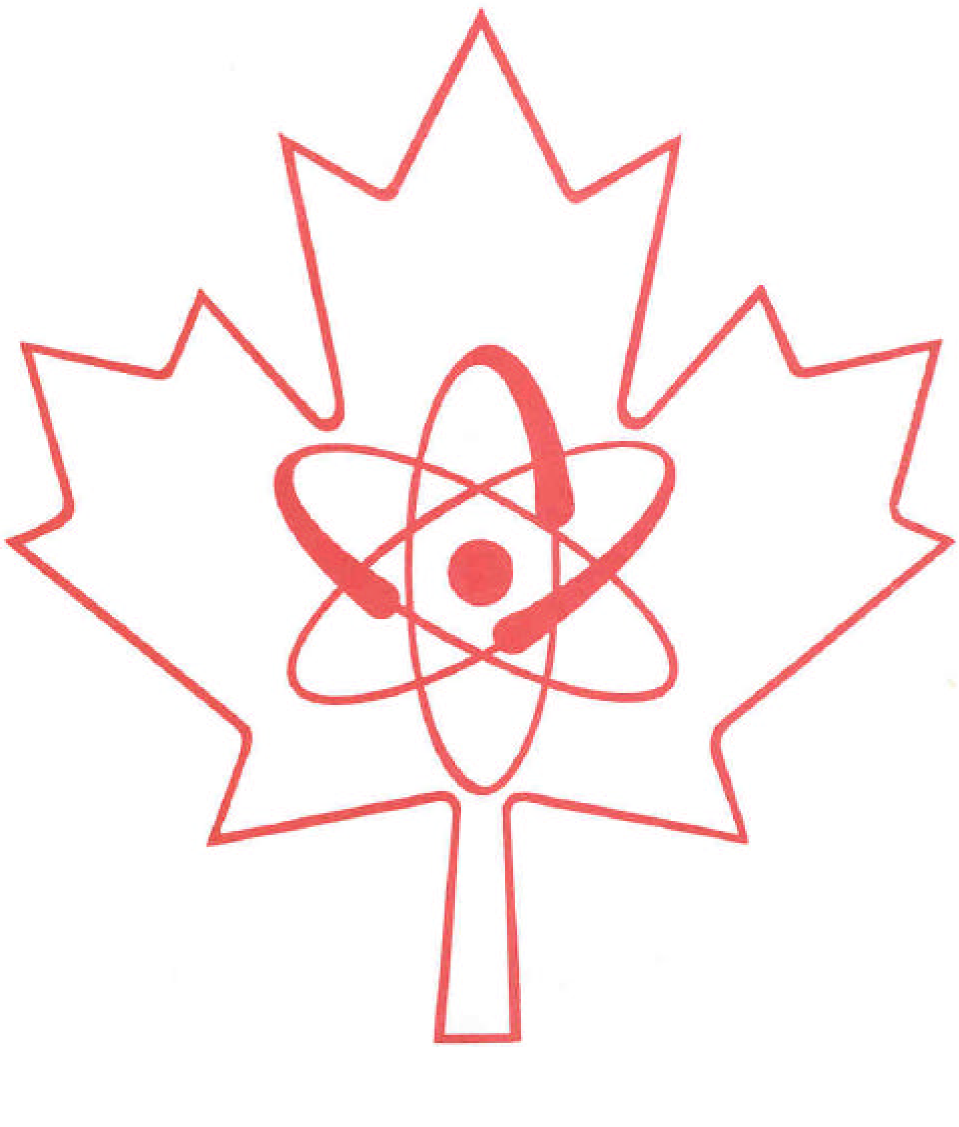
Science
A Curriculum Guide
For the Middle Level



September 1993

Science

A Curriculum Guide for the Middle Level

Saskatchewan Education, Training and Employment

September 1993

Acknowledgements

Saskatchewan Education, Training, and Employment gratefully acknowledges the professional contributions and advice given by the following members of the Science Curriculum Advisory Committee:

Dr. Glen Aikenhead
Professor, Science Education
University of Saskatchewan

Ms. Ingrid Benning
Teacher
Saskatoon S.D. No. 13

Ms. Isabelle Campeau
Teacher
Regina S.D. No. 4

Ms. Shannon Dutson
Vice-Principal
Potashville S.D. No. 80

Sr. Phyllis Kapuschinski
Professor, Science Education
Faculty of Education
University of Regina

Mr. Wayne Kiel
Principal
Buffalo Plains S.D. No. 21

Mr. David Leuschen
Trustee (SSTA)
Wakaw S.D. No. 48

Mr. Larry Mossing
Teacher
Regina S.D. No. 4

Dr. Ray Rystephanick
Assistant Dean, Faculty of Science
Professor, Physics
University of Regina

Dr. Ron Steer
Professor, Chemistry
University of Saskatchewan

Mr. Peter Stroh
Teacher
St. Paul's R.C.S.S.D. No. 20

Mr. Ernest Toth
Assistant Director of Education (LEADS)
Buffalo Plains S.D. No. 21

Previous Advisory Committee members: Dr. Frank Bellamy, Ms. Joan Bue, Ms. Mary Hicks, Mr. George Huczek, Mr. Vlademir Murawsky, Mr. Lynn Phaneuf, Mr. William Shumay, Mr. James Taylor, Dr. William Toews, Mr. Lyle Vinish, Mr. Randy Wells.

Saskatchewan Education, Training and Employment wishes to thank many others who contributed to the development of this Curriculum Guide:

- the Science Program Team;
- pilot teachers; and,
- other contributing field personnel.

This document was completed under the direction of the Mathematics and Natural Sciences Branch, Curriculum and Instruction Division, Saskatchewan Education, Training and Employment .

Preface

Much of the foundation for curriculum renewal in Saskatchewan schools is based on the *Directions* (Saskatchewan Education) reports of the 1980s. The excitement surrounding the recommendations for Core Curriculum developments will continue to build as curricula are implemented with the objective of preparing students for the 21st century.

Science is one of the Required Areas of Study. It incorporates the Common Essential Learnings, the Adaptive Dimension, and other initiatives related to Core Curriculum. To make the appropriate connections from the *Directions* philosophy to the science classroom, a number of documents have been produced.

As we strive to achieve the goal of scientific literacy in Saskatchewan schools, much collaboration and cooperation among individuals and groups will be required. Science teachers, as a key part of the change process, must build on the best and prepare for the future.

Table of Contents

Introduction

Science Program Philosophy, Aim, and Goals

The philosophy and spirit of science education renewal in Saskatchewan is reflected not only in the program aim and goals, but in the documents developed to support the new curricula, and in the inservice packages designed and utilized for implementation. In addition, the philosophy for science education is closely related to the concept of Core Curriculum based on the *Directions* philosophy for Saskatchewan.

The major aim of the K-12 Science program is to develop scientific literacy in students. The key question that arises is "What is scientific literacy?".

For Saskatchewan schools, scientific literacy has been defined by seven Dimensions of Scientific Literacy that are the foundation for the renewed curriculum (Hart, 1987). Actively participating in K-12 Science will enable a student to:

- understand the **nature of science** and scientific knowledge as a unique way of knowing;
- understand and accurately apply appropriate science **concepts**, principles, laws, and theories in interacting with society and the environment;
- use the **processes of science** in solving problems, making decisions, and furthering understanding;
- understand and appreciate the joint enterprises of **science** and **technology** and the relationships of these to each other in the context of **society** and the **environment**;
- develop numerous manipulative **skills** associated with science and technology, especially with measurement;
- interact with the various aspects of society and the environment in ways that are consistent with the **values** that underlie science; and,
- develop a unique view of technology, society, and the environment as a result of science education, and continue to extend this **interest and attitude** throughout life.

Each of these Dimensions has been defined further by a series of factors, which delineate the Science curriculum. The factors of scientific literacy are defined and examples are given starting on page 70. Consult *Science Program Overview and Connections K-12 (Draft, 1989)* for more information about them.

The study of science should help students make better sense of the world in which they live. The objective is not to have students be able to repeat the words which teachers or scientists or others use to describe the world, although they may do that. It is to have students create their own conceptual maps of what surrounds them every day, and to realize that those concepts and the maps which describe the links between concepts are tentative, subject to questioning, and revised through investigation.

Teaching Science at the Middle Level (Grades 6 to 9)

Carl Sagan, in the introduction to Stephen Hawking's ***A Brief History of Time***, addresses the relationship between science and creative questioning. He writes:

> We go about our daily lives understanding almost nothing of the world... Except for children (who don't know enough not to ask the important questions), few of us spend much time wondering why nature is the way it is... (page ix)

Creative questioning drives science. The ability to conceive creative questions should be fostered at the Middle Level. To do this, educators can:

- encourage and assist students to create questions about what is around them;
- give students an opportunity to explore and to discover answers to the questions they create; and,
- ask students to analyze, compare, and evaluate the answers they discover.

In Middle Level science classes, stimulate creative questioning by your students. This guide advocates a constructivist view of science teaching. Students must be actively involved in doing science and thinking about science in order to understand science.

Each of us has our own idea of what is meant by the term science. For many of us, our opinion was formed during science classes we took in high school and in university. We also have our own view of how science should be taught. This also may have been formed by modelling ourselves after what we saw in our science teachers. The first step in science teaching is to sort out our thoughts about science and about the teaching of it.

Science involves constructing an understanding of how the natural world works. We observe what is around us, ask questions, and seek answers. **The questions we ask and the way we seek the answers is what distinguishes science from other ways of knowing about the world**. This construction process is done through activities. Words in textbooks are not the way understanding is communicated. Words do not give meaning to concepts. Words in textbooks are useful as a comparison between what the reader understands and what the writer understands. Words in textbooks may serve as examples of how to communicate understanding, or may confirm or contradict an understanding. **But concrete experiences are the basis for insight into the concepts. This is what Middle Level science must provide for students**.

The core of a good science program is activity-based. Through activities comes the broad view of science expressed above, the science which is defined by the seven Dimensions of Scientific Literacy. When activities are analyzed, we find that they always encompass more than one of the Dimensions of Scientific Literacy, and most can be adapted to develop understanding of all seven Dimensions. **The factors of scientific literacy are the primary foundational objectives for the K-12 science curriculum.** Students who understand these factors understand how science works, and understanding of the factors is developed best through activities.

Middle Level students are immersed in the world of their peers, their environment, their problems, and their development. Early adolescents are aware of the reciprocal nature of peer and community influence. They are curious about things that interest them, capable of mature thinking, and concerned about the quality of their lives. They can be emotional, reluctant to accept authority, and easily bored. Therefore, Middle Level science classes must provide opportunity and guidance for students to discover the science in what is around them and in what they do. They must see what they study as relevant to themselves and to their situation. The Middle Level curriculum guide is designed as a foundation and support for teachers who are trying to encourage such inquiry.

To capture students' interest, ask students to examine the phenomena that they encounter everyday. Students come into science classrooms with vast experience in identifying, prodding, manipulating, and investigating phenomena in order to cope with the world. Bicycle riders have vast experience in the physics of force, motion, balance, momentum, and friction. They also have learned to infer much about their surroundings through visual cues. How deep and muddy is the puddle? How soft is the path?

All students have a constantly changing "picture of the world". **Science class gives them a chance to reexamine, rethink, and reconceptualize their experience from a scientific perspective**. To be scintifically literate is to be able to view the world with science as a frame of reference. This does not mean extinguishing other points of view. Scientifically literate people understand how science works and how science interprets events. Scientifically literate people do not think that science is the only mode of explanation. Science is one context for examining themselves, their ideas, and their lives.

Saskatchewan Education, Training, and Employment's view of science instruction is expressed in the recommendation for lesson planning on page 38 of the guide. Science lessons feature four phases: engaging; exploring (or experiencing); evaluating; and extending. Such lessons may last for a number of class periods. Activities should form the core of each phase in this lesson planning framework.

Engaging ties the science curriculum to students' prior experiences, and to students' interests and needs. During this phase of the lesson, students' conceptions are explored, clarified, and stated. Students are encouraged to share their ideas, understandings, and reactions with each other. Such peer interaction fulfills one of the basic needs of adolescents. The direction the next phases of the lesson take is determined by what is discovered and discussed during this phase.

Exploring involves the investigation of questions raised during the engaging phase of the lesson. The investigations may involve student-designed investigations or activities suggested by teachers. Students should be encouraged to identify and use both community and multimedia resources to further their investigation. Community resources may be persons with expertise, sites to visit, or people who can suggest where information can be obtained. Multimedia resources may be oral histories, written materials, CD-ROM information bases, computer networks, or audio-visual productions.

The **evaluation** phase involves two levels of evaluation. Students must evaluate the results of their research and investigations. Is the information valid and useful? In addition, they must evaluate their understanding of the concepts in light of the results of their explorations. This is a critical phase. In cooperative learning groups, students can challenge each others' explanations and ideas. The evaluation phase is student evaluation of concepts and their notions of those concepts. This is when it is valuable for students to read explanations and illustrations of the concepts they have been studying.

Extending gives students a chance to take the results of their evaluation and put those results to the test. Follow-up of unanticipated discoveries or hypotheses enhances the understanding of what surrounds us.

The Role of Writing and Reading in the Science Curriculum

The goal of science education is to help students become scientifically literate. Scientific literacy for Saskatchewan students is defined by the factors of the Dimensions of Scientific Literacy. In addition, the goals of the Common Essential Learnings and the Adaptive Dimension further diversify the purpose of science education. A key phrase, important to all these goals is 'writing to learn'.

Writing in science classes can play an important role in moving science away from the paradigm of memorizing facts towards understanding the complex interrelationships implicit in the Dimensions of Scientific Literacy, and the Common Essential Learnings. Reading can broaden horizons or be a source of comparison of ideas during concept development. Reading can provide illustrations of how ideas and concepts can be expressed, or stimulate discussion, analysis, and evaluation.

Two forms of writing are important for students in science classes. They may write to inform or they may write to reflect. Both forms foster analysis, synthesis, and evaluation.

Writing to inform may include many components. Brainstorming, categorizing, cooperative learning, making experience charts, making books and charts, researching, webbing – all may be involved in the process of producing a piece of writing. How these aspects interact is outlined in page 142 of **English Language Arts: A Curriculum Guide for the Elementary Level** (Saskatchewan Education, 1992). This outline is reproduced in this guide as Appendix 1.

Writing to inform is targeted for specific audiences and for specific purposes. Before beginning writing, students should have a clear understanding of the audience. Is it their parents? Is it the members of a

grade four class? Is the purpose to inform, to persuade, or to compare? When students read, they can analyze the writing to determine the audience and purpose. The figure on the following page is taken from page 43 in **English Language Arts: A Curriculum Guide for the Elementary Level**. It will serve as a good model for you to help students learn to express their ideas and conceptions and for the students as they organize their writing. Writing to inform focuses on objective data – what the students can observe with their senses. Through writing, students clarify and refine their conceptions and ideas.

What is written could form part of the individual's or group's portfolio, or could be collected as a class newspaper, magazine, newscast, or journal. If the writing is collected, consider reproducing it and distributing it through the school or community. **Wherever possible encourage students to use a word processor to draft, revise, and complete their writing assignments. Encourage the use of correct keyboard technique, and investigate the possibility of your school offering keyboarding courses at the elementary or early middle years level.**

A quiet time for writing – whether it is five minutes or fifteen minutes – at the end of a class, the end of a day, or while waiting to make more observations during an investigation can give students a time to organize their thoughts, rework their internal concept maps, and reflect upon what they have been studying. The myth of the aloof, objective scientist who records only measurements should be eliminated from the science classroom. **Writing and reading about what they are seeing, thinking, and reading should become a daily part of the students' regimen**. Writing may include observations, speculations, digressons, information, and synthesis of any of the above.

During the process of writing for reflection, students have an outlet for their feelings about what they are learning, and for expressing their ideas about how they can assimilate or accommodate the information they are acquiring. It is a time for reflection into values and attitudes.

Sentence stems may occasionally be provided to help students get started, but reflective writing should not be turned into student responses to a series of questions. Possible stems are:

- It is still confusing to me that ...
- I learned that I ...
- I think that this is related to ...
- What really surprised me was...

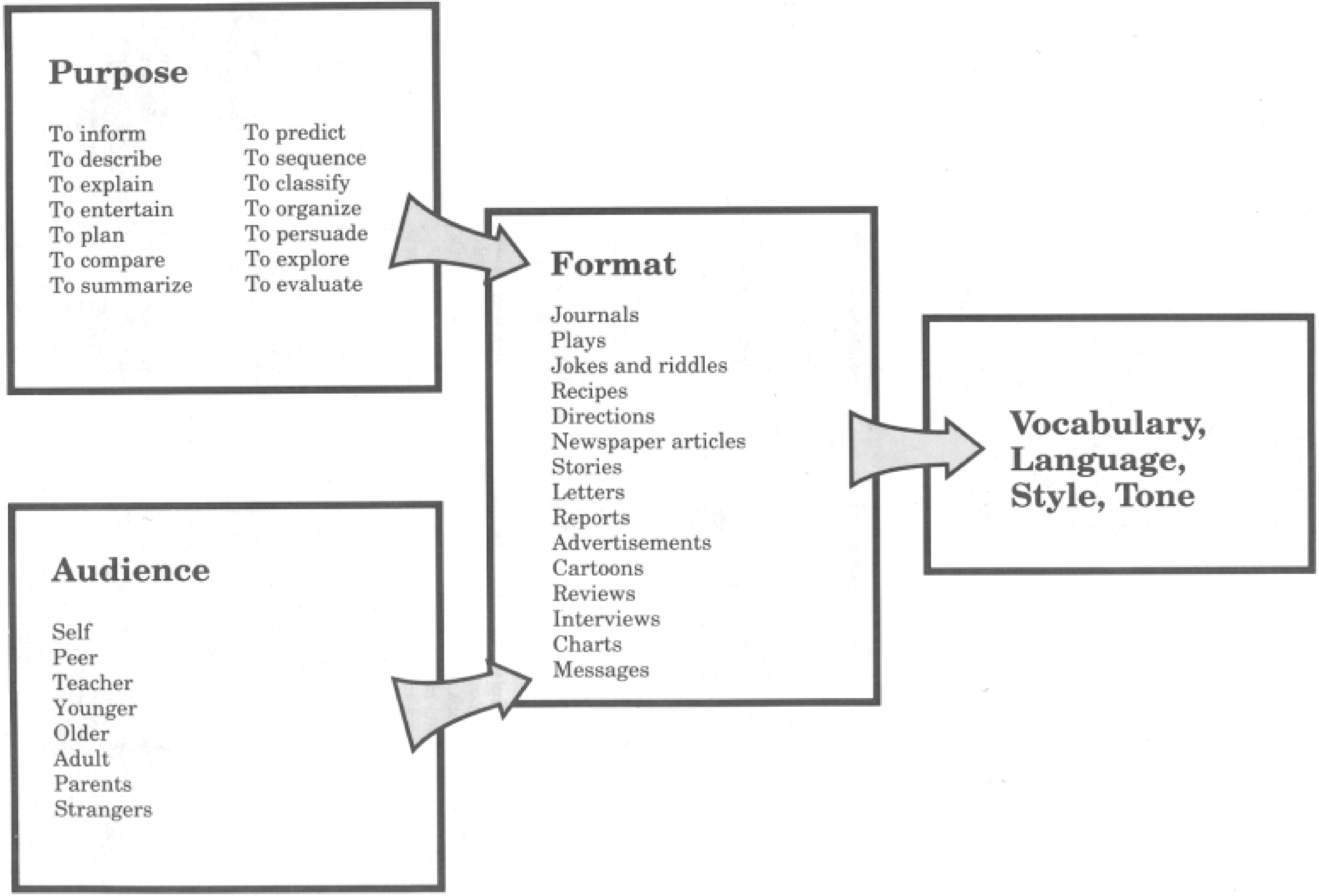
Alternatively, a question or two may be used to initiate writing:

- What did I enjoy (hate, accomplish) in class today?
- What did I learn today?

Tips about using journal writing are found in **English Language Arts: A Curriculum Guide for the Elementary Level**, page 107. This page is reproduced in this guide as Appendix 2.

Refer to the **English Language Arts: A Curriculum Guide for the Elementary Level** for a more comprehensive discussion of writing and reading.

Figure 1: **Decisions Writers Make** - from *English Language Arts: A Curriculum Guide for the Elementary Level*



Possible writing activities

Ways to use science writing and reading in a Middle Level classroom are as diverse as the imaginations of the students.

♦ A school or community newsletter dealing with science topics which have been studied in one of the core units, and which have an application in the community might be produced. Begin by brainstorming in small groups to produce a list of topics which are of particular interest. Compile a class list and assign one topic to each group.

  Ask each group to arrive at a consensus on the division of labour for the research, writing, proof-reading, and production tasks. Set a deadline for each phase of the project. Produce some sort of project progress report sheet or chart to hang on the wall, to be completed at various stages of the work.

  Decide with the class how the individual reports will be compiled, duplicated, and distributed. This is an ideal opportunity to encourage the use of a word processing program, or a desktop publishing package.

♦ Write a script for a television commercial. Pick topics which are related to what is being discussed in class and then give them a little twist. For example, promote the advantages of buying a house right on a major earthquake (plate boundary) fault, of living in a condo complex built in an empty room of a potash mine, or the merits of a super solution they have created. Divide the tasks as in the activity above.

For other examples, consult the **Suggested activities** section at the end of each unit. To create some writing activities specific to the curriculum, organize a hour long session at your next institute for all teachers of Middle Level science. Group the teachers in pairs or threes and assign one of the units in the Middle Level curriculum. Ask the teachers to create three writing activities that focus on the concepts in the unit they have been assigned. The figure on page 4 will be useful for this activity. Collect, duplicate, and distribute the product to all participants.

Reading

An important type of reading is the reading of material written by peers. Peer review can be an important part in the development of writing ability and focus for both the writer and the reader.

By reading a variety of materials related to what they are studying, students see that **not all science information comes from one textbook** and that there is intrinsic interest for many people in the topics of science.

Most nonfiction is described as expository text, written to inform or to evaluate. It is not necessary to read it as we usually read fiction, from the start of the book to the finish of the book. Most nonfiction can be read in nonsequential chunks without losing meaning. Try reading a mystery novel that way! There are several strategies which can be used to help students make sense of the nonfiction they are reading. Scanning the Table of Contents, headings, illustrations, and first sentences of paragraphs can help the students understand the topic of the writing. If individuals or small groups then create a list of what they know about the topic and list questions they have about the topic, they are then more able to place what they read into their context of how the world works. Once they have completed their reading, writing in reflective reading logs, or revising concept webs or maps drawn before reading can help them assimilate the material.

Consult **Science: A Bibliography for the Middle Level** for recommendations about fiction and nonfiction which can be used during science classes. One example of a book referenced in the bibliography which mixes fiction, nonfiction, and references to other sources of readings is **Force and Machines**. Encourage students to keep logs of science-related reading. Additional strategies for guiding students' reading of expository text are found on page 104 of **English Language Arts: A Curriculum Guide for the Elementary Level**, reprinted as Appendix 3 of this guide.

Science Challenge

Science challenge is a way of giving students the maximum opportunity to extend their learning in a direction of their choosing or in a style of their own. The starting point may be something that intrigued a student during the exploration phase or evaluation phase of the lesson. It may be the extension part of the lesson. There is no set formula for what science challenge is or what must be done during science challenge.

Structured programs may be used during science challenge. Science Olympics is one such program. The Youth Science Foundation in Ottawa has an information booklet describing how to organize a Science Olympics event in your classroom. ***Science Is...*** (see *Science: A Bibliography for the Middle Level*) has many pages of ideas for Science Olympic challenges.

Science fair projects also fall under the category of science challenge activities. The Youth Science Foundation publishes a series of booklets explaining how to use science fair projects in the classroom. In addition, ***Science 10: A Curriculum Guide for the Secondary Level*** has three pages of suggested topics for science fair projects. Students at the Middle Level may wish to use one of these ideas or they may use one or more of them to initiate a brainstorming session which will generate their own ideas.

Science Challenge may take the form of a logic puzzle for the students to solve in small groups. A question which requires divergent or lateral thinking skills may be used in a class discussion or on an exam as a science challenge. It may be a challenge to build a three-dimensional model to explain some concept, or to create an analogy using the basic form "A ________ is like a _______because ______________."

In short, science challenge encourages students to step outside the traditional confines of science lessons and get away from asking the question "What do we have to know for the exam?" to asking "Why is ...?" or "How does ...?"

Related Documents

Saskatchewan Education, Training, and Employment has produced the following documents to support the Middle Level science program.

Science: A Curriculum Guide for the Middle Level contains the specific information needed to plan and deliver the Middle Level courses.

Science: Program Overview and Connections K-12 (Draft, 1989) contains important sections on the philosophy and rationale behind the teaching of science, and on planning for instruction in science for all teachers from kindergarten to grade 12. Sections of this document will also be useful for administrators, teacher-librarians, and others.

Science: An Information Bulletin for the Middle Level –Key Resource Correlations lists the key resources which have been recommended to help achieve the factors and objectives outlined in the Curriculum Guide. It is organized so that the resources, with page or chapter references, are listed for each topic in the Curriculum Guide. It was packaged with this guide.

Science: A Bibliography for the Middle Level contains an annotated listing of resources which can be used to enrich the science program and to assist in implementing Resource-Based Learning in the classroom. Each annotation contains a recommendation about the topic(s) for which the resource is most appropriate.

The Factors of Scientific Literacy

Before using this Curriculum Guide, teachers should be familiar with the *Science Program Overview and Connections K-12*, a document that provides background information about the factors of scientific literacy. A list of the factors, their definitions, and examples of instances in science where these factors are important, or can be developed, is also found beginning on page 70 of this Curriculum Guide. Many of the factors identified as components of the Dimensions of Scientific Literacy can be developed during the Middle Level curriculum.

Students will exhibit varying degrees of sophistication in dealing with some factors of scientific literacy. Some may be at a rudimentary level in understanding; others will be advanced. The teacher will need to adapt the course to meet these student variations.

In order to emphasize as many of these factors as possible during the course, and to concentrate on those less well developed, teachers must have a thorough understanding of each factor and exhibit good lesson planning and lesson reflection skills. Lesson reflection means that, at the end of the lesson, the teacher thinks about what happened. **Based on assessment of student interests, understandings, strengths and needs, the teacher identifies what was understood and what needs more work**. The teacher must verify the connections among the goals, factors and objectives. The section in this Curriculum Guide on Unit Planning, beginning on page 38, provides general and specific information regarding unit and lesson planning.

The curriculum in K-12 science in Saskatchewan schools is the attainment of the factors of scientific literacy. Attainment of these factors involves understanding, ability, and appreciation. The scope and depth of the Middle Level science curriculum is guided by the factors.

Figure 2: **Using This Curriculum Guide**

Unit overview

- gives the spirit and nature of the unit
- may contain instructions for the teacher

Concept development

- outlines how the unit fits into the development of that strand of science from grades 1-10

Factors of Scientific Literacy

- lists factors which can be stressed
- together with the lists in the other core units, ensures that each factor important for that grade level is listed for emphasis at least once during the grade

Foundational and learning objectives

- foundational objectives are those which all students must accomplish during the course of the unit or the grade
- learning objectives are **suggestions** of ways that the foundational objectives might be accomplished
- teachers, in consultation with the students, may select objectives from those listed, or create new objectives which will help achieve the foundational objective

Suggested activities are included with each unit. These are not compulsory activities but are included to supplement those which are found in the resources recommended for support of the curriculum, in personal files, and during reading and other professional development activities. Most of the activities are intended to be done by student groups of two, three, or four students. This cooperative group activity is essential for development of science concepts through group small group discussion and interaction.

Both **resources** listed in the Elementary Level Curriculum Guide and in the Bibliography, and **activities** found in the Elementary Level Curriculum Guide may be useful at the Middle Level. Question the students and involve them in activities to find out about their concepts and preconceptions with regard to the topics you will study. Concept mapping is a good technique to discover and clarify what is known and to evaluate progress. Resources recommended for the Elementary Level may in many cases prove to be an appropriate starting place for considering a topic at the Middle Level.

Figure 3: **Course Overview**

	Grade 6	Grade 7	Grade 8	Grade 9
Core Units	Chemicals and Reactions	The Basics of Life	Adaptation and Succession	Saskatchewan – Environment[4]
	Earthquakes and Volcanoes	Saskatchewan – The Land	The Moving Crust[2]	Chemistry and You
	Ecosystems	Force and Motion	Solutions	Using Electricity
	Exploring Space	Structures and Designs	Energy Resources in Saskatchewan[3]	Risks and Limits
	Energy in Our Lives	Renewable Resources in Saskatchewan[1]	Earth and Space	
Optional Units	Growth and Development	Microorganisms	Consumer Product Testing	The Atmosphere
	Human Body Control Systems	Temperature and Heat	Plant Growth	Fluids and Pressure
	Earth's Climate	Resource Use	Energy and Machines	Diversity of Life

Superscripts indicate the *Saskatchewan Resource Series* units to use with this curriculum.

1. Forestry
2. Potash
3. Petroleum
4. • Agriculture
   • Energy and the Environment

The order that the units appear on this chart should not dictate the order they are used in the classroom. The order in which they are used is an instructional decision based on the year's plan and on what is best for the community in which the school is located.

Recommendations for allocating time

- Spend a **minimum** of 10% of the time available for the course on each core unit. This would be approximately 4 weeks for a full year course and 2 weeks for a semestered course.

- At least one optional unit must be integrated with a core unit or completed independently of the core units.

- Aim to spend 30% of class time on optional units or optional topics within core units.

Scheduling scenarios

These scenarios are provided for a number of reasons. They show that the units need not be presented in the order in which they appear in the Guide. They also illustrate that core or optional units may be integrated or taught concurrently. They give an example of how the time requirements for each unit can be expressed in either semestered or in non-semestered classrooms.

Following are some questions that may be used to guide your scheduling decisions:

- Do you want to do your life science unit(s) during autumn, winter, or spring?
- Are there some times during the year when community resources for a particular unit (people, places to visit) are more available?
- Can you coordinate your schedule with other schools in the division or classroom in your school in order to share resources?
- Are major holiday periods going to come at key parts of the course? (You probably wouldn't want to have students doing plant growth experiments in the classroom during the period which includes Christmas holidays.)

Grade 8 nonsemestered classroom

- ***Saskatchewan Resources*** (integrated unit incorporating **The Moving Crust** and **Energy Resources in Saskatchewan**)
  August 31 - November 13 (11 weeks)

- **Consumer Product Testing**
  November 16 - December 22 (5½ weeks)

- **Solutions**
  January 10 - February 18 (6 weeks)

- **Earth and Space**
  February 21 - April 22 (8 weeks)

- **Adaptation and Succession** (taught concurrently with **Plant Growth**, for a 5-week share of the time)
  April 25 - June 17 (8 weeks)

- **Plant Growth** (taught concurrently with **Adaptation and Succession**, for a 3-week share of the time)
  April 25 - June 17 (8 weeks)

Grade 9 semestered classroom

- **Using Electricity**
  February 1 - February 25 (4 weeks)

- **Chemistry and You**
  February 28 - March 18 (3 weeks)

- **Risks and Limits**
  March 21 - April 7 (3 weeks)

- **The Atmosphere**
  April 18 - May 13 (4 weeks)

- **Saskatchewan – Environment**
  May 16 - June 15 (4½ weeks)

Guidelines To Using Resource Materials

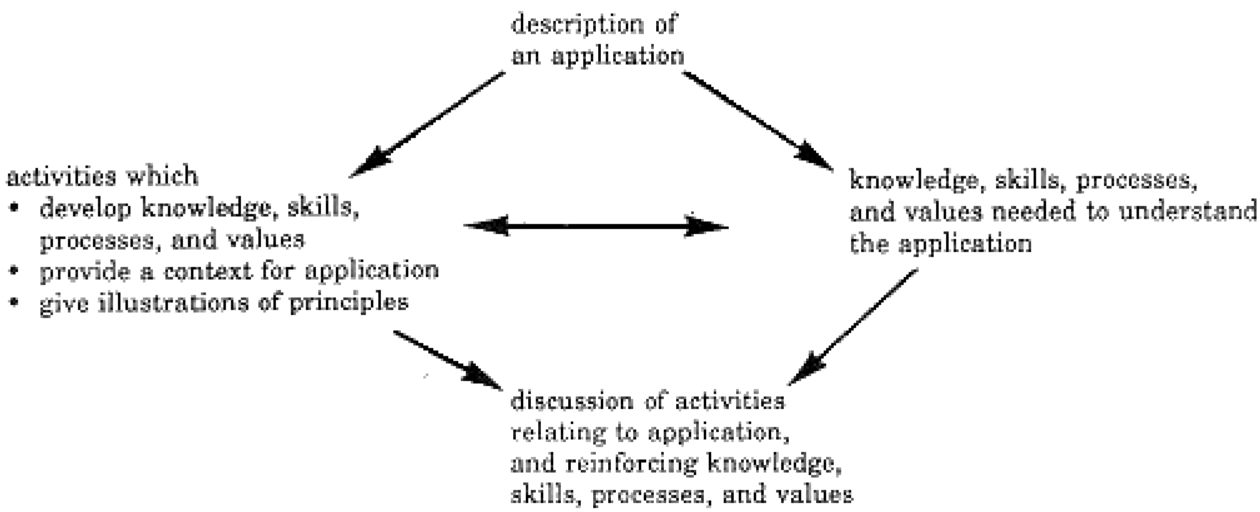
To facilitate a resource-based approach, the use of a variety of resources instead of a single textbook is highly recommended. A Resource-Based Learning approach requires long-term planning and coordination within a school or school division. In-school administrators, teacher-librarians, and others need to take an active role to assist with this planning. Consult the *Bibliography*. As new resource materials become available, **Information Bulletins** may be issued as updates. They will indicate which new resources are appropriate for use, as well as those resources that are no longer available.

Instructional approaches which apply the Adaptive Dimension, promote equity, emphasize group work, and develop independent learning abilities make it possible to utilize limited resources in a productive way.

A Science-Technology-Society-Environment (STSE) Approach to Science Education

The STSE approach recommended for science in Saskatchewan schools differs from the way science has traditionally been presented. The ideal is to introduce a topic for study through the description of an application. In order to understand the science behind the application, knowledge and skills must be developed, along with activities which give purpose to the newly acquired knowledge and skills. Alternatively, the activities may immediately follow the discussion of the application, and serve to develop the knowledge and skills needed to understand the application. The arrows on Figure 4 are meant to show the variety of paths from the description of an application to the final discussion.

Figure 4: **An STSE Approach to Science Education**



Core Curriculum and Other Initiatives

Core Curriculum: Plans for Implementation (Saskatchewan Education, 1987) defines the Core Curriculum as including seven Required Areas of Study, the Common Essential Learnings, the Adaptive Dimension, and Locally-Determined Options.

Understanding the Common Essential Learnings: A Handbook for Teachers (Saskatchewan Education, 1988), as a foundation document for Saskatchewan Education, Training, and Employment, defines and expands on an understanding of these essential learnings.

Other Saskatchewan Education, Training, and Employment documents elaborate on the concept of Core Curriculum. See the references in this Curriculum Guide and in *Science Program Overview and Connections K-12 (Draft, 1989).*

Other supportive initiatives for Core Curriculum developed by Saskatchewan Education, Training, and Employment include Gender Equity, Indian and Métis perspectives, and Resource-Based Learning. These initiatives can be viewed as principles that guide the development of curricula as well as instruction in the classroom. The initiatives outlined in the following statements have been integrated throughout the curriculum.

The Adaptive Dimension in the Middle Level Science Curriculum

The Adaptative Dimension aims to meet learner needs and is an expectation inherent in the Goals of Education. It is an essential ingredient of any consideration of instructional approaches. In *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) the Adaptive Dimension is defined as:

> the concept of teachers exercising their professional judgement to develop an integrated plan that encompasses curricular and instructional adjustments to provide an appropriate education that is intended to promote optimum success for each child.

The continuum of curricular programs authorized by Saskatchewan Education, Training, and Employment – Regular, Transitional, and Alternative programs – recognizes the need for variation in curriculum content and delivery mechanism. The continuum indicates that within each program, and therefore within each course of study, adaptation is required. Teachers are empowered to adjust the instructional materials or the classroom setting in order to meet student needs. As professionals, teachers must ensure that the instructional approaches are also adapted. This implies that teachers have at their "fingertips" a broad, strong repertoire of instructional strategies, methods, and skills and that conscious planning takes place to adapt these approaches to meet student needs.

The cues that some students' needs are not being adequately met come from a variety of sources. They may come to the perceptive teacher as a result of monitoring for comprehension during a lesson. The cue may come from a unit test, or from a student need or background deficiency that has been recognized. A student's demonstrated knowledge of, or interest in, a particular topic may indicate that enrichment is appropriate. The adaptation required may vary from presenting the same content through a slightly different instructional method, to choosing varied materials because of a known information background deficit, to establishing an individual or small group enrichment activity. The duration of the adaptation may range from five minutes of individual assistance, to offering the student substantive enrichment opportunities. The diagnosis of the need may be handled adequately by the classroom teacher, or may require the expertise of other support specialists such as the school's resource teacher or the Regional Coordinator – Special Education.

The recognition of the need for adaptive instruction is dependent upon the professional judgement of the teacher. The decision to initiate adaptive practices must be an informed one. While the practice of adapting instruction may occur through the placement of students in programs other than those defined as regular, **the most frequent application of the Adaptive Dimension will occur as teachers in regular classroom settings adjust their use of both resources and instructional approaches**. By such adjustments, the Foundational Objectives of the curriculum can be met by all students. **The Foundational Objectives do not change.**

Instructional Approaches: A Framework for Professional Practice identifies a hierarchy of approaches – models, strategies, methods, and skills. The four basic **models** of instruction do not change, whether used in a "regular" class setting, or with a small group as an adaptive approach. The strategies, methods, and skills may be altered or adapted. Hence a framework for inservice, investigation, and discussion among professionals has been established.

The essence of the Adaptive Dimension rests in the phrase "seeking other ways". **If teachers can make adjustments in the science program to accommodate diversity in students learning needs and make the curriculum, instruction, and the learning environment more meaningful and appropriate for each student, the Adaptive Dimension has been incorporated into the science classroom**.

Some ways this can be done in the science classroom include:

- altering the pace of the lesson to give students sufficient time to explore, create, question, and experience as they learn;
- monitoring the use of science vocabulary;
- varying the methods of instruction used so that the learning styles of all students are accommodated;
- expecting a variety of forms of response, including, but not limited to oral, written, graphical, and visual modes; and,
- modifying student assessment so that it reflects the activities of the classroom and the abilities of the students.

Common Essential Learnings

Science offers many opportunities for incorporating the Common Essential Learnings into instruction. The purpose of this incorporation is to help students better understand factors which form the Dimensions of Scientific Literacy and to prepare students for their future learning both within and outside the K-12 educational system. The decision to focus on a particular Common Essential Learning within a lesson is guided by the needs and abilities of individual students and by the particular demands of science. Throughout a Core Unit, it is intended that the **Foundational Objectives for Science and the Common Essential Learnings** will have been developed to the extent possible, regardless of the topics selected.

It is important to incorporate the **Foundational Objectives for Science and the Common Essential Learnings** in an authentic manner. For example, some topics may offer many opportunities to develop the understandings, values, skills, and processes related to a number of the foundational objectives. The development of a particular foundational objective, however, may be limited by the nature of the topic under study.

It is intended that the Common Essential Learnings be developed and evaluated within subject areas. Therefore, **Foundational Objectives for Science and the Common Essential Learnings** are included in the introductory section of each Core Unit in this Curriculum Guide. Since the Common Essential Learnings are not necessarily separate and discrete categories, it is anticipated that working toward the achievement of one foundational objective may contribute to the development of others. For example, many of the processes, skills, understandings, and abilities required for the Common Essential Learnings of Communication, Numeracy, and Critical and Creative Thinking are also needed for the development of Technological Literacy.

Incorporating the Common Essential Learnings into instruction has implications for the assessment of student learning. Assessment in a unit which has focused on developing the Common Essential Learnings of Communication and Critical and Creative Thinking should reflect this focus. Assessment strategies can allow students to demonstrate their understanding of the important concepts in the unit and how these concepts are related to each other and to previous learning. Questions can be structured so that evidence or reasons may accompany student explanations. **If students are encouraged to think critically and creatively throughout a unit, then the assessment strategies for the unit should also require students to think critically and creatively**.

It is anticipated that teachers will build from the suggestions in this Curriculum Guide and from their personal reflections in order to better incorporate the Common Essential Learnings into the teaching of science.

Throughout this Curriculum Guide, the following symbols may be used to refer to the Common Essential Learnings:

COM	Communication
CCT	Critical and Creative Thinking
IL	Independent Learning
NUM	Numeracy
PSVS	Personal and Social Values and Skills
TL	Technological Literacy

Incorporating the Common Essential Learnings into Science Instruction

The science curriculum from Kindergarten to grade 12 involves the development of the factors within the Dimensions of Scientific Literacy. The main goal is to promote an interest in, and an understanding of, science.

The Common Essential Learnings should be planned and developed within the context of good science lessons. As lesson planning is taking place, consideration should be given to how to incorporate the Common Essential Learnings. The **Factors of Scientific Literacy Which Should Be Emphasized**, and the **Foundational Objectives for Science and the Common Essential Learnings** outlined at the beginning of each Core Unit, provide appropriate starting points in planning.

Science-Technology-Society-Environment Inter-relationships (Dimension D) help to develop

Technological Literacy. Technology, as it is developed within this Dimension, is studied within a social context. The connections between science and technology are elaborated. Furthermore, the impact that technology has on society, on science, and on the environment is developed. Technology is defined as more than the gadgets and gizmos that are often the only things associated with it. Most of the topics within the Middle Level science curriculum can help to develop Technological Literacy.

Scientific and Technical Skills (Dimension E) also helps to develop Technological Literacy. Many scientific and technical skills in use today exist because of materials and instruments which have been developed through advances in technology. The impact that these new things have on our lives and on the environment is very important.

Numeracy can be developed through various factors of scientific literacy which are linked closely with this Common Essential Learning. Some of these include the empirical nature of science (A5), quantification (B8), probability (B19), accuracy (B21), measuring (C5), using numbers (C7), using mathematics (C17), and using quantitative relationships (E13). To anyone who understands science, the importance of Numeracy is readily apparent.

Problem solving can lend itself to developing Numeracy. Any other quantitative applications, of which there are many, further develop this Common Essential Learning. Students should be given many opportunities to develop ways in which quantities can be measured, recorded, manipulated, analyