	-The student wrote separate responses for the 2 parts of the question (insulating properties of bark and of soil). -The student recognized the importance of bark as protection of cambium from surface fire and soil as protection of buried roots and seeds from surface and ground fire.	-The student responded to only 1 of the 2 parts of the question OR -The student did not specify the kind of fire that thick bark/deep soil protect against.	-The student responded to only 1 of the 2 parts of the question AND -The student did not specify the kind of fire that thick bark/deep soil protect against.	-The student did not answer the question directly.

Handout M15-1: Insulating Power

Names: ____

Here are two experimental questions:

- Can thick bark insulate the phloem, cambium, and xylem of a tree from fire's heat?
- Can soil insulate seeds and roots from fire's heat?

Find out by measuring and graphing the pattern of temperature change beneath different amounts of insulation.

Get organized:

- TIMER calls out 15-second intervals and "Heat on/off!"
- HEATER runs hair dryer.
- OBSERVER watches thermometer, calls out temperature.
- RECORDER writes down temperature observations.

Set up the experiment:

Set up the thermometer so the OBSERVER can see it.
For a soil model: Tape the thermocouple wire to a table top.
For a tree trunk model: Tape the thermocouple wire to the surface of an empty coffee can or oatmeal box, covered with paper.

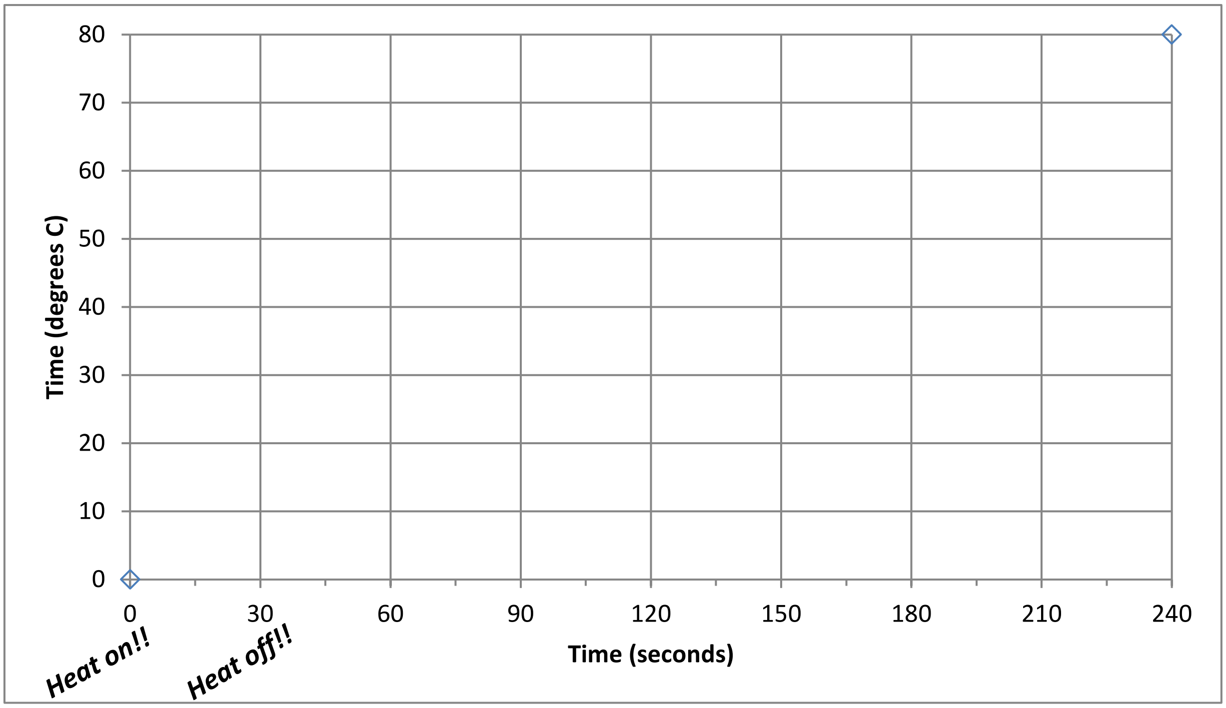
Do the first experiment with just a thin piece of fabric covering the thermocouple (tape or clip the fabric in place). Do the next experiments with 5 layers of insulation (Steps 9-11 below) or 10 layers of insulation (Steps 12-14).

Time (seconds)	Temperature (ºC)		
	0 layers (Obs 0)	5 layers (Obs 5)	10 layers (Obs 10)
0 – HEAT ON			
15			
30 – HEAT OFF			
45			
60			
75			
90			
105			
120			
135			
150			
165			
180			
195			
210			
225			
240			

Procedure:

1. HEATER, position the hair dryer about 20 centimeters from the table or coffee can, pointing at the thermocouple tip (which you can't actually see now because it's under cloth).
2. OBSERVER, turn the thermometer on. Set it to degrees Celsius. Report the temperature.
3. RECORDER, write down the temperature at "0" seconds using the appropriate column in the table for the layers of insulation being tested (0, 5, or 10).
4. TIMER, call out "Zero, heat on!" HEATER, turn the hair dryer to "high."
5. TIMER, call out "Fifteen." OBSERVER, report the temperature. RECORDER, write it down.
6. TIMER, call out "Thirty. **Heat off**!" **HEATER, turn the hair dryer off**. OBSERVER, call out the temperature. RECORDER, write it down.
7. Every 15 seconds until 4 minutes have passed: TIMER, call out the time in seconds. OBSERVER, report the temperature. RECORDER, write it down.

8. Graph your results. Connect the points. Label it “Obs 0,” meaning “observed pattern with 0 layers of insulation.”



9. What do you think will happen if you add 5 layers of insulation? Use a pencil to draw the temperature pattern you expect in the graph above. This line shows your **hypothesis**. Label the line “Hyp 5” to indicate “hypothesized pattern with 5 layers.”

10. Use the set of insulation with 5 layers and repeat the experiment (steps 1-7). On the graph above, plot your data and label the line “Obs 5” to indicate “observed pattern with 5 layers.”

11. Compare your observed results with the results you predicted in step 9. Use specific examples from your data and use complete sentences to describe how accurate your predictions were.

12. What if you add 5 <u>more</u> layers of insulation, for a total of 10 layers? On the graph, pencil in a line to show your hypothesis and label it “Hyp 10.”

13. Use the thickest set of insulation (10 layers). Repeat steps 1-7. On the graph above, plot your data and label the line “Obs 10.”

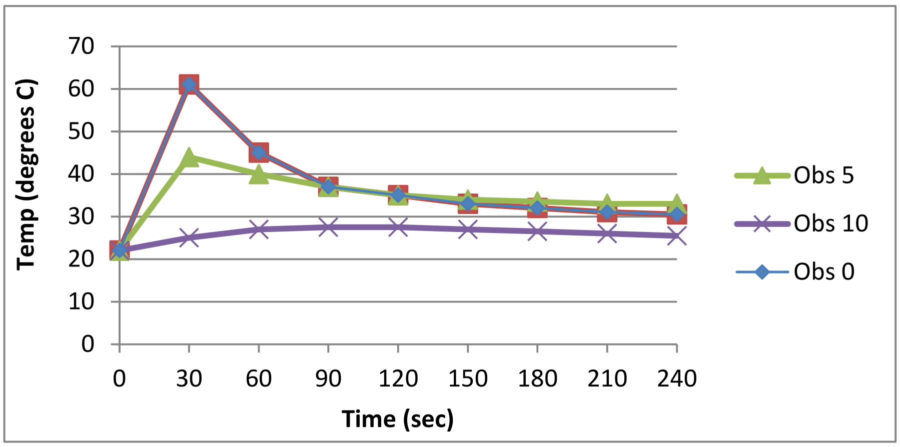
14. Compare your observed results with the results you predicted. Use specific examples from your data and use complete sentences to describe how accurate your predictions were.

15. Can thick bark really protect a tree? Can soil really protect underground seeds and roots? Answer both questions regardless of which question you tested. Using complete sentences, explain why or why not.

Answer Key for Handout M15-1: Insulating Power

A completed data table and graph might look like this – except we did not insert hypothesized lines.

		Temperature (° C)		
		0 layers	5 layers	10 layers
Time (sec)		Obs 0	Obs 5	Obs 10
0	HEAT ON	22.0	22.0	22.0
30	HEAT OFF	61.0	44.0	25.0
60		45.0	40.0	27.0
90		37.0	37.0	27.5
120		35.0	35.0	27.5
150		33.0	34.0	27.0
180		32.0	33.5	26.5
210		31.0	33.0	26.0
240		30.5	33.0	25.5



15. Can thick bark protect a tree from all 3 kinds of wildland fire – ground, surface, and crown? Can soil really protect underground seeds and roots from all 3 kinds of fire? Answer both questions regardless of which question you tested. Using complete sentences, explain why or why not.

Thick bark can protect a tree from surface fires because it can keep the cambium layer from heating up to lethal temperatures. Of course, the longer the fire burns, the deeper the heat will penetrate into the bark, phloem, cambium, and xylem. Thick bark does not insulate leaves or the buds at the tips of branches, so it cannot protect a tree from crown fire. Thick bark cannot protect a tree from ground fire either. If a fire smolders in the duff around the base of the tree, it can kill the tree's roots, and it can kill the cambium at ground level.

Thick soil can protect underground seeds and roots from surface fire because it can keep them from heating up to lethal temperatures. Of course, the longer the fire burns, the deeper the heat will penetrate. But if there is a lot of burnable material (like duff) on top of the soil or mixed in with it, and if that material burns, the resulting ground fire can kill buried seeds and roots – and even burn them up. So thick soil may not protect buried seeds and roots from ground fires, and it does not offer any protection against crown fires.