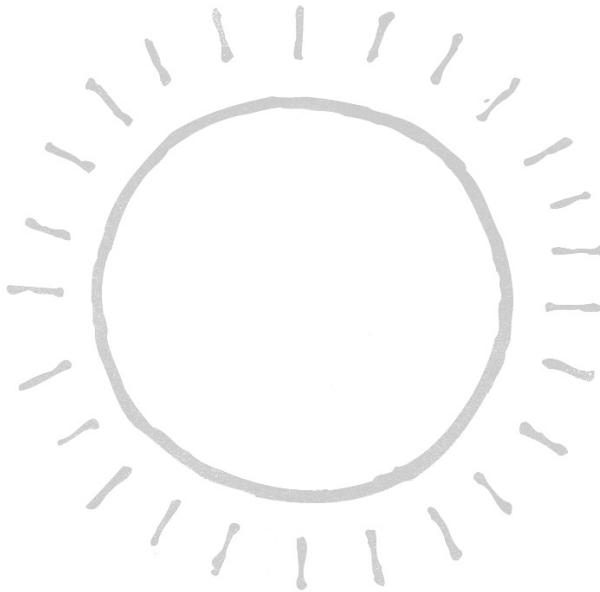


Let's Do Science

Grade Four

Light and Shadows



Science Alberta Programs for Your Classroom



Science-In-A-Crate

From digging for dinosaur bones to balancing a budget or learning about light, each trunk-sized "crate" contains everything you need to bring science and math to life in any learning environment. Science-In-A-Crate uses seven highly visual, hands-on and minds-on activities to illustrate how science is used in everyday situations, all directly linked to Alberta curriculum.

Crates are self-contained—they include everything you need to conduct science learning activities—including an activity guide with detailed, step-by-step instructions for each activity.

Visit www.sciencealberta.org for a complete listing of the crates available or call 403-220-0077 for a program guide.

Wonderville.ca

Step inside the whimsical world of Wonderville.ca, where colourful characters and enchanting environments stimulate learning through exciting online activities.

Wonderville.ca is an award-winning web site that makes science relevant, fun, and accessible to children, youth and families. Wonderville.ca is chockfull of world-class science content in a format that children and youth want to use—exciting digital activities, printable experiments, career videos and hidden science facts. The intriguing and engaging activities directly meet Alberta science curriculum knowledge outcomes from Grades 3 to 7.

Surf to Wonderville.ca to engage in the experience.



Light and Shadows Before You Begin

Light is an everyday phenomenon. In this unit, children discover the properties and behaviour of light through free exploration and simple investigations. They learn about light sources, transparent, translucent and opaque materials, and the predictable characteristics of shadows. Students also discover that mirrors, prisms and a variety of other materials can affect the path of light by reflecting or refracting (bending) it, and that refraction can separate sunlight into its component colours.

Topic D: Light and Shadows

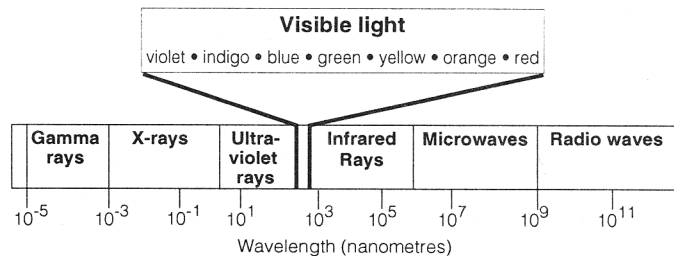
(Suggested time: 6-8 weeks)

In this unit, children discover the properties and behaviour of light through free exploration and simple investigations (see *Before You Begin* above). Try to use a space in the classroom that can be made quite dark.

Background Information

Light is the part of the *electromagnetic spectrum* sensed by our eyes. The electromagnetic spectrum (see Fig. 1) is the set of all waves that have simultaneously varying electric and magnetic fields associated with them and travel through space at 300,000 kilometres per second (a velocity commonly referred to as the speed of light). Electromagnetic waves differ from one another only in wavelength: the shorter the wavelength, the higher the frequency (cycles per sec), and the more “energetic” the wave.

