

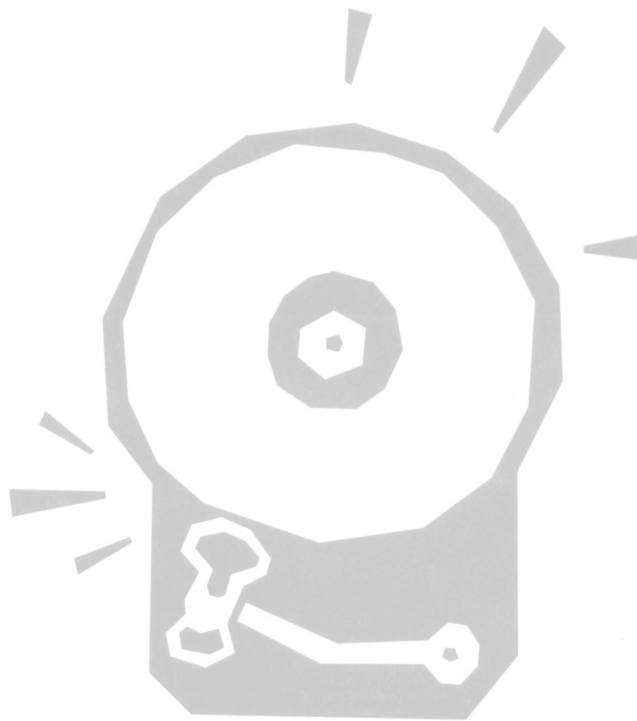
Let's Do Science

Grade Three

Hearing and Sound

3

Hearing and Sound



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Hearing and Sound

Before You Begin

Sound is a critical part of our ability to observe and sense our environment and, in turn, appreciate these surroundings. It is a part of the life experience before birth. Sound is used for communication by all animals and is an endless source of entertainment. Children experiment, in their early years, with their voices and with objects that produce sounds. In this unit, children will investigate sound as a form of energy, learn that sound travels differently through solids, liquids and gases, and learn that technologies to control sound have been developed.

Topic D: Hearing and Sound

(Suggested time: 8 weeks)

This unit can be done at any time of year. If your school has a winter or spring concert or production, you may wish to plan this unit to coincide with it. Some schools also try to have at least one fine-arts performance by a professional group each year. You could then use actors or performers to demonstrate the importance of voice and instrument sound projection. You could also have the music coordinator address these issues with your class. If you are planning a field trip in the spring into a natural area, this unit could also be tied in to correspond to that time, as the sounds of nature “explode” in May.

Choose a time of year when students are not doing other independent research so that they will have time to make an instrument and put extra time into developing these instruments at home.

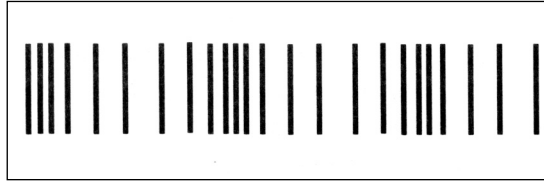
Coordinate your music and gym classes, if possible, to incorporate rhythm activities. Gather CD or MP3 players for student use at centre activities.

Background Information

Figure 1.
Compressional sound waves.

As detailed in the grade 1 unit *Senses*, our bodies are equipped with specialized organs that detect various forms of energy in our environment. Sound is energy transmitted by vibrations and detected by our ears.

When a sound source vibrates, it creates pressure waves that transport energy outward in all directions by alternately compressing and spreading out the distance between molecules of the medium the waves are travelling through, be the medium air, water, wood or any other gas, liquid or solid (see Fig. 1).



Because molecules must be present to transmit sound waves, you do not hear sound in the

vacuum of space, contrary to the cinematically grand spacecraft explosions depicted in some films!

Sound travels through different media at different speeds. Generally, the denser the media, the faster sound travels through it. For example, the speed of sound through room-temperature air is 344 metres per second but nearly 15 times this speed through steel (over 5,000 metres per second). By contrast, the speed of light clocks in at a whopping 300,000,000 metres per second. This fact accounts for the delay experienced between sighting a lightning strike and hearing thunder.

This brings us to an interesting question: why are some sounds loud and noisy like thunder and others soft and harmonious like a humming voice? What accounts for differences in loudness, pitch and timbre?

The easiest way to visualize what is going on is to consider the vibration produced by plucking a taut length of string from its rest position. It takes more and more energy the harder you pluck. This energy is transformed into vibrational energy when you release the string: the harder you pluck, the more energy you transfer and the louder the resulting sound. You can watch the distance covered by the vibration (its amplitude) shrink in size and hear the sound die down as it shrinks because the amplitude of the sound waves created by the vibrating source is also diminishing (see Fig.

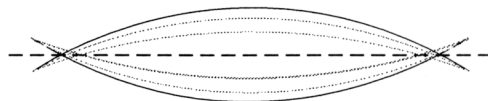
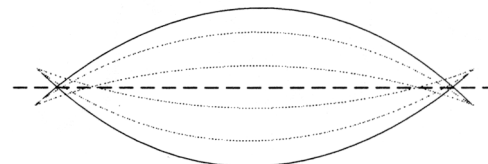


Figure 2.
Two vibrating strings of equal length, one with considerably less amplitude than the other.



2). Thus, the loudness of a sound is related to the amplitude of the sound waves.

The pitch of a sound (i.e., whether it is low or high) is determined by how fast the source is vibrating, or the frequency of the vibration.

Sound frequency is often expressed in hertz (Hz), the frequency of cycles (vibrations) per second. The higher the frequency, the higher the sound. Humans can hear up to 20,000 Hz whereas bats commonly work with sound in the vicinity of 100,000 Hz. Middle C on the piano vibrates at 263 Hz. The frequency a string vibrates is proportional to its tension (how taut it is pulled) and inversely proportional to its length, thickness and density. In other words, if you are playing a violin, there are several ways you can produce a higher note: you can turn the tuning peg to tighten the string; you can use a fingertip to hold the string you are playing against the neck of the violin, thereby shortening the portion of the string that is vibrating; or you can play on the higher strings, which are made of progressively thinner or less dense materials.

If you listen to a violin and a flute play the same note, your ear detects that the frequency of the vibration produced by the two instruments is the same, yet the sound of each instrument is unique. This is due to a difference in timbre, another aspect of sound waves. Very rarely do we hear sounds produced by a source vibrating at a single frequency. Usually sound is a composite of smaller frequencies piggybacked onto the primary sound wave (see Fig. 3). These small idiosyncrasies result in a unique quality to the sound called its *timbre*. The enormous variety in the sound of human voices is a good example.

What constitutes harmonious sound and what makes noise? Granted this can sometimes be a judgment call based on different tastes in music but, for the most part, harmonious sound is produced by vibrations that repeat in a regular pattern, whereas noise is the product of irregular, random vibrations (see Fig. 4).

Figure 3.
a. Sound wave without (primary) and b. with (composite) superimposed timbre wavelets.

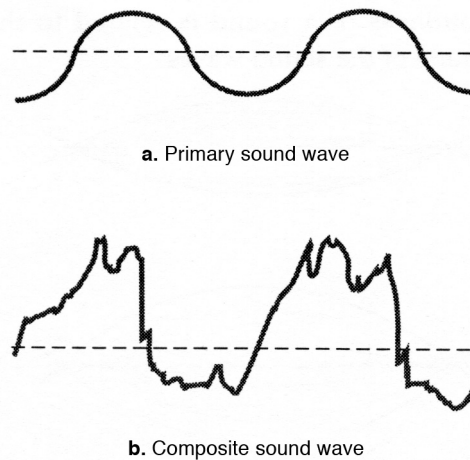
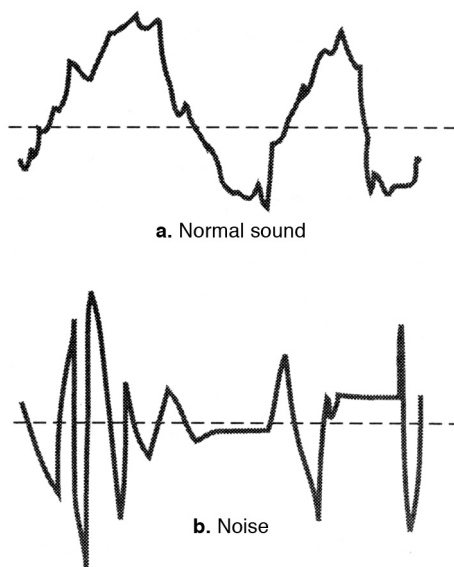


Figure 4.
a. A regular sound wave (normal sound) and b. an irregular sound wave (noise).



How do we go about reducing or eliminating unwanted noise or amplifying desired sound? Sound radiates outward from its source until it encounters objects in the environment that absorb, transmit and reflect the sound waves to varying degrees. This fact can be used in the design of sound-proofing and sound-amplifying devices. Good sound-absorbing materials have a porous structure that dissipates the energy carried in sound waves, changing it into heat. Carpets, fabric and the acoustic ceiling tiles riddled with little holes are good sound absorbing materials. Hard, smooth surfaces act exactly the opposite, bouncing sound waves around in a room. This is why washrooms tiled in glazed ceramic are acoustically live spaces.

A common way to amplify sound is by use of a microphone. A microphone detects sound waves and transforms them into alternating electric currents that can be boosted in strength and re-emitted as amplified sound. Other amplification techniques depend on the fact that energy carried by sound waves is additive; if you design a device that focuses sound waves in one direction the individual wave energies build on one another and amplify the sound. Just cup your hands around your mouth and shout to produce this effect. The fleshy protuberances on each side of our head, called an ear or an *auricle*, works in much the same way, helping to amplify sounds in our environment by focusing them down the auditory canal that leads to the eardrum. The greater the area catching and focusing sound waves, the greater the amplification. This time cup your hands behind your ears and notice the improvement. Something else you might take notice of is our ability to discern the direction from which sound is coming. Sound generated by a vibrating source reaches each of our ears at a slightly different time. Our brain uses this time delay, or phase shift, to interpret the direction of the sound source.

Our ears both detect and analyze sound in our environment. These remarkable organs have three primary parts: the external ear (which includes the auditory canal) mentioned above, the middle ear and the inner ear. The eardrum (or tympanic membrane) separates the outer ear from the middle ear. When sound hits the eardrum, it vibrates in response

and transmits this vibration to the auditory ossicles of the middle ear – a string of three tiny bones with imaginative nicknames: the *malleus* (hammer), *incus* (anvil) and *stapes* (stirrup) (see Fig. 5). From here the vibrations are transferred to the fluid-filled inner ear, where their frequency, intensity and timbre initiate nerve impulses in the *cochlea* (a process known as transduction). The nerve

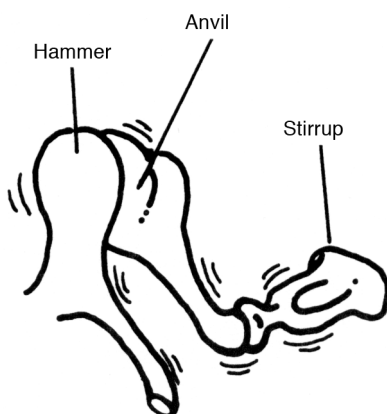


Figure 5.
The auditory ossicles.

impulses then travel via the cochlear nerve to the brain, where they are interpreted (sensed) as pitch, loudness and timbre.

Anything that interferes with the transmission of vibration through this complex chain diminishes our capability to hear. A common problem among children is a build-up of fluid in the middle ear (secretory otitis media) which impedes the transmission of vibrations from the eardrum through the auditory ossicles. Diseases can cause erosion, destruction or seizing up of the ossicles. A deterioration of the transduction process in the cochlea is the most common reasons for hearing loss in old age, but injury to the cochlea can also come about due to prolonged exposure to loud sound. Even short, single bursts of loud sound can inflict substantial harm.

What counts as loud? If we measure loudness in decibels, anything over 90 decibels is considered dangerous. A nearby airplane engine measures 110-120 decibels, the sound inside an airplane during flight is 100 decibels, a noisy office 60-70 decibels, ordinary conversation 40 decibels and a whisper 10 decibels. The decibel scale is logarithmic rather than linear so ordinary conversation is 1,000 times the volume of a whisper and a nearby airplane engine is 100,000,000,000 times louder than a whisper!

Many communities endeavour to control noise levels. The City of Calgary noise by-law, for example, restricts the level and duration of sound permitted within city limits.

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 Expectation

Students will be able to:

Describe the nature of sound, and demonstrate methods for producing and controlling sound.

Specific Learner Expectations

Students will be able to:

1. Identify examples of vibration.
2. Recognize that sound is the result of vibration and demonstrate that the larger the vibration, the louder the sound.
3. Recognize that there are ways of measuring the loudness of sounds and that loud sounds pose a danger to the ear.
4. Recognize that pitch is the result of differences in the rate of vibration, and predict how a change in the rate of vibration will affect a sound.
5. Demonstrate a variety of ways of producing sounds; for example, by striking an empty glass, by blowing air into a bottle, by constructing and using a device that involves vibrating strings.
6. Use sound-producing devices that the student has constructed to demonstrate methods for controlling the loudness, pitch and quality of sound produced.
7. Identify examples that show that sound can travel through a variety of materials, including solids, liquids and air, and that sound travels in all directions.
8. Describe how the human ear senses vibrations.
9. Compare the range of hearing in humans and other animals; for example, dogs and bats.
10. Recognize that certain sounds have characteristics that cause them to be interpreted as pleasant or unpleasant, and identify these characteristics.
11. Describe changes in hearing that result from continued exposure to loud noise, and from the natural process of aging.
12. Construct and evaluate different kinds of sound-proofing and sound-amplifying devices.
13. Explain the role that sound plays in communication.

Cross-curricular Connections

Music

- Listen to and create instruments.
- Identify sounds and instruments in an orchestra.
- Vary sound and pitch in singing.
- Explore rhythm.

Health

- Examine the ear and hearing.

Drama

- Participate in reader's theatre activities.
- Experiment with voice projection.
- Use sound effects.
- Perform with puppets.
- Dance.

Children's Alternative Frameworks

Children do not tend to associate sound with waves or vibrations. It is simply the result of an action—something has happened to make the sound. It is exciting to observe them as they start to see patterns emerge from their activities: thin, fast, tight short things give a high pitch; loose, long, slow, thick things give a low pitch. They are amazed by tuning forks, so try to have a variety on hand.

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 learner expectations.

