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Grade Two

Hot and Cold Temperature

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Hot and Cold Temperature

Before You Begin

Children experience hot and cold temperatures on a daily basis: food is often too hot or too cold to be eaten, bath water must be adjusted to a comfortable temperature and the weather outdoors can call for considerably different clothing than the temperature indoors. This unit allows students to extend their exploration of hot and cold temperatures in a structured environment, introducing ways to infer and describe the temperature of an object through techniques of observation and measurement. Students also learn how temperature is controlled in buildings and how insulation is used to keep things hot or cold.

Topic D: Hot and Cold Temperature

(Suggested time: 6-8 weeks)

Materials required for the activities should be collected several weeks prior to starting the unit. A list of items that can be collected by students and their families could be sent home. A community or school nurse may be able to supply thermometers for taking body temperature or agree to be a guest speaker for this topic.

Background Information

Sit next to a swimming pool for even a short period of time and you will inevitably observe the following scenario. Two people walk up to the edge of the pool and dip their toes in. One draws back, starts to shiver and exclaims how cold the water is. The other shakes his or her head in disbelief, laughs that the water is warm and jumps right in. The water can't be two temperatures at once. What's going on?

Our sense of hot and cold is a highly subjective method of determining temperature. (See the grade 1 unit Senses.) We can talk in relative terms and say that one object feels hotter or colder than another, but an accurate judgment of an object's true temperature is quite difficult without the use of a tool. For an objective temperature reading we turn to thermometers.

In Canada, we calibrate our thermometers to the *Celsius temperature scale*. On this scale, based on conditions at sea level, 0°C is defined as the temperature at which water freezes, 100°C is defined as the temperature at which water boils and single degrees of temperature equal 1/100th of the temperature difference between these two points. (Here in Alberta we live at altitudes well above sea level, so water boils at less than 100°C.) Sometimes, especially in scientific applications, this same temperature scale is referred to as the *centigrade scale*.

Thermometers come in many forms and measure temperatures over different ranges, depending on the purpose for which they are being used. A candy thermometer used in the kitchen covers a much higher range of temperatures than the thermometer used to gauge weather conditions outdoors or the thermometer designed to indicate internal body temperature.

In any discussion of temperature, it is important to make a distinction between temperature and heat. *Heat* is a form of energy produced by the random motion of molecules (the more motion, the more heat), whereas *temperature* is a relative measure based on an arbitrary scale, such as the Celsius scale just described.

The temperature of an object should not be confused with the quantity of heat it possesses. It is possible for one object to have a low temperature and possess a large amount of heat, or for another object to have a high temperature and yet contain a very small amount of heat. Consider equal amounts of water and mercury placed over the same burner for a few minutes. Even though they have received the same amount of heat, the temperature of the mercury will be much higher than the temperature of the water. We can conclude that the quantity of heat required to raise the temperature of water one degree is greater than the quantity required to raise the temperature of mercury the same amount. In fact, it takes 32 times as much heat. The amount of heat required to produce a one degree increase in temperature in a given quantity of

material is different for nearly every substance and is called the *specific heat* of the substance.

If a material has a high specific heat, as does water, it has the potential to absorb and release great quantities of heat without going through tremendous temperature swings. The air temperature near a large body of water remains cool during the day because the water absorbs heat from the air. At night, the water releases its stored heat back into the atmosphere, making the air a pleasant temperature. The high specific heat of water also helps explain why water is so effective at extinguishing fire. The water absorbs heat energy from the burning material, cooling it below the temperature required for combustion.

As heat is applied and temperature rises, various things happen, depending on the nature of the substance. Nearly all substances expand when they are heated. As a general rule, gases (air, for example) expand the most, liquids expand somewhat less and solids expand the least. Many materials become warmer until they reach the substance-specific temperature at which they transform into another phase of matter: upon sufficient heating a solid will turn to liquid and a liquid will turn to gas. (See the grade 2 unit Exploration of Liquids for a more detailed explanation of phase change.) Other materials, such as organic compounds like wood, break down into their constituent components when a certain temperature is reached. If this chemical breakdown is accompanied by a sudden release of energy in the form of light and heat, the substance is said to ignite and burn.

How does heat get from one place to another? There are three different ways heat can travel from place to place or from substance to substance: by conduction, by convection and by radiation.

In the process of *conduction*, heat travels from one molecule of a substance to the next, using the molecules somewhat as stepping stones. The molecules of some substances make better stepping stones than others. They are said to be good *thermal conductors*. Silver is an extremely efficient thermal conductor followed by copper, gold, brass, zinc, tin, iron, steel and lead, in descending order of relative conductivity. For example, conduction can make the metal handle of a pan become quite hot in spite of the fact the handle is not in direct contact with the heating surface. Poor thermal conductors include wood and other organic substances, minerals, resins, glass, clay and most liquids and gases. Poor thermal conductors are often used as *insulators*, preventing heat from escaping or entering a volume of space. Many windows leave a layer of air sandwiched between two panes of glass to decrease the amount of heat that can escape from inside the building on a cold day. Similarly, fur and feathers trap air close to an animal's body to prevent a rapid loss of body heat. Conversely, ceramic tiles are sometimes used to prevent rapid heat gain:

this is a primary function of the space shuttle tile skins during re-entry to the Earth's atmosphere.

Convection is the movement of molecules within fluids (gases and liquids) that occurs when there is a difference in temperature between one portion of the fluid and another. The cooler portion is denser than the warmer portion, so it flows downward, pushing the warmer fluid (and heat) upward. If no heat is added to the fluid, the cool and warm portions mix until the existing supply of heat energy is evenly distributed throughout the fluid and a state of *thermal equilibrium* is attained. If the fluid is heated from below, the newly warmed portion rises, allowing cooler fluid to flow to the bottom where it, in turn, is heated and rises. This sets up a circulation of fluid called a *convection current*, the principle behind heating systems for buildings. You also find convection currents redistributing heat in lakes and oceans, and speeding the cooking process in convection ovens.

Of course, one of the best ways to get warm is to stand near a crackling, hot fire. Have you ever noticed how your outstretched hands become toasty warm, yet the air around them is a comfortable temperature? How does the heat get from the fire to your hands without altering the temperature of the intervening air? The heat travels to you from the fire by means of *infrared radiation*. This is energy that falls just outside the portion of the electromagnetic spectrum we detect as light. Just as light travels through various transparent media (air, glass, water, etc.), infrared radiation can pass through air without heating it greatly. Heat is transferred directly to an object from an infrared source.

No one likes to get too hot or too cold. One way we avoid uncomfortable environments is by using devices called *thermostats* to regulate temperature swings in our homes and public buildings. A thermostat measures the temperature in its immediate vicinity and automatically triggers the furnace to come on if the temperature falls below a pre-set value. Likewise, it signals the air conditioning unit to spring into action or the furnace to shut off if the temperature exceeds the value defined as the top of the comfort zone.

Our bodies come equipped with a thermostat that regulates our internal temperature in much the same way. A healthy person's body temperature fluctuates no more than a few tenths of a degree from 37°C. A biological thermostat located in the hypothalamus of the brain functions as a constant monitor. If an excessively hot external environment or vigorous exercise has raised your body temperature, the hypothalamus signals your body to begin sweating and breathing faster as ways to shed excess heat and cool down. Likewise, if you have been in a cool environment that has dropped your body temperature, the hypothalamus signals your body to begin shivering, a mechanism whereby rapid muscle contractions produce heat and bring your temperature back up to 37°C.

Elementary Science Program of Studies

General and Specific Learner Expectations

The following general and specific learner expectations have been taken directly from the 1996 Elementary Science Program of Studies. The specific learner expectations (SLEs) are referred to by number in the second column of the activities table.

General Learner Expectations

Students will be able to:

Recognize the effects of heating and cooling, and identify methods for heating and cooling.

Specific Learner Expectations

Students will be able to:

1. Describe temperature in relative terms, using expressions such as hotter than, colder than.
2. Measure temperature in degrees Celsius (°C).
3. Describe how heating and cooling materials can often change them: for example, melting and freezing, cooking, burning.
4. Identify safe practices for handling hot materials and for avoiding potential dangers from heat sources.
5. Recognize that human body temperature is relatively constant and that a change in body temperature often signals a change in health.
6. Identify ways in which the temperature in homes and buildings can be adjusted: for example, by turning a thermostat up or down, opening or closing windows, using a space heater in a cold room.
7. Describe, in general terms, how local buildings are heated:
   - identify the energy source or fuel;
   - recognize that most buildings are heated by circulating hot air or hot water; and
   - describe how heat is circulated through the school building, and through homes.
8. Describe the role of insulation in keeping things hot or cold, and identify places where some form of insulation is used: for example, clothing, refrigeration, coolers, homes.
9. Identify materials that insulate animals from the cold: for example, wool, fur and feathers, and identify materials that are used by humans for the same purpose.
10. Design and construct a device to keep something hot or cold.
11. Describe ways in which temperature changes affect us in our daily lives.

Cross-curricular Connections

Mathematics

- Read a thermometer and graph/compare/contrast temperatures.

Ecology

- Conserve household energy.