Figure 1.
Electromagnetic spectrum.

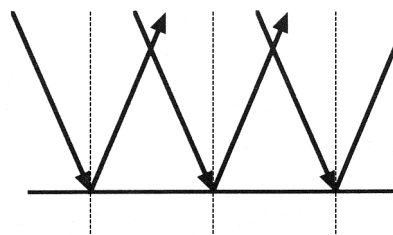


Waves a bit shorter and more energetic than violet are called ultraviolet and waves a bit longer than red are called infrared. Prolonged exposure to ultraviolet rays can cause skin cancer and the formation of cataracts on the eyes. Unfortunately, we can't sense the presence of ultraviolet light. We can, however, detect infrared light—as heat. Because infrared heat is normally present in combination with sunlight, it is extremely hazardous to look at focused, concentrated sunlight. In fact, intensely bright light from any source can permanently damage the delicate light-sensing retina at the back of the eyeball. Infrared heat can set objects on fire. It should be noted, however, that heat is not necessarily generated alongside light. *Luminescent* objects shine without producing heat.

Now that we've seen what light is, let's look at how it is generated. To do this, we have to acknowledge that light, in addition to acting like a wave, also acts like a particle. *Photons* are packets of light energy emitted by atoms or molecules (combinations of two or more atoms) dropping from a highly energized, excited state to a less excited state. You could say light production is one way atoms and molecules work off pent-up excess energy.

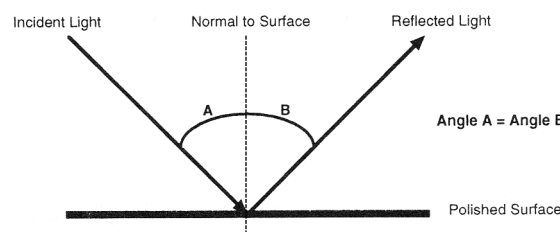
Different colours are produced by photons having slightly different amounts of energy. Each type of atom or molecule is unique in the set of photon energies it can absorb and reflect. Dark-coloured objects are made of atoms or molecules that readily absorb photons of most wavelengths. Light-coloured objects are more selective, reflecting most photon wavelengths for us to see. The denser these light absorbing or reflecting atoms and molecules are in an object, the less light gets through. If the density is so great that no light gets through, the object is *opaque*. If some fraction of the light falling on an object makes it through to the other side, the object is *translucent*. *Transparent* objects simply let photons pass by virtually (but not entirely) untouched, as we'll see in the upcoming discussion of refraction. First, let's look at reflection.

Figure 2.
Reflection of light off a polished surface.



Reflection is what happens when light “bounces” off a surface. Just how well a surface reflects light depends on the texture of the reflecting surface (see Fig. 2).

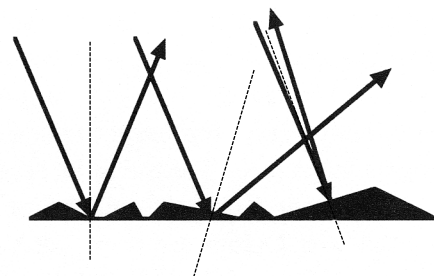
Figure 3.
Angles of incident and reflected light on a polished surface.



The direction of reflected light is completely predictable on a polished surface. If you draw a “normal” (perpendicular) line to the surface, the angle the incoming light makes with respect to

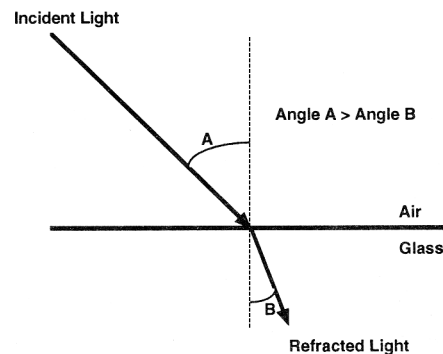
the normal (angle A) equals the angle the reflected light makes to the normal (angle B). Angle A is called the *angle of incidence* and angle B is the *angle of reflection*. Smooth, shiny surfaces make good mirrors (see Fig. 3) because all the incoming light is reflected at the same angle.

Figure 4.
Reflection of light off a rough surface.



The rougher the surface texture, the less likely it is that an image (multiple light rays in a fixed relationship to one another) will be reflected off the surface intact. The angles of incidence of the light rays will be the same but the angles of reflection will differ, leading to a general scattering of the light rays and a loss of the original image (see Fig. 4).

Figure 5.
Refraction of light from one
transparent medium to another.



In the case of transparent materials, light rays are *refracted* or bent as they go from one transparent medium into another at an angle (air into glass, glass into water, etc.). Generally, when light travels into a denser medium it is slowed slightly. This results in its being bent toward the normal and when it leaves the glass it bends away from the normal (see Fig. 5). There

is an equation to determine how much the light will be bent.

Called *Snell's Law* after Willebrod Snell (1591-1626), who discovered the relationship experimentally, it calculates the *index of refraction*, a constant, for light traversing the boundary between two specific media.

We've been talking about a theoretical ray of light to this

point. Visible light is made up of several different wavelengths, which appear as different colours when light is passed through a medium denser than air, such as a glass prism or a rain drop. This occurs because each of these wavelengths is bent through a slightly different angle during refraction.

Shadows are simply the absence of light. They are created by opaque or partially opaque (*translucent*) objects that reflect or absorb most or all the light falling on them. For this reason, shadows always form on the side of the object opposite the light source and take on the general shape of the object blocking the light.

The size of the shadow of an object will depend on a number of factors, including the size of the light source; the distance from the light source to the object; the angle at which the light source is striking the object; and the topography of the ground on which the shadow is cast.

Theoretically, one would expect shadows to be jet black. We see faintly illuminated detail inside a shadow because light reflects off nearby surfaces and this weaker, scattered light—coming from entirely different angles from the original light source—fills in the shadow to some degree. In fact, shadows cast in locations overhung by large expanses of daytime sky tend to be slightly blue for this very reason. The bright sky reflects blue light and softly backfills the shadow.

Did you know that electromagnetic waves other than light produce shadows too? Consider X-rays. The soft parts of our bodies can't stop these high-energy rays, but our dense bones and teeth can, leaving well defined shadows on film sensitive to X-ray emissions.

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:

Identify sources of light, describe the interaction of light with different materials and infer the pathway of a light beam.

Specific Learner Expectations

Students will be able to:

1. Recognize that eyes can be damaged by bright lights and that one should not look at the sun—either directly or with binoculars or telescopes.
2. Identify a wide range of sources of light, including the sun, various forms of electric lights, flames and materials that glow (luminescent materials).
3. Distinguish objects that emit their own light from those that require an external source of light in order to be seen.
4. Demonstrate that light travels outward from a source, and continues unless blocked by an opaque material.
5. Describe changes in the size and location of sun shadows during the day—early morning to mid-day to late afternoon.
6. Recognize that opaque materials cast shadows, and predict changes in the size and location of shadows resulting from the movement of a light source or from the movement of a shade-casting object.
7. Distinguish transparent materials from opaque materials by determining if light passes through them and by examining their shadows.
8. Classify materials as transparent, partly transparent (translucent) or opaque.
9. Recognize that light can be reflected and that shiny surfaces, such as polished metals and mirrors, are good reflectors.
10. Recognize that light can be bent (refracted), and that such objects as aquaria, prisms and lenses can be used to show that light beams can be bent.
11. Recognize that light can be broken into colours and that different colours of light can be combined to form a new colour.

12. Demonstrate the ability to use a variety of optical devices, describe how they are used and describe their general structure. Suggested examples include: hand lens, telescope, microscope, pin hole camera, light-sensitive paper, camera, kaleidoscope. Students meeting this expectation will be able to provide practical descriptions of the operation of such devices, but are not required to provide theoretical explanations of how the devices work.

Cross-curricular Connections

Art

- Use shading.
- Add shadows.
- Choose colours (primary, secondary).
- Create stained glass.

Health

- Understand the human eye and vision.

Mathematics

- Study symmetry.

Drama

- Work with shadow puppets.
- Stage action plays.

