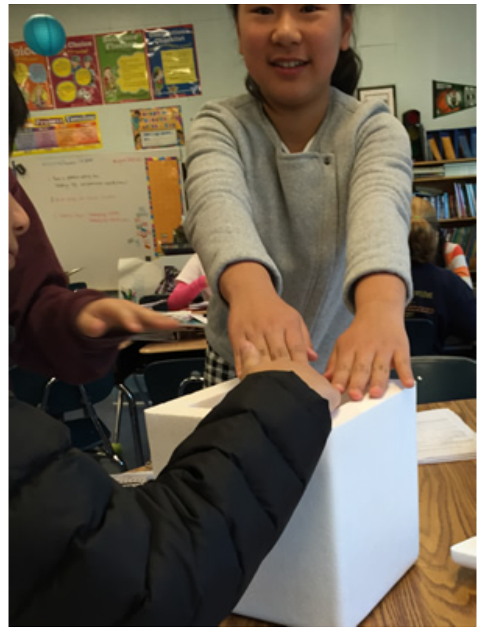
Where did the thermal energy go?

Plan Investigation 3



In both the Motion Energy sequence and so far in the Thermal Energy sequence, the investigations have focused on objects (balls, pompoms, propellers, rocks, etc.). What about air? While students (or anyone else) would not readily consider air to be an object, air is matter—it has both mass and volume—and energy (such as motion or thermal energy) can be transferred to it or from it. This is a key energy concept. When the ball stops rolling, it is because its motion energy has been transferred to the environment around it, some as motion energy (moving the air) and some as thermal energy due to friction. Ultimately, all energy "degrades" to thermal energy in the environment.

Air becomes the focus of this investigation, and the results can help students address an unanswered question from an earlier investigation: When the rock cooled off, where did the energy go? Did its thermal energy move to the air?

In this investigation students place a hot object (a cup of hot water, which is a substitute for the warm rock) inside a tiny, closed "room" (a small covered box) and monitor the air temperature for change. The results allow students to answer the question: Can thermal energy move to the surrounding air?

By the end of this investigation, students are introduced to the following key ideas related to thermal energy:

1) Thermal energy can transfer to air.
2) Changes in energy can sometimes be so small that they are imperceptible, and thus we need to rely on our reasoning to answer the question, *Where does the energy go?*.
3) When energy appears to have been lost, it is possible that it transferred to the environment.

Learning Targets Introduced in this Investigation

- Some thermal energy of a warm object is transferred to the environment.
- When thermal energy is transferred to the environment, temperature changes in the environment may be too small to observe.
- Evidence and reasoning can help you infer that energy is transferred to the environment.

Sequence of Experiences		
1. Introduction	All Class	15 Minutes
2. Explore	Small groups (4)	15 Minutes
3. Tell the Energy Story	Small groups (4)	15 Minutes
4. Make Meaning	All Class	15 Minutes
5. Video Montage (Time Permitting)	All Class	
6. Unit Wrap Up Probe	Individual	

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Materials

For the class:

- 1 classroom digital thermometer
- 3 large sheets of paper
- 6 large (class size) energy cubes. The cubes should have an M on one face, an Elas on one face, a Th on one face, and possibly an E on one face if the class has investigated Electrical Energy.

For each group of 4:

- 1 digital stem thermometer
- 1 alcohol thermometer
- 1 polystyrene box
- 1 hot cup half filled with 110° F water
- 1 cup cover
- 6 small (student size) energy cubes

Materials for each group of 4 students

Preparations

- Review the Energy Cube Rules (available on the Focus on Energy website in the Resources for Teachers section).
- Review set up of the polystyrene box and cup of water system. (See page 5)
- On a large sheet of paper or whiteboard draw a table as shown below. Use the table to record the data collected by the class. Note that the order is different than the order used in the Student Notebooks, to allow for easier comparison.
- The italicized notes in the table provide an example of how you might summarize the student data.

	Temperature Change
Cup of Water	*(-5°F; -6°F; -5°F; -4°F; -4°F; -6°F;)*
Box Air Temperature	*(+11°F; +13°F; +10°F; +9°F; +11°F; +14°F;)*

- Watch the *Thermal 3: Setting Up and Using Equipment video* available on the *Focus on Energy* website on the Curriculum -> Thermal Energy -> Resource Quick Links page.

Thermal 3: Setting Up and Using Equipment Video

1. Introduction

All class – 15 Minutes

Ask the question.

Remind students of the previous thermal energy investigation and the unproven claim that the rock's thermal energy moved into the surrounding air.

> *Today's investigation question is, "Where did the thermal energy go?" When any object loses thermal energy, we need to ask, Where does the energy go? Can some or all of that thermal energy move into the air?*

Check to be sure students understand that although we can't see thermal energy, temperature changes can tell us if an object has gained or lost thermal energy.

> *When an object's temperature increases, that's how we know it has gained thermal energy. When an object's temperature decreases, that's how we know it has lost thermal energy.*

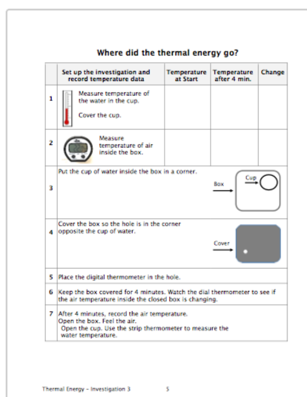
Note: If students question whether air is an "object," agree that air is quite different than the objects they have been working with, but remind them that today's investigation will help answer that question.

Show the equipment and set up for the investigation

> *To help us investigate today's question, we will use a "tiny room," with no windows or doors, a cover, and with a thermometer inside of it that we can watch closely. If we see that the air temperature in the tiny room increases, we will know that the air has gained thermal energy.*
>
> *Instead of using a rock, we will use a covered cup of hot water. The advantage of the water is that we can stick a thermometer in it to measure even small changes in its temperature. With the rock, we had to use our hands.*
>
> *Remember the important question is "When an object loses thermal energy, can that thermal energy move to the air?"*

Tell students that **step-by-step instructions** for the investigation are found in The Thermal Energy Student Notebook p. 6, *Where did the thermal energy go?.* They will also need to answer the questions on Page 7, *Track the energy flow inside the box*.

Digital Thermometer. Show students how to use the buttons on the digital thermometer to turn it on and off, and to select between Fahrenheit and Celsius temperature scales. Tell them they will measure and record (a) the temperature of the (room temperature) air inside the box with the digital stem thermometer and b) the temperature of the hot water with the strip thermometer before they put the lid on the cup.



Where did the thermal energy go?

	Set up the investigation and record temperature data	Temperature at Start	Temperature after 4 min.	Change
1	Measure temperature of the water in the cup. Cover the cup.			
2	Measure temperature of air inside the box.			
3	Put the cup of water inside the box in a corner. Box Cup			
4	Cover the box so the hole is in the corner opposite the cup of water. Cover			
5	Place the digital thermometer in the hole.			
6	Keep the box covered for 4 minutes. Watch the dial thermometer to see if the air temperature inside the closed box is changing.			
7	After 4 minutes, record the air temperature. Open the box. Feel the air. Open the cup. Use the strip thermometer to measure the water temperature.			

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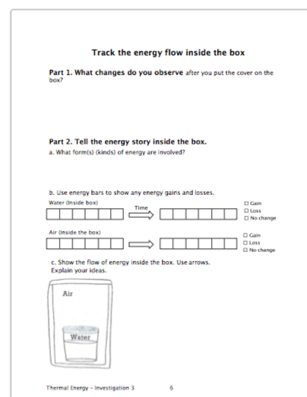


Track the energy flow inside the box

Part 1. What changes do you observe after you put the cover on the box?

Part 2. Tell the energy story inside the box.

a. What form(s) (kinds) of energy are involved?

b. Use energy bars to show any energy gains and losses.

Water (Inside box) Time ☐ Gain ☐ Loss ☐ No change

Air (Inside the box) ☐ Gain ☐ Loss ☐ No change

c. Show the flow of energy inside the box. Use arrows. Explain your ideas.

Air

Water

Thermal Energy – Investigation 3 6

2. Explore

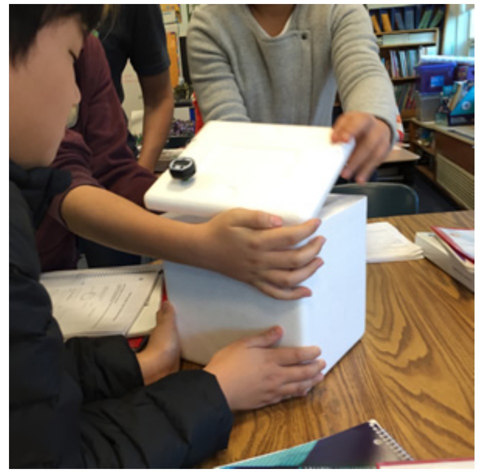
Small Groups – 15 Minutes

Have students move to small groups of 4.

Distribute 1 Styrofoam box, 1 alcohol thermometer, 1 digital thermometer, 1 hot cup full of hot tap water (approx. 110° F / 43°C), and one cup cover to each group.

Remind students to follow the instructions on page 6, *Where did the thermal energy go?,* of the student notebook.

Once students set up and cover the boxes, allow 4 minutes for changes to occur. During that time students will be interested in monitoring the changes on the digital thermometer, which start to occur almost immediately after the box is covered.



After 4 minutes, have students:

- Record the air temperature in the box
- Remove the cover, feeling the warm air in the box
- Remove the cup cover to check and record the temperature of the water in the cup.
- Calculate and record temperature change in the last column of the data table.

Note: Because water and air are different materials, a cubic centimeter of water can store much more thermal energy than a cubic centimeter of air. As a result, the water in the cup will release only a small portion of its thermal energy (small temperature change) as it warms the air in the box. This means that, after four minutes, the temperature change of the air will be much greater than the temperature change of the water.

Students will also have to complete Page 7, *Track the energy flow inside the box*, of the Student Notebook.

Collect the equipment so groups will have a space to work on their whiteboard or large sheet of paper.

Create a simple class data table to summarize group data. (see example)

	Temperature Change				
	DJ table	Natalie's table	Peter's table	Helena's table	Sophia's Table
Cup of water	-5 c	-5 °C	-2½ °C	-2 °C	1°C
Box "room" air temperature	+11.1	+9.1 °C	+9	+12.4 °C	11.2°C

3. Tell the Energy Story

All Class – 15 Minutes

Distribute the markers, energy cubes, and a large sheet of paper or a whiteboard to each group of 4.

Ask students to

- identify the *components* of the system they select and *use energy cubes* to tell the energy story of what happened.
- *begin* the story just after they close the box and *end* the story after opening the box.

Remind them to consider all of the Energy Tracking Lens questions that are listed at the front of their notebooks as they work on their energy stories.

Let them know they need to work efficiently since they have only 10 minutes.

4. Make Meaning

All Class – 15 Minutes

Have students form a discussion circle around a large sheet of paper or a whiteboard.

The purpose of this discussion is to consolidate students' understanding that temperature changes provide information that help track thermal energy flow of the cup of hot water inside the tiny room.

Discussion question: When a warm object (a cup of hot water) cools, where does the thermal energy go? Do we have evidence to answer this question?

- Ask one group to use the whiteboard and cubes to narrate the story as they move the energy cubes from one component to another. Remind them that, as they tell their energy stories, they should be sure they are considering all of the Energy Tracking Lens questions that are listed in their notebooks.
- Ask the class if each Energy Tracking Lens question has been addressed. Have students use the energy cubes to illustrate their response to any missing question.
- Did another team track the energy flow differently or use different components?
- Remind students that the purpose of today's investigation was to answer a question we could not answer in the previous thermal energy investigations: "Did the rock's (and the ball's) thermal energy move into the air?"

  Do we have an answer to the investigation question?
  ➔ Yes, when the rock lost thermal energy, the classroom air gained thermal energy.

  How do we know? What would the indicator be?
  ➔ We probably would not be able to measure any temperature change, but since we know the rock lost thermal energy, the air must have gained some of that thermal energy.

Here's the final question:

Since we know that the rock on the desk lost thermal energy (became cooler) and we now know that air can gain thermal energy, why didn't we notice the classroom becoming warmer?

Possible Thought Experiment re imperceptible differences:

Imagine I give you a pail full of sand to hold –it will have millions of grains of sand in it–and then I add 1 more grain of sand.

Will the pail feel heavier after I add the 1 grain of sand?
➔ no

Does the pail actually weigh more after I add the 1 grain of sand?
➔ yes, since a bucket of sand has weight, we know that each individual grain of sand must have a tiny bit of weight.

Sometimes changes are so small that our senses, or even our measurement tools such as thermometers or scales, cannot tell the difference. We can't always depend on our senses or even on our instruments, so sometimes we need to depend on our knowledge and our thinking.

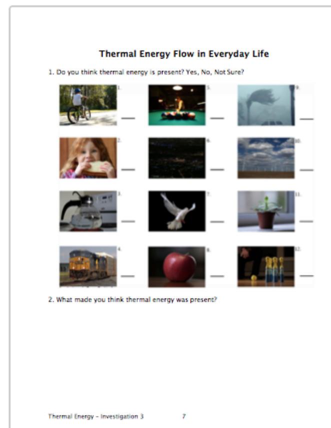
Add to the Model of Energy

Direct the group's attention to the list of statements about energy that is the developing Model of Energy. Today's investigation question was, *"Where did the thermal energy go?"*
What would the class would like to add?

5. Video Montage (time permitting)

All Class

Classroom observations have shown us that this is an engaging way to end the thermal energy unit. If at all possible, find the time for the activity, including Notebook page 8, *Thermal Energy Flow in Everyday Life*, and a short discussion.


Thermal Energy Flow in Everyday Life

1. Do you think thermal energy is present? Yes, No, Not Sure?

2. What made you think thermal energy was present?

Thermal Energy – Investigation 3 7

Ask students to turn to the last notebook page where they'll find a familiar set images from the energy video montage. Explain that you are going to show the video again. This time, students should put a Y (yes) or N (no) or NS (not sure) next to the still from any clip where they think thermal energy is part of the story. Remind students that they have learned that an object can have more than one kind of energy at the same time.

After they answer question 2 in writing, discuss the reasoning they used to decide whether thermal energy was present.

What did you see in the clips that convinced you thermal energy was present?

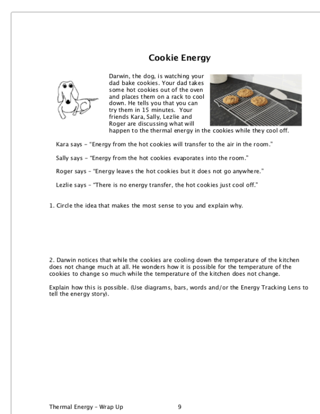
You can expect that some students will infer that where there's motion energy, some of it will transform to thermal energy, for example, the train wheels rolling on a track, cue stick moving in a person's hand, bird's wing beating, bicyclist's legs moving.

6. Unit Wrap Up Probe

Individual

If you don't have time to implement the Unit Wrap Up Probe during this class period, find time to administer the probe prior to starting the next Unit:

- Ask students to turn to page 9 in the Student Notebook.
- Read questions aloud and check that students understand them.
- Allow 5-10 minutes for students to write their responses to the questions.


Cookie Energy

Darwin, the dog, is watching your dad bake cookies. Your dad takes some hot cookies out of the oven and places them on a rack to cool down. He tells you that you can try them in 15 minutes. Your friends Kara, Sally, Lezlie and Roger are discussing what will happen to the thermal energy in the cookies while they cool off.

Kara says – "Energy from the hot cookies will transfer to the air in the room."

Sally says – "Energy from the hot cookies evaporates into the room."

Roger says – "Energy leaves the hot cookies but it does not go anywhere."

Lezlie says – "There is no energy transfer, the hot cookies just cool off."

1. Circle the idea that makes the most sense to you and explain why.

2. Darwin notices that while the cookies are cooling down the temperature of the kitchen does not change much at all. He wonders how it is possible for the temperature of the cookies to change so much while the temperature of the kitchen does not change.

Explain how this is possible. (Use diagrams, bars, words and/or the Energy Tracking Lens to tell the energy story).

Thermal Energy – Wrap Up 9

Wrap Up Probes are formative assessments. As such they are opportunities for both students and teacher to reflect on their learning. Plan time for students to discuss their responses to the probe, raise questions and clarify any area of confusion.

You might choose to collect students' notebooks before this discussion and project Wrap Up probe questions to guide the discussion. Or, you might have students keep their notebooks so they can refer to their responses during the discussion. At the conclusion of the discussion, you might provide time for students to revise their responses if they wish.

The interpretation guide (on the *Focus on Energy* website, in Curriculum Units -> Thermal Energy -> Resource Quick Links) will help you interpret student multiple choice answers and open-ended explanations.

Student Notebook – Page 6

Where did the thermal energy go?

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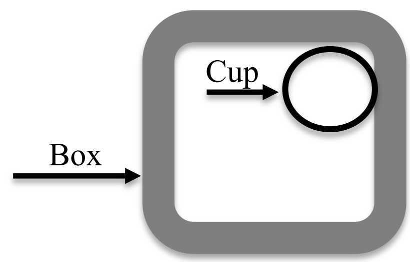
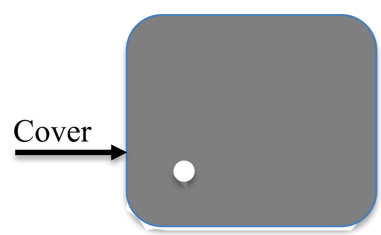
3	Put the cup inside the box in a corner. 			
4	Cover the box so the hole is in the corner opposite the cup of water. . 			
5	Place the digital thermometer in the hole.			
6	Keep the box covered for 4 minutes. Watch the dial thermometer to see if the air temperature inside the box is changing.			
7	After 4 minutes, record the air temperature. Open the box. Feel the air. Open the cup. Use the strip thermometer to measure the water temperature.			