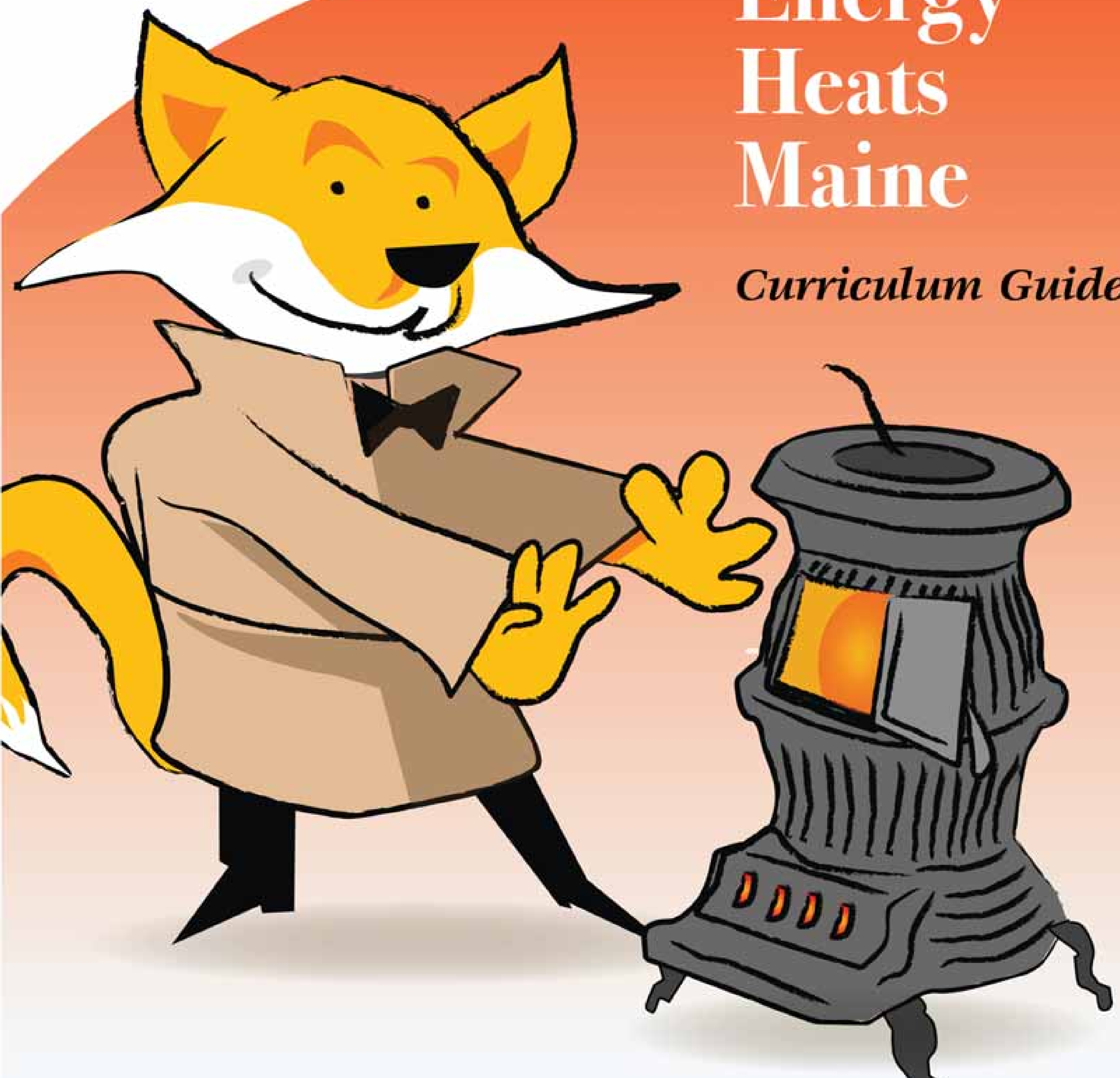
PowerSleuth

Energy Heats Maine

Curriculum Guide



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Energy Heats Maine is available for download at no cost at www.powersleuth.org

Energy Heats Maine

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Energy Education Curriculum for Maine Students in Grades 4-8

Introduction

Developing an understanding of energy as a source of light, heat, and power is essential for making advancements in energy-related technology and for making responsible and informed decisions about its use. The Sun is the initial source of all light and heat energy on Earth. Harnessing that energy for power and using that power to satisfy the wants and needs of humans requires a conceptual understanding of energy. *Benchmarks for Science Literacy* states: “Energy is a mysterious concept, even though its forms can be precisely defined and measured....Although learning about energy does not make it less mysterious, it is worth trying to understand because a wide variety of scientific explanations are difficult to follow without some knowledge of the concept of energy.”