Children's Alternative Frameworks

Students are aware that by turning on a light in a dark room they are able to see things. The concept of the interaction between different light sources and objects can be confusing. Objects can only be seen when light waves hit them and are reflected back to the eye.

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
Determining students initial ideas about light		<i>Explorations in Science, Level 4, Casting Shadows (Discovery Circle)</i> , p. 8	overhead, filmstrip projector, flashlights, classroom objects (paper, books, erasers), chart paper	Students list what they know about light and what they want to know about light. At the end of the unit they go back to the chart and add the things they learned. They see if they can answer the questions they initially had. They work with partners or in small groups to record the information. Record observations in notebooks.
Exploring the school and home environment to identify different sources of light. Light sources are either natural or artificial	2, 3	<i>Innovations in Science, Level 2, Light and Shadows (Light All Around Us)</i> , p. 5 (could be adapted for grade 4) <i>Explorations in Science, Level 4, Light Moments (We're Going on a Light Hunt)</i> , p. 10	flash cards, white cards, or white paper plate	Partner when gathering information on natural and artificial light, first in the school, then in the home environment.
Exploring how light travels outwards from its source	4	<i>Explorations in Science, Level 4, Casting Shadows (Travelling Light)</i> , p. 12 <i>Explorations in Science, Level 4, Light Moments (Cornering Light)</i> , p. 13	scissors, cardboard tubes, 4 cardboard squares, Plasticine, candle, flashlights, tape, opaque (waxed paper)	Small group activity; students can develop a different method of testing light and how it travels.
Changing the path of light using mirrors		<i>Explorations in Science, Level 4, Mirror Images (Amazing Mirrors)</i> , p. 18 <i>Explorations in Science, Level 4, Mirror Images (How to Move a Straight Line)</i> , p. 17	mirrors, flashlight, shoe boxes, paper, scissors, Plasticine mirrors	Small group activity.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Observing that light blocked with various materials produces a shadow	4, 5, 6, 7	<i>Explorations in Science, Level 4, Casting Shadows (Size, Shape and Sharpness)</i> , p. 14	bright light source, three-dimensional objects of various shapes, Plasticine, white paper on cardboard to be used as background	Partner work. Observations can be recorded in journals.
Exploring shadows on a sunny day	4, 5, 6	<i>Explorations in Science, Level 4, Casting Shadows (Does Twice As Far Make Twice As Large?)</i> , p. 17	overhead projector or other light source, large ball, paper, ruler, line master 37	Could be used as introductory lesson for discussing size in relation to distance of shadows.
Sorting or classifying a variety of materials into opaque, translucent and transparent groups	6, 7, 8	<i>Explorations in Science, Level 4, Casting Shadows (What Is a Shadow?)</i> , p. 10	opaque paper (construction paper), translucent paper (waxed paper), plastic wrap, transparent paper (cellophane), scissors, artificial light source or sunlight (sunny window)	Small group activity, sorting materials used into casting dark, light or no shadows. Observations can be recorded in journals.
		<i>Innovations in Science, Level 2, Light and Shadows (Block It Out)</i> , p. 8	waxed paper, foil, plastic wrap, tissue paper, construction paper, cardboard, fabric, light source	Graphs or charts can be made on similarities and differences of materials and the amount of light that passes through them.
		<i>Innovations in Science, Level 3, Is Seeing Believing? (Activity Card 69: Looking at Light)</i>	variety of glass containers, flour, milk powder, icing sugar	Partner work.
Searching for reflective materials in classroom objects, and the use of mirrors	9	<i>Explorations in Science, Level 4, Mirror Images (Where, Oh Where Is a Reflection?)</i> , p. 10	classroom objects	Small group activity or partner work exploring objects in the classroom.
		<i>Explorations in Science, Level 4, Light Moments (Light-The-Messenger)</i> , p. 11	mirrors, foil, flashlights, Bristol board squares (various colours and white), black matte squares of cardboard	Students test which are most reflective. Observations can be recorded with diagrams or responses in journals.
Exploring images in mirrors	9	<i>Innovations in Science, Level 2, Light and Shadows (Reflections)</i> , p. 18	flashlights, cardboard or construction paper for targets, foil, mirrors, metal objects, including spoons	Targets should be made before the lesson. Observations can be recorded in journals.
		<i>Innovations in Science, Level 3, Is Seeing Believing? (Reflections)</i> , p. 23	Bristol board, foil or Mylar film (found at craft or hardware store), shiny spoons, paper cups	Students to provide containers for activity. Diagrams in journals.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Investigating lenses and bending of light (<i>refraction</i>). Light is bent when it passes through water, prisms and lenses	10	<i>Explorations in Science, Level 4, Light Moments (Light Can Bend)</i> , p. 17	glass containers (with straight and curved sides), flashlight, small box or card with slits, glass slides, liquids (water, oil, milk)	Partner work. Record diagram in journals.
		<i>Explorations in Science, Level 4, Mirror Images (Which Way Is Up?)</i> , p. 13	mirrors (flat and curved), metallic objects, cardboard, tape, reflective paper	
		<i>Explorations in Science, Level 4, Light Moments (Through the Looking Glass)</i> , p. 21	magnifying glass, white cardboard, flashlights	Safety first: flashlights.
		<i>Innovations in Science, Level 3, Is Seeing Believing? (Activity Card 70: Looking Through Water)</i>	water jars, pencil	Small group activity.
Discovering the visible spectrum (the colours of the rainbow)	11	<i>Explorations in Science, Level 4, Light Moments (The Many Colours of Light)</i> , p. 23	objects that refract light (prisms, crystals, mirrors, jewellery, feathers, nylons, cotton, water, glass cup, magnifying glass, cardboard)	Small group activity.
		<i>Innovations in Science, Level 3, What's Up (Making Rainbows)</i> , p. 13	overhead projector or screen, glass screen, glass dish, bubble makers, wire garbage ties, plastic ring, liquid dish detergent, fish tank, small mirrors, shallow bowls, various types of prisms (triangular or pendant type), sponges and clothespins, spray bottle and vinegar	
		<i>Explorations in Science, Level 4, Light Moments (A Colour Puzzle)</i> , p. 26	paints, brushes, acetate or cellophane of different colours, strong light source, tape, white screen	Make a colour wheel from either activity.
		<i>Innovations in Science, Level 3, Is Seeing Believing? (Changing Colours)</i> , p. 9	blackline master 7, cardboard, glue, crayons, scissors	

Key Activity	SLE	Print Resources	Essential Materials	Comments
Using and Building a Variety of Optical Devices				
Constructing a pinhole viewer to view the sun safely	1, 12	<i>Innovations in Science, Level 6, Sky Science (Spot the Sun), p. 20</i>	shoe box, aluminum foil, black construction paper, white paper, scissors, tape, needles	View on a sunny day.
		<i>Explorations in Science, Level 6, Cosmic Connections (Sun Camera), p. 12</i>	Mylar mirrors, pocket mirrors, boxes, binoculars, paper	Safety first.
		<i>Explorations in Science, Level 4, Light Moments (Pinhole Photos), p. 32</i>	can, box, foil, waxed paper or black paint, nail, tape, white paper	
Using a magnifying hand lens	12	<i>Explorations in Science, Level 4, Light Moments (Through the Looking Glass), p. 21</i>	magnifying glass, white cardboard for screen	Small group activity. Illustration of the light ray's path can be placed in journals. Through this activity and discussion, lead to the function of a camera.
Using simple telescopes	12	<i>Explorations in Science, Level 4, Light Moments (Awesome Optical Instruments), p. 34</i>	short lens (40 to 100 mm), long lens (80 to 300 mm), shaving (convex) mirror, plain mirror, cylindrical tubes (one larger than the other)	Parent volunteers should be present for this activity.
Using microscopes				
Using magnifiers	12	<i>Innovations in Science, Level 4, Microworlds (A Closer Look), p. 15</i>	clear acetate rectangles, newspaper or magazine pictures, drinking straws, plastic containers, plastic wrap, elastics, clear cylindrical glass jars, magnifying glasses	

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Making periscopes	12	<i>Explorations in Science, Level 4, Mirror Images (Seeing Around Corners)</i> , p. 20	mirrors, Plasticine, scissors, metre sticks, cylinders, milk cartons, tape	
Making kaleidoscopes	11, 12	<i>Explorations in Science, Level 4, Mirror Images (Kaleidoscope Discovery)</i> , p. 23	kaleidoscopes, paper-towel tubes, plastic, mirrors, pieces of paper, Mylar film scissors, elastics	
Exploring optical illusions	12	<i>Innovations in Science, Level 3, Is Seeing Believing? (Shifting Shapes)</i> , p. 12	tracing paper, coloured pencils, graph paper	
Making shadow projects	6, 8	<i>Explorations in Science, Level 4, Casting Shadows (Shadow Pictures)</i> , p. 26 <i>Explorations in Science, Level 4, Casting Shadows (Weird and Wonderful Inventions)</i> , p. 31 <i>Innovations in Science, Level 2, Light and Shadows (Shadow Dance)</i> , p. 27	light source, photographic paper (medium grade), 3 large, deep trays, developer, water, fixer, tongs, transparent covers, stiff cardboard, opaque objects various materials as required by the students overhead or other projectors, music	Small group activity. A professional photographer can be invited to demonstrate. Parent volunteers should be present for this classroom activity. Students provide own materials or use classroom materials for invention. They should include a plan and devise a test for their invention.
Observing reflective properties of bubbles	9	<i>Explorations in Science, Level 4, Light Moments (The Special Light of Bubbles)</i> , p. 27	materials to make frames for blowing and dipping bubbles, string, containers, bubble solution (liquid dishwashing detergent), glycerin	
Creating a stroboscope	12	<i>Explorations in Science, Level 4, Light Moments (Catch the Action)</i> , p. 30	cardboard, drawing compass, pencil, scissors, utility knife, dowels, straw, masking tape, flashlight, cardboard box, line master	

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

Bibliography

- Butzow, Carol M. and John. *Science Through Children's Literature: An Integrated Approach*. Teacher Ideas Press, 1989. ISBN 0-87287-667-5.
- Campbell, Steve et al. *Explorations in Science, Level 4, Casting Shadows*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88150-0.
- Campbell, Steve et al. *Explorations in Science, Level 4, Mirror Images*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88144-6.
- Campbell, Steve et al. *Explorations in Science, Level 4, Light Moments*. Don Mills, Ontario: Addison-Wesley, 1992. ISBN 0-201-88159-4.
- Campbell, Steve et al. *Explorations in Science, Level 4: Assessment Handbook*. Don Mills, Ontario: Addison-Wesley, 1993. ISBN 0-201-60680-1.
- Campbell, Steve et al. *Explorations in Science, Level 5: Assessment Handbook*. Don Mills, Ontario: Addison-Wesley, 1993. ISBN 0-201-60681-X.
- Campbell, Steve et al. *Explorations in Science, Level 6, Cosmic Connections*. Don Mills, Ontario: Addison-Wesley, 1993. ISBN 0-201-88169-1.
- Explore! A Book of Science*. Addison-Wesley Publishers Limited, 1992. ISBN 0-201-55509-3.
- Ostlund, Karen. *Science Process Skills: Assessing Hands-On Student Performance*. Addison-Wesley Publishing Company, 1992. ISBN 201-29092-8.
- Peturson, Rod and Neil McAllister. *Innovations in Science, Process and Inquiry, Level 2*. Toronto: Harcourt Brace & Company, Canada, 1996. ISBN 0-7747-0189-7.
- Peturson, Rod and Neil McAllister. *Innovations in Science, Process and Inquiry, Level 3*. Toronto: Harcourt Brace & Company, Canada, 1996. ISBN 0-7747-0184-6.
- Peturson, Rod and Neil McAllister. *Innovations in Science, Process and Inquiry, Level 4*. Toronto: Harcourt Brace & Company, Canada, 1996. ISBN 0-7747-0176-5.

Peturson, Rod and Neil McAllister. *Innovations in Science, Process and Inquiry, Level 6*. Toronto: Harcourt Brace & Company, Canada, 1996.

ISBN 0-7747-0182-X.

Tolley, K. *The Art and Science Connection: Hands-On Activities for Intermediate Students*. Pearson Education Canada, 1994. ISBN 0-201-45545-5.