Language Arts

- Write descriptive poetry, read and write stories about winter and/or summer sports.

Health

- Learn safe practices for handling hot materials and how to treat simple burns.
- Take body temperature.

Drama

- Dramatize stories and songs about the cold: winter sports, building a snowman or snow fort, being in places where it is warm.

Children's Alternative Frameworks

Children sometimes hold beliefs about heating and cooling that are not consistent with current scientific knowledge.

- Body temperature changes according to the temperature outside.
- Hot and cold are not related to energy but are substances that can be added to, or removed from, an object.

Children of this age are convinced that some materials generate heat (for example, a warm hat) so they will need many experiences to help them understand that warm objects are often so because of their insulative properties.

Try placing a down jacket and a cotton sweater outside on a cold winter day. Children will probably believe that the temperature inside the jacket will be warmer than inside the sweater. They do not realize that each piece of clothing has a different capacity to hold the heat generated by a body.

The questioning techniques of the teacher are very important in this unit.

Activities

Classroom teachers have identified the following activities that address the Specific Learner Expectations (SLEs) in the Program of Studies. The list is not prescriptive and teachers may select activities that are most appropriate for their students.

Activities have been listed under two headings: Key Activities and Extension Activities. Key activities are supported by authorized resources and identify "powerful and practical" means for achieving learner expectations. Extension activities represent alternative ways of achieving or supporting learning expectations.

Key Activities

Key Activity	SLE	Print Resources	Essential Materials	Comments
Finding warm and cold places	1	*Explorations in Science, Level 2, It's Raining, It's Shining (Hot or Cold?)*, p. 10	thermometers, cans or cups, hot and cold water	Use of a station approach will allow for maximum student exploration and discovery. Observing the students involved in these activities will give you some idea of students' initial ideas and/or misconceptions about this topic.
		The Art and Science Connection: Hands-on Activities for Primary Students (Tolley) *(Investigating Hot and Cold)*, p. 109	tissue paper, small brushes, stiff brushes, black tempera paint, liquid starch, water, construction paper	
Developing the skill of reading a thermometer in degrees Celsius	2	*Innovations in Science, Level 2, Cool It (It's Cold Outside)*, p. 8	thermometers, a teacher-made map of the area around the school, crushed ice (if no snow is available), three containers of water labelled A, B and C, chart paper, line masters 1 and 2	Thermometers should be filled with alcohol, not mercury, for safety reasons. Digital thermometers are the easiest for students to read and plastic-backed recessed thermometers are the safest. Children at this age have some difficulty reading thermometers accurately. They may not have developed the skill, particularly taking negative readings. **Note**: Depending on your students' needs, you might need to re-visit the SLE (Reading a Thermometer) throughout the unit. **Note**: Science and educational supply companies offer thermometers that are environmentally friendly.
		Explorations in Science, Level 2, It's Raining, It's Shining (Temperature Throughout the Day), p. 11	thermometers, recording sheets, line masters 1 and 2	
		Explorations in Science, Level 2, It's Raining, It's Shining (Temperature in Different Spots), p. 12		

Key Activity	SLE	Print Resources	Essential Materials	Comments
Examining ways that animals adapt to winter		*Innovations in Science, Level 2, Looking for a Home (The Long, Cold Sleep)*, p. 29	mural paper, cardboard, drawing paper, colouring and painting materials	
		Innovations in Science, Level 2, Looking for a Home (Going South for the Winter), p. 33	cardboard, masking tape	
		Explorations in Science, Level 3, Discovering Adaptation (Living in the Dead of Winter), p. 24	magnifying glasses	
Studying preparations for different kinds of weather	8, 9, 11	*Explorations in Science, Level 2, It's Raining, It's Shining (An Imaginary Trip)*, p. 23	needed materials from home	This activity might be done twice; a winter trip to a warm destination, a summer trip to a cold one.
		Explorations in Science, Level 2, Today's Forecast (Through the Window), p. 21	line master 2	
		Innovations in Science, Level 2, Looking for a Home (The Long, Cold Sleep), p. 29		
Investigating how to keep things cold or warm	8, 9, 10	*Innovations in Science, Level 2, Cool It (Wrap It Up)*, p. 27	snowball or ice cubes, plastic bags with ties, insulation materials (foil, waxed paper, fabric, newspaper), winter clothing, black line master 27	**Note**: Winter is an opportune season for this activity. Reading *Sadie and the Snowman* (Morgan) is an obvious L.A. integration activity. Invite students to create their own investigations about different kinds of insulating materials or combinations of insulating materials. (What happens if you use two insulating materials simultaneously?) It is more meaningful to the students when they create their own "What if…?" investigations.
		Innovations in Science, Level 2, Cool It (Stay Cool), p. 31		
		Explorations in Science, Level 2, It's Raining, It's Shining (Keeping Warm—Being Cool), p. 24	empty detergent bottle, insulating materials (fabric, foil, waxed paper, cotton batting, wool)	Invite students to create their own investigations about different kinds of insulating materials or combinations of insulating materials. (What if…?)
		Explorations in Science, Level 2, Wet and Wonderful (Ice Melting/Keeping Machine), p. 23	ice cubes, plastic containers, salt, bins of building materials	