PowerSleuth presents energy concepts that have been identified as essential knowledge in the state and national science standards for students in grades 4-8. *Maine Learning Results: Parameters for Essential Instruction* is the resource for the state standards, and *Benchmarks for Science Literacy* and the *National Science Education Standards* are the sources for the national standards. Through this curriculum, students develop a conceptual understanding of energy while, simultaneously, becoming aware of the pervasive use of energy in their lives and strategies to use energy wisely and efficiently.

Background

The *PowerSleuth* curriculum was developed as part of a three-year project, funded by Efficiency Maine, a program of Maine’s Public Utilities Commission (PUC). The project’s primary goal was to develop a coherent set of standards-based energy education curriculum materials and companion website (www.powersleuth.org) for Maine students in grades 4-8. Three units were developed: *Energy Lights Maine* for grades 4-5; *Energy Heats Maine* for grades 6-7; and *Energy for Maine* for grades 7- 8. Each curriculum unit consists of lessons that follow a conceptual storyline mindful of Maine students and designed with consistent pedagogy. The lessons are research-informed and aligned with the 2007 *Maine Learning Results: Parameters for Essential Instruction*. Although the curriculum units were designed for specific grade spans, teachers can use them flexibly across the 4-8 grade levels. Several agencies across Maine served as content advisors to the Maine Mathematics

and Science Alliance in making connections to Maine's energy context including the Maine Public Utilities Commission, Maine Energy Education Program, Maine Public Service, Maine Department of Environmental Protection's Air Quality Division, and the Maine Lung Association. The *PowerSleuth* materials were reviewed and field tested by Maine educators. The development of a connected, coherent set of energy education curriculum materials designed with a conceptual flow establishes an important and necessary teaching resource for teachers in Maine and beyond.

Instructional Goals

Students will:

- understand essential energy-related concepts identified in state and national standards
- identify uses of energy in their Maine-based daily lives
- become aware of the efficient and responsible use of energy

Inquiry-Based Instructional Model

The lessons in these units are inquiry-based to help students construct an understanding of energy related concepts through direct experiences over time. The content of the lessons target essential knowledge about energy as identified in state and national standards. Through the experiences provided to the students, common misconceptions about energy related concepts are also addressed.

"Scientific inquiry refers to the activities of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world." (*National Science Education Standards*). The format of the *PowerSleuth* lessons supports an inquiry-based instructional model, and each lesson includes three phases. The first phase, **Engage**, sets the stage for learning by providing a common experience for all students, generating interest in the focus of the lesson, and eliciting prior knowledge. Providing a common experience for all students at the beginning of each lesson allows students from various backgrounds, interests, and expertise to make predictions, based on that experience, during the upcoming science investigations and offers all students an equal opportunity to learn. In addition, research on how students learn science shows that when students are expected to identify their current understanding of a concept, their awareness of how their own thinking changes over time is enhanced as they confront situations that challenge that current understanding. The second phase, **Explore**, is designed to provide students with direct, hand-on experiences that help build conceptual understanding of energy related concepts. During this stage, students carry out focused investigations that target the specific learning goal identified in each lesson, collecting, organizing, and analyzing data related to each investigation. The last stage, **Reflect and Discuss**, brings closure to each lesson as students reflect on the claims they generate, based on their data, and supported by the evidence they collected during their investigations. Students draw conclusions that reveal their conceptual development.

Scientists' Notebooks and Science Talk

Two specific features are incorporated into each lesson. The **scientist's notebook** is a place where students record all aspects of each investigation, including their evolving understanding of the targeted concept. Entries include predictions, focus questions, data, observations, drawing, claims, evidence, conclusions, and reflections. Several student recording sheets are included in these lessons. These can be inserted into students' notebooks without modifications, revised to make them more student-directed, or eliminated in favor of open-ended student entries into the notebooks. Several informative resources are available that provide background information on scientists' notebook as well as suggestions for implementing the notebook strategy in the classroom. Teachers are encouraged to refer to these resources:

Campbell, B., and Fulton, L. (2003). *Science notebooks: writing about inquiry*. Portsmouth, NH: Heinemann.

Fulwiler, B. (2007). *Writing in science*. Portsmouth, NH: Heinemann.

Klentschy, M. (2008). *Using science notebooks in the elementary classroom*. Arlington, VA: NSTA Press.

Worth, K., Winokur, J., Crissman, S., and Heller-Winokur, M. (2009). *Science and literacy – a natural fit: A guide for professional development leaders*. Portsmouth, NH: Heinemann.

Science talk through discussions is an essential component of the inquiry process. Besides being a rehearsal for writing, it provides a vehicle for students to develop academic vocabulary specific to the discipline of science. It also provides an opportunity for all students to enhance their verbal fluency and skill. This is particularly critical for students who are learning English as a second language, for students with special needs, and for those who need language enrichment opportunities. Demonstrations by students with concrete materials as they are explaining an idea to their classmates often enhances the clarity of the explanation, connects specific words to specific objects, and encourages students into using more precise vocabulary as they talk.

Lesson Planning and Pacing

For planning purposes, each lesson is divided into a certain number of sessions. Each session is designated as a 40-50 minute instructional period. Some lessons require one or more sessions to teach. Those that require more than one session often have suggestions as to how the lesson can be divided into multiple instructional periods. The actual number of sessions a lesson spans will depend on the prior experiences of students and the depth of instruction.

Formative Assessment

In an era of accountability, educators agree that assessment is an integral part of the educational experience for students. Formative assessment strategies help teachers become aware of students' current thinking about an idea or concept and guide instructional decisions. Seeing the connection between the variety of ideas that students often bring to a new learning experience and the targeted learning goal contributes to the design of effective learning experiences for all students. *PowerSleuth* incorporates several formative assessment strategies throughout the units. The source for several of these techniques is *Science Formative Assessment* (Keeley, P. 2008), a valuable resource for teachers with an interest in expanding their repertoire of formative assessment strategies. Another valuable reference is *Uncovering Student Ideas in Science* (Keeley, P.), a series of four books with formative assessment probes designed to elicit students' current thinking about a particular concept. Volumes 1-4 in this series offers probes in life, earth/ space, as well as physical science.

Research on Student Learning

Students often come to classroom science with a wide range of preconceptions about everyday science phenomena. Being aware of common misconceptions provides a wealth of knowledge to teachers about their students and the design of learning experiences that will help students develop an understanding of essential science concepts. Research about how students learn science is available and that research base is incorporated in the *PowerSleuth* curriculum. All lessons target energy concepts deemed as essential in the state and national standards and are designed to address common misconceptions identified in the research. A rich source of this research is *Making sense of secondary science* (Driver, R. 1994).

Home Involvement

Efforts are made throughout the units to include families in the learning process. However, accommodations in the form of school assistance are required for students whose families cannot, for whatever reason, collaborate in the learning process or establish a supportive learning environment at home. Sensitivity to this issue when assigning home projects is recommended.

Materials and Safety

Most of the materials that are used in the *PowerSleuth* lessons are relatively inexpensive and readily available. It may be necessary to obtain a few materials from a scientific supply company or a local high school science department. Consider using recycled materials and/or purchasing supplies locally when appropriate. Some advanced planning is necessary not only when it comes to gathering materials for lessons, but in thinking about how materials will be stored, distributed, and managed when working with students. Tips and suggestions for managing materials are offered throughout the lessons as a guide.

Specific safety concerns are noted at the beginning of each lesson however, students should be made aware of and follow safety rules according to school policy. The National Science Teachers' Association www.nsta.org has several resources regarding elementary science safety. Teachers are encouraged to refer to:

Kwan, T. (2002). *Exploring safely: a guide for elementary teachers.* Arlington, VA: NSTA Press.

PowerSleuth Companion Website

The *PowerSleuth* website, wwwpowersleuth.org, is the online resource to supplement the *Energy Lights Maine*, *Energy Heats Maine*, and *Energy for Maine* modules. The companion website features activities, projects, video clips, links, the lesson plans, and other resources for each of the *PowerSleuth* modules. Teachers are encouraged to check the site frequently for updates and tips from other *PowerSleuth* teachers.

Energy Heats Maine

Overview

Questions often asked of people from Maine are "*How cold* ***are*** *Maine winters?*" and "*How* ***do*** *Maine people keep warm?*" Anyone who has lived in Maine knows that staying warm is part of life here. Despite familiarity with heat, few people from Maine or elsewhere stop and think about what they really understand about this form of energy.

The *Energy Heats Maine* instructional unit targets the following learning goals:

Students will progress toward a scientific understanding of heat and thermal energy as they:

- confront common misconceptions about heat and thermal energy.
- associate thermal energy with the movement of molecules.
- distinguish heat as thermal energy that is moving from one place to another.
- describe how heat transfers from warmer systems to cooler systems.
- discover that the rate of heat transfer can be altered by using insulating materials.
- recognize conduction, convection, and radiation as mechanisms of heat transfer.
- differentiate between a heat source and an object affected by a heat source.
- apply understandings of heat to everyday situations.
- tie understandings of heat to issues such as energy efficiency and energy conservation.

Several instructional challenges arise as middle school students confront the concept of thermal energy. Despite students' familiarity with heat, research shows that heat is an unexpectedly difficult and often misunderstood concept. Why? Developing an understanding of heat requires students to synthesize a number of abstract concepts. Defining "heat" involves its association with the molecular activity of substances. This may be problematic for students with limited understanding that matter is made up of smaller particles (atoms and molecules) constantly in motion. Even though state and national science standards identify the concept of heat resulting from the motion of molecules as a grade-level expectation in middle school, its level of abstraction is significant. However, high quality instructional experiences over time will help students develop a scientific understanding of heat.

Even as students develop a basic understanding of the molecular nature of thermal energy, the concept itself remains challenging. What *is* energy? Students often think of energy as a substance or matter. It is important to remind students throughout this unit that heat is a form of energy and that energy is not matter.

Lesson One

In the first lesson of *Energy Heats Maine* students are introduced to *The Mitten Problem*, a formative assessment task that uses a familiar context to motivate and engage students in thinking about heat sources and objects affected by heat. This task reveals whether students believe an insulating object, a mitten, produces its own heat. Listening to students explain and discuss their conceptions prior to instruction allows teachers to be more purposeful in tailoring experiences, questions, and language usage to the needs of students when discussing heat. While students' initial ideas are tested through a simple investigation in this lesson, students do not formally revisit the underlying concepts of *The Mitten Problem* until later in the instructional unit.

Why take the time to "uncover" students' current thinking? Examining students' conceptions prior to instruction is a powerful way to direct learning. It helps with choosing instructional experiences that will specifically target students' developing ideas. It also allows language and questioning strategies to be chosen and used more purposeful. As students discuss their thinking while working with *The Mitten Problem*, listen carefully to what students are saying. The lessons that follow are designed to target commonly held naïve ideas that research has identified as being typically held by students in this age span. Taking students' current ideas into account and designing experiences that help students confront these ideas will allow students to discover more scientifically accepted understandings and develop deeper conceptual understandings.

Lesson Two

Lesson 2 of *Energy Heats Maine* introduces students to thermal energy and the idea that heat is transfer of thermal energy. Physicists distinguish heat from thermal energy. Thermal energy is associated with the energies of the particle motion that all matter has. Matter is made up of tiny particles (atoms and molecules) that are in constant motion. Whether the molecules are vibrating in place, as in solids, or randomly bumping into other molecules, as in liquids and gases, molecules are always moving. The greater the motion and the more the mass, the more thermal energy a substance has. Thus the amount of thermal energy a substance has is dependent on its temperature and quantity. Heat, on the other hand, is thermal energy that is "in transit" – energy that is moving from one object, substance, or system to another. In other words, heat is the flow of thermal energy. It describes energy that is being transferred between two interacting systems at different temperatures. A simple mantra to help with this distinction is: "heat is thermal energy that is on the move." What causes this movement? Thermal energy moves when there are temperature differences. It moves from warmer objects and substances to cooler ones. In this lesson, students observe first hand evidence of molecular motions, as well as virtual simulations of matter at various temperatures. These experiences provide a foundation for a conceptual connection between matter and energy. Students may not discriminate between thermal energy and heat initially, but they should be able to associate molecular activity with heat. However, particle motion and its relationship to heat energy are abstract concepts, but students' understanding about them will develop over time.

Lessons Three, Four and Five

Lessons 3, 4, and 5 explore specific aspects of heat transfer. The focus in Lesson 3 is that heat, not "cold" is transferred. Lesson 4 addresses the directionality of movement, specifically, the idea that heat transfers from warmer substances to cooler ones. In Lesson 5, students investigate the methods of heat transfer: conduction, convection, and radiation.

Lessons Six, Seven and Eight

In Lessons 6, 7, and 8 students apply their understanding of heat transfers by investigating ways to influence the effect of the transfers.

Lesson Nine

In Lesson 9 students continue to apply their understanding of heat transfers as they are guided through strategies designed to teach others how to conserve heat in their homes.

Much of what students know about heat developed from their everyday experiences that started when they were young. Thus, intuitive ideas about heat often complicate their thinking. "Heat", "hot", "warm", and "cold" are words that students use to describe objects, and they often believe that certain materials are intrinsically "warm" (jackets, blankets) or "cold" (metals). When students define heat, they often describe it in terms of things "having heat" (the sun, living things, sources of heat, warm objects) as if heat were a substance. They sometimes equate heat with its effect on objects (things melting, expanding, rising). When students are asked to describe heat transfers they often reveal their belief that heat moves by its own accord (heat "rises", "steams", "waves", or "builds up") and/or that heat varies in strength.

The pervasive misuse of the words "heat" and "energy" in our own everyday language contributes to misconceptions about heat ("heat rises", "heats up", "all out of energy"). In an attempt to avoid generating or reinforcing students' misconceptions, word choice is carefully considered throughout the lessons in *Energy Heats Maine*. While students encounter the term "thermal energy" in the lessons, the term "heat" is primarily used throughout this unit. Educators often find themselves encountering a variety of definitions and uses of the terms *thermal energy*, *heat energy*, and *heat*. These terms are often used interchangeably in many references, yet they mean different things. Some sources refer to "heat" as "heat energy" to remind students, especially younger students, that heat is a form of energy. In this set of materials, the word "heat" is used to refer to thermal energy that is in transit. "Heat" is what is most familiar to students. Text appearing in gray alerts teachers to other commonly held ideas related to heat, many of which revolve around the use of terminology, and offers instructional suggestions.

The primary focus of this unit is on heat. *Energy Heats Maine* builds upon the knowledge that energy is required for things to happen. Lessons place priority on examining where heat comes from and where it goes. The source of heat is usually more evident than where it goes because some heat diffuses away as radiation and random molecular motion. Maintaining a focus on heat transfers – where heat is coming from and where it is it going- guides students toward an understanding of thermal energy and its application in their everyday lives. This is especially important in these times of growing interest in energy efficiency.

Students use thermometers in a number of the investigations in the *Energy Heats Maine* unit. Students may need supplementary instruction on the safe use of thermometers, depending on their prior experiences. Computer probeware, if available, may be more effective than traditional thermometers in helping students observe small changes in temperature during heat transfer.

Since temperature increases when something is heated, the terms *heat* and *temperature* are often used interchangeably, despite having different meanings. While it is not expected that students differentiate between the two terms until high school, the differences should be noted here. Heat is a form of energy. When heat is quantified, it is done so by taking into account the *total* energy of the molecules in a particular substance. Temperature, on the other hand, is a measure of the *average* energy of the molecules moving in a substance. In any substance, molecules are moving with a range of energies, and interacting with each other as well. The interaction changes their energies. An object's temperature is obtained by averaging the thermal energies of all the molecules together. Temperature is not energy. It is a measure – a number – related to the average molecular movement in a substance. Temperature is measured using different scales: Celsius, Fahrenheit, and Kelvin. The Kelvin scale was developed to accommodate extremes of "hot" and "cold." Absolute zero on the Kelvin scale is the (theoretical) point at which molecular movement ceases.