Key Activities

Key Activity	SLE	Print Resources	Essential Materials	Comments
Exploring sounds that objects make		<i>Explorations in Science, Level 3, Sound Effects (Free Exploration), p. 7</i>	various types of musical instruments, elastics, books, coins, tuning forks, yogurt containers, beans and similar objects, pop bottles	This initial exploration and recording will give the teacher insight into student's prior knowledge about sound. The teacher may want to create a concept map with students at the end of the activity to illustrate the student's prior knowledge.
Identifying, comparing and classifying sounds	3, 10, 13	<i>Explorations in Science, Level 3, Sound Effects (Mystery Sounds), p. 10</i> <i>Innovations in Science, Level 3, Sounds Around (Soundscapes), p. 5</i> <i>Innovations in Science, Level 3, Sounds Around (Music to Your Ears), p. 9</i> <i>Sound: Teacher's Guide (Delta) (Sound Detectives), p. 6</i> <i>Innovations in Science, Level 6, Super Sonics (Sound Sources), p. 8</i>	collection of small objects and coins, cloth strips for blindfolds foam pieces, marbles, paper clips, plastic buttons, rubber stoppers, sleigh bells, small wooden blocks, sound boxes, washers, work sheet I sound logs	Have students spend a recess without talking or making any other types of sound to appreciate and explore other ways of communicating.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Experimenting with vibrations to produce various sounds	1, 2, 4, 5, 10	<i>Explorations in Science, Level 3, Sound Effects (Yogurt Record Player)</i> , p. 24	small plastic yogurt container, straight pins, records (expendable), record player	Extension activity: tie string to a pencil inside a shoe box and rub hand along rosin string (the box amplifies the sound). (See <i>Early Start to Energy</i> , p. 55).
		<i>Explorations in Science, Level 3, Sound Effects (Crazy Kazoos)</i> , p. 12	combs of various sizes, cardboard tubes of various lengths, tissue paper, waxed paper, elastics	To create different sounds, change the size of combs, the size of teeth and the distance between the teeth.
		<i>Innovations in Science, Level 3, Sounds Around (Good Vibes)</i> , p. 13	elastics, hard-cover books, variety of string materials (wool, string, wire, ribbon)	
Investigating how vibrations can travel through air and make objects move	1, 2, 7	<i>Explorations in Science, Level 3, Sound Effects (Dancing Salt)</i> , p. 13	tuning forks, salt, yogurt containers, waxed paper, plastic wrap, elastics	
		<i>Innovations in Science, Level 6, Super Sonics (Watching Radio)</i> , p. 13	tin can with both ends removed, plastic wrap, elastics, radio, fine sand, spoon, round balloons	
Making musical instruments and learning how they make sound	5, 6	<i>Explorations in Science, Level 3, Sound Effects (Make a Guitar)</i> , p. 32	large plastic bottle, pieces of wood 8 x 40 cm, fishing line, screw eyes, small blocks of wood or matchboxes, safety goggles	Variables to change include different sized bowls, drumheads made of different materials or drumsticks made of different materials. An extension of this is to make shakers using different materials (for example, popcorn seeds, beans, beads, safety pins) in sets of the same size containers (for example, yogurt tubs, drink juice bottles). See <i>Fun With Physics (Cash) (Shakers)</i> .
		<i>Innovations in Science, Level 3, Sounds Around (Making Music)</i> , p. 26	various materials to build instruments (for example, straws, plastic bowls and containers, elastics, aluminum foil, pie plates, combs, bottles, empty juice cans)	
		<i>Innovations in Science, Level 6, Super Sonics, Activity card 41, (I'm a Scientist: Banjo Maker)</i>	band instruments: drums, cymbals, tambourines, shakers, triangle, wooden spoons	
		<i>Innovations in Science, Level 6, Super Sonics, Activity card 42, (Hit It!)</i>		
		<i>Explorations in Science, Level 3, Sound Effects (Drums)</i> , p. 20	plastic bowls of different sizes, wooden dowels or chopsticks, plastic bags	