Key Activity	SLE	Print Resources	Essential Materials	Comments
Investigating different ways of melting ice or snow	3, 8	*Innovations in Science, Level 2, Cool It (The Race Is On)*, p. 5 *The Art and Science Connection: Hands-on Activities for Primary Students* (Tolley) *(Using Heat Energy to Melt Ice Cubes)*, p. 113	ice cubes, paper towel ice cubes, containers, brushes, tempera paint	The first few days of a snowfall are ideal for this activity.
Exploring applications of freezing in food preparation	3, 4	*Innovations in Science, Level 2, Cool It (Frozen Treat)*, p. 24 *Innovations in Science, Level 2, Cool It (Icy Icicles)*, p. 13	plastic sandwich bags, milk, sweetened condensed milk, liquid or powdered flavouring, twist ties, large self-closing bags, pickling salt, snow, plastic spoons	Cooking activities provide opportunities to discuss and demonstrate safe practices for handling hot materials. **Note**: Student food allergies. **Safety**: This is a good opportunity to reinforce concepts such as "hot glass looks like cold glass."

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Exploring weather and its effects on people	8, 9, 11	*Explorations in Science, Level 2, Today's Forecast (Weather Report)*, p. 10		
Making Baked Alaska	3, 4, 8, 10		ingredients for Baked Alaska	This activity could be done as a series of investigations by the students and then a demonstration of Baked Alaska by the teacher. It is another opportunity to discuss safe handling of hot materials.
Building a model thermometer	1, 3	*Innovations in Science, Level 2, Cool It (It's Cold Outside, Cool It Centre)*, p. 11	pop bottle (glass if possible), straw, coloured water, modelling clay or stopper	Use a single-serving pop bottle or the 1-litre size because a large volume of water takes a significant amount of time to gain and lose heat. The following questions might be useful: What is happening to the water? Why? What do you think will happen when we move the bottle outside?
Examining the temperature scales on different devices, including a thermostat	1, 6		a variety of thermometers (oven, fish tank, clinical, central heating thermostat)	Locate print resources that have pictures of the different models if the actual objects cannot be found. Students can draw their home thermostat and report how and when their families adjust the thermostat.
Collecting information related to the seasons and presenting the information in graph form	1, 10	*Explorations in Science, Level 2, Today's Forecast (Seasonal Graphs)*, p. 22	index cards, drawing materials, mural paper	This activity should be done throughout the year. Keeping the graphs will allow for comparison and discussions on how we are affected by changes in temperature.
Examining bird feathers to see how they help birds adapt	9	*Explorations in Science, Level 3, Discovering Adaptation (Fine Feathered Friends)*, p. 22	feathers (contour and downy feathers), magnifying lenses, zippers, Velcro and balance scale	

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Examining and discussing the various types of fur and feathers that different types of animals have	9		feathers, leather, fake fur, fabric	Different types of fabrics also can be used to represent a certain type of animal fur or feather. Discuss how these are related to factors such as climate and temperature. Using materials provided, have students design a coat for themselves for survival in a certain climate (for example, a coat for the Arctic).
Preparing a mural about the variety of ways animals and people adapt to seasonal changes	9		mural paper, magazines, postcards, drawing paper	The mural can be divided into four different sections to identify seasonal changes easily. Cooperative groups can be formed where each group works on a different season.
Demonstrating evaporation and condensation using a kettle and cold plate. (This activity is also recommended as a key activity in the Liquids unit)	3, 4	*Explorations in Science, Level 2, It's Raining, It's Shining (How Does It Rain?)*, p. 17	kettle, pie plate, ice cubes	This activity should be done with small groups of students. This will allow maximum student participation and identification of safe practices for handling hot materials.

Assessment

For a broader discussion of science classroom assessment techniques see *Assessing Student Learning* in the introduction of this publication on p. 15. Good places to begin looking for the unit-related ideas are *Explorations in Science* assessment handbooks, *Innovations in Science* teaching notes, Unit tests and Portfolio ideas, Alberta Education sample tests at **www.education.gov.ab.ca** and Alberta Assessment Consortium at **www.aac.ab.ca**

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