Lesson Matrix

Overview	Key Ideas	Lesson Goals	Connection to Learning Goals from • *Benchmarks for Science Literacy (BSL)*, • *National Science Education Standards (NSES)*, • and *Maine Learning Results (MLR)*
Lesson 1: The Mitten Problem *(1-2 sessions)* In this introductory lesson, students are presented with a formative assessment probe, *The Mitten Problem*, to elicit their ideas about sources of heat energy. Students design and conduct a follow up investigation to further investigate their developing ideas about heat.	• Objects and substances are not inherently "warm" or "cold."	• Explore their current ideas about heat. • Be able to differentiate between a heat source and objects or substances affected by a heat source.	• Energy appears in different forms. Heat energy is the disorderly motion of molecules. BSL 4E(6-8) • Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. NSES B(5-8) 8
Lesson 2: Molecules on the Move *(2 sessions)* Through direct observations and computer simulations students are introduced to the concept that heat is the transfer of thermal energy.	• Matter is made up of particles (atoms or molecules) that are moving. • The arrangement and motion of the particles of matter differs depending on temperature. At higher temperatures, particles have greater energy and are more spread out. At lower temperatures, particles have less energy and are more compact. • Heat is a form of energy that is related to the random motion of molecules. • Models are used by scientists to explain ideas.	• Describe the motion of particles (atoms or molecules) of matter at different temperatures and in different states. • Recognize the random motion of molecules as thermal energy. When thermal energy is transferred from one object to another, the amount of energy transferred is called heat. • Be introduced to the idea that all matter has thermal energy. • Consider the benefits and limitations of models.	• Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. BSL 4D/M3ab (6-8) • In solids, the atoms or molecules are closely locked in position and can only vibrate. In liquids, they have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions. BSL 4D/M3cd (6-8) • Models are very useful for communicating ideas about objects, events, and processes. When using a model to communicate about something, it is important to keep in mind how it is different from the thing being modeled. BSL 11B/E4**(3-5)

Lesson Matrix

Overview	Key Ideas	Lesson Goals	Connection to Learning Goals from • ***Benchmarks for Science Literacy* (BSL),** • ***National Science Education Standards* (NSES),** • **and *Maine Learning Results* (MLR)**
Lesson 3: Mixing Water *(2 sessions)* Students design and carry out an investigation to monitor the temperature of water when equal volumes of hot and cold water are mixed.	• Heat can be transferred from one place, object, or system to another. • Mixing water of two different temperatures results in a sample of water with an intermediate temperature that is predictable given the starting and ending temperatures.	• Explain resulting temperatures in terms of the change in thermal energy. • Describe how heat spreads from one place to another including how cooler materials can become warmer and vice versa.	• Describe several different types of energy forms including heat energy, chemical energy, and mechanical energy. MLR D3(6-8) h • When warmer things are put with cooler ones, the warmer things get cooler and the cooler things get warmer until they all are the same temperature. BSL 4E/E2a* (3-5) • Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature. NSES B (5-8) • Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. BSL 4E/M3* (6-8)
Lesson 4: Where is Heat Coming From and Where is it Going? *(2-3 sessions)* In this investigation, students expand on their understanding of thermal energy transfers by focusing on the directionality of heat transfers. Students collect temperature data from two interacting containers of water and from their results infer that heat is transferred from warmer matter to cooler matter until both substances reach the same temperature.	• Energy can move from one place, object, or system to another. • Substances heat or cool as a result of energy transfer.	• Explain resulting temperatures in terms of energy transfer. • Explain how heat moves from one place to another including how cooler materials can become warmer and vice versa. • Describe conditions necessary for heat transfer; namely that heat is transferred 1) when there is a difference in temperatures between interacting matter and 2) from warmer matter to cooler matter until both reach the same temperature.	• When warmer things are put with cooler ones, the warmer things get cooler and the cooler things get warmer until they all are the same temperature. BSL 4E/E2a* (3-5) • Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature. NSES B (5-8) • Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. BSL 4E/M3* (6-8)

Lesson Matrix

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Lesson 5: **Conduction, Convection, Radiation** ***Investigating Heat Transfers*** *(2-4 sessions)* Heat moves from warmer matter to cooler matter in different ways. Students consider heat transfers that occur in every day situations and investigate three specific ways that heat moves: conduction, convection, and radiation.	• Energy can move from one place, object, or system to another. • Substances heat or cool as a result of energy transfer. • Energy always transfers from warmer matter to cooler matter until both reach the same temperature. • Heat transfers occur in three ways: by radiation, conduction, convection.	• Explain how heat moves from one place to another including how cooler materials can become warmer and vice versa. • Describe how heat moves by conduction, convection, and radiation. • Give examples of heat transfers that occur in every day situations.	• Describe how heat is transferred from one object to another by conduction, convection, and/or radiation. MLR D3(6-8) j • Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. Thermal energy can also be transferred by means of currents in air, water, or other fluids. In addition, some thermal energy in all materials is transformed into light energy and radiated into the environment by electromagnetic waves; that light energy can be transformed back into thermal energy when the electromagnetic waves strike another material. As a result, a material tends to cool down unless some other form of energy is converted to thermal energy in the material. BSL 4E/M3* (6-8) • Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature. NSES B (5-8)

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Lesson 6: Testing Heat Transfers through Different Materials *(1 session)* Students continue investigating heat transfers, focusing on transfer by conduction. Students discover that heat is conducted through different materials at different rates by performing a simple experiment. They begin to consider how knowledge of heat transfers can be used to safely and efficiently utilize heat transfers in everyday situations.	• Different materials conduct thermal energy at different rates. Metals conduct heat rapidly. Plastic and wood do not conduct heat rapidly. • Recognize that some materials conduct heat better than others. Knowledge of thermal conductivity differences is used to develop safe and efficient products and technologies for people.	• Recognize that a thermal conductor is a material that allows heat to readily transfer through it. • Recognize that heat is conducted at different rates through different materials.	• Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature. NSES B (5-8) • Describe how heat is transferred from one object to another by conduction, convection, and/or radiation. MLR D3(6-8) j • Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. Thermal energy can also be transferred by means of currents in air, water, or other fluids. In addition, some thermal energy in all materials is transformed into light energy and radiated into the environment by electromagnetic waves; that light energy can be transformed back into thermal energy when the electromagnetic waves strike another material. As a result, a material tends to cool down unless some other form of energy is converted to thermal energy in the material. BSL 4E/M3* (6-8) • Design and safely conduct scientific investigations including experiments with controlled variables. MLR B1(6-8) b • Explain why it is important to identify and control variables and replicate trials in experiments. MLR C1(6-8) b • Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. BSL 3C/M8**

Lesson Matrix

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Lesson 7: **Building an Insulated Water Bottle** *(3-6 sessions)* Students investigate the insulating properties of a variety of materials. Using their knowledge of heat transfers, students design an insulated water bottle.	• Different materials conduct thermal energy at different rates. Metals conduct heat rapidly. Other materials, such as plastic and wood, do not conduct heat rapidly. • Knowledge of thermal conductivity differences is used to develop products and technologies that allow people to safely and efficiently use heat. • Depending on how they are used, materials can be used to slow or accelerate heat transfers.	• Recognize that a thermal conductor is a material that allows heat to readily transfer through it. • Recognize that heat is conducted at different rates through different materials. • Use their knowledge of heat transfers to design an insulated water bottle.	• Heat moves in predictable ways, flowing from warmer objects to cooler ones until both reach the same temperature. NSES B (5-8) • Describe how heat is transferred from one object to another by conduction, convection, and/or radiation. MLR D3(6-8) j • Thermal energy is transferred through a material by the collisions of atoms within the material. Over time, the thermal energy tends to spread out through a material and from one material to another if they are in contact. Thermal energy can also be transferred by means of currents in air, water, or other fluids. In addition, some thermal energy in all materials is transformed into light energy and radiated into the environment by electromagnetic waves; that light energy can be transformed back into thermal energy when the electromagnetic waves strike another material. As a result, a material tends to cool down unless some other form of energy is converted to thermal energy in the material. BSL 4E/M3* (6-8) • Design and safely conduct scientific investigations including experiments with controlled variables. MLR B1(6-8) b • Explain why it is important to identify and control variables and replicate trials in experiments. MLR C1(6-8) b • Design a solution or product. MLR B2 (6-8) b • Communicate a proposed design using drawings and simple models. MLR B2 (6-8) c • Evaluate a completed design or product. MLR B2(6-8) e • Suggest improvements for their own and others' designs and try out proposed modifications. MLR B2(6-8) f

Lesson Matrix

Overview	Key Ideas	Lesson Goals	Connection to Learning Goals from • ***Benchmarks for Science Literacy (BSL),*** • ***National Science Education Standards (NSES),*** • **and *Maine Learning Results (MLR)***
Lesson 8: **Energy Warms Maine** *(1-2 sessions)* What sources of heat are available to Maine people to keep their homes warm? In this lesson, students are introduced to Maine residents who are asking for students' help in recommending a home heating fuel before the upcoming winter.	• Energy in fuels used to heat our homes can be traced back to the sun. • People use resources – both renewable and nonrenewable – to maintain and improve their existence. • Perfectly designed solutions do not exist. All solutions have trade-offs, such as safety, cost, efficiency, aesthetics, and environmental impacts. Solutions have constraints.	• Identify different fuels used for heating Maine homes. • Describe several factors that need to be considered when selecting a fuel for heating. • Describe the benefits and challenges of using various fuels to heat Maine homes.	• Identify personal choices that can either positively or negatively impact society including population, ecosystem sustainability, personal health, and environmental quality. MLR C3(6-8) b • Identify factors that influence the development and use of science and technology. MLR C3 (6-8) c • Different ways of obtaining, transforming, and distributing energy have different environmental consequences. BSL 8C/M2 • In many instances, manufacturing and other technological activities are performed at a site close to an energy resource. Some forms of energy are transported easily, others are not. BSL 8C/M3 • Some resources are not renewable or renew very slowly. Fuels already accumulated in the earth, for instance, will become more difficult to obtain as the most readily available resources run out. How long the resources will last, however, is difficult to predict. The ultimate limit may be the prohibitive cost of obtaining them. BSL 8C/M10** (SFAA) • By burning fuels, people are releasing large amounts of carbon dioxide into the atmosphere and transforming chemical energy into thermal energy which spreads throughout the environment. BSL 8C/M11**

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Lesson 9: **Draft Busters** ***Energy Knowledge in Action!*** *(3 sessions)* Students identify sources of unwanted heat transfer within their school and homes and make suggestions as to how these types of transfers can be slowed. Students further investigate how buildings are heated.	• There are a number of simple ways to slow unwanted transfer(s) of heat. • It is everyone's responsibility to use energy efficiently or wisely. Conservation of heat is linked to our use of natural resources, which impacts our environment, economy, and national security.	• Identify and describe steps that can be taken to conserve energy and the reasons for doing so. • Produce media that will interest, convince, and persuade an audience to take action in conserving energy used for heating.	• Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. NSES B(5-8) 8 • Identify personal choices that can either positively or negatively impact society including population, ecosystem sustainability, personal health, and environmental quality. MLR C3(6-8) b • Different ways of obtaining, transforming, and distributing energy have different environmental consequences. BSL 8C/M2 • Some resources are not renewable or renew very slowly. Fuels already accumulated in the earth, for instance, will become more difficult to obtain as the most readily available resources run out. How long the resources will last, however, is difficult to predict. The ultimate limit may be the prohibitive cost of obtaining them. BSL 8C/M10** (SFAA) • By burning fuels, people are releasing large amounts of pollution and carbon dioxide into the atmosphere and transforming chemical energy into thermal energy which spreads throughout the environment. BSL 8C/M11** • Summarize and apply information presented. MLR-ELA E1(6-8)b • Select appropriate media, relevant to audience and purpose that support oral, written, and visual communication. MLR-ELA E2(6-8)e • Explain the role of media in forming opinions. MLR-ELA F1(6-8)b