Key Activity	SLE	Print Resources	Essential Materials	Comments
Experimenting to determine how tension, thickness and length affect the pitch of a plucked string	4, 5, 6	<i>Explorations in Science, Level 3, Sound Effects (Stringing Along)</i> , p. 22	string or fishing line, nails, wooden board about 40 cm long, plastic ice cream pail, weights (for example, marbles, washers), safety goggles	
Exploring how the pitch of a sound alters when the length of a column of air is changed	1, 2, 4, 5, 6	<i>Explorations in Science, Level 3, Sound Effects (Panpipes)</i> , p. 18 <i>Explorations in Science, Level 3, Sound Effects (Water Trombone)</i> , p. 19	plastic straws, tape, Plasticine, scissors straws or hoses of large diameter, containers as deep as straws are long	The concept to be discovered is that the shorter length creates a higher pitch and a longer length creates a lower pitch.
Discovering that sound travels through solids and liquids as well as air and that each medium conducts sound differently	7	<i>Explorations in Science, Level 3, Sound Effects (Hidden Sound)</i> , p. 15 <i>Innovations in Science, Level 3, Sounds Around (On the Line)</i> , p. 16 <i>Innovations in Science, Level 6, Super Sonics (Travelling Sound)</i> , p. 23 <i>Innovations in Science, Level 6, Super Sonics (Forks Full of Sound)</i> , p. 26	wire cooling racks, coat hangers, string, forks, spoon paper cups, toothpicks, string or wire dinner fork, string, tuning fork metre sticks, glass aquarium filled with water, sound logs	One can also put a vibrating tuning fork on a wooden table or on a wooden box (desk). These cups can be made stronger by using small yogurt containers instead (<i>Fun With Physics</i> , p. 34).
Investigating how to amplify and direct sound	6, 12	<i>Explorations in Science, Level 3, Sound Effects (Megaphones & Ear Trumpets)</i> , p. 26 <i>Explorations in Science, Level 3, Sound Effects (Stethoscope)</i> , p. 28 <i>Innovations in Science, Level 3, Sounds Around (Speak Up!)</i> , p. 19	large pieces of stiff paper plastic or rubber tubing, funnels (or plastic bottles with bottoms cut)	Students can also cup their hands to direct the voice or use a long cardboard tube. Integration with language arts: read <i>Innovations in Science, Level 5 Student Book (Stethoscopes)</i> , p. 151.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Discussing the structure of the ear and how it works	8, 9, 11	<i>Explorations in Science, Level 3, Sound Effects (Testing Hearing), p. 31</i> <i>Innovations in Science, Level 6, Super Sonics (Hear, Here), p. 33</i>	device that makes a sound (ticking clock), blindfold sound sources such as tape recorders, radios, CD players, etc.	Integration with language arts: <i>Innovations in Science, Level 6, Student Book, p. 110</i> . Conduct a hearing test on a blindfolded volunteer.
Experimenting with different materials to see which ones most effectively reduce noise	10	<i>Explorations in Science, Level 3, Sound Effects (Muffled Music), p. 29</i> <i>Innovations in Science, Level 6, Super Sonics (Sound Stoppers), p. 29</i>	tape recorder, CD player, or radio, cardboard box, muffling materials (foam chips, newspaper, Styrofoam, plastic bags)	
Discovering that sounds can be used by humans and other animals to communicate	13	<i>Innovations in Science, Level 3, Sounds Around (Getting the Message), p. 24</i> <i>Explorations in Science, Level 3, Six Legs or Eight? (Sounds Abound), p. 21</i> <i>Innovations in Science, Level 3, Who's Who at the Zoo? (Why Do Animals Make Different Noises?), p. 26</i>	chart paper, writing paper, tape recorder, mural paper, bells, alarms, sirens, whistles blindfolds noisemakers, blindfolds, chart paper	

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Making a variety of sounds using hands and voice		<i>Innovations in Science, Level 6, Super Sonics, Activity card 37 (Alphabet Sounds)</i> <i>Innovations in Science, Level 6, Super Sonics, Activity card 38 (Body Talk)</i>		
Producing sound effects		<i>Innovations in Science, Level 6, Super Sonics (Sound Effects), p. 39</i>	balloon, cellophane, uncooked rice, bowl, wax paper, cake pan, recipe cards, tape recorder	Integration with language arts: <i>Extending the Experience</i> , p. 41.
		<i>Innovations in Science, Level 6, Super Sonics (Sonic Spectacular), p. 44</i>	pillows, tape recorder and microphone, sound effects materials from Level 3, <i>Sound Effects</i> theme	Integration with drama and language arts: produce a radio play with sound effects.
Investigating noise pollution	3, 10, 11	<i>Innovations in Science, Level 6, Super Sonics (Noise Annoys), p. 36</i> <i>Innovations in Science, Level 6, Super Sonics, Activity card 47 (What's Noise?)</i>	poster paper, blank sheets of paper, felt pens, paints	Have students conduct a survey.
Forming an orchestra		<i>Innovations in Science, Level 3, Sounds Around (Putting It Together), p. 30</i>	tapes and CDs of symphonic music, tape or CD player	
Reflecting sound	12	<i>Make It Work: Sound (Scholastic) (Reflecting Sound), p. 12</i>	thick card, craft knife, cardboard tubes, egg tray, modelling clay, tape recorder and microphone, clock or watch with faint tick	
Recording sound		<i>Make It Work: Sound (Scholastic) (Recording Sound), p. 18</i>	tape recorder, microphone, umbrella, sticky tape, tapes, earphones	
Exploring how the spokes and tires of a bicycle can produce different-pitched sounds	1, 2, 4, 5, 6	<i>Explorations in Science, Level 3, Sound Effects (Musical Bike), p. 16</i>	bicycle, pieces of stiff plastic	Students learn that the speed of the wheel and the pitch of the sound are related.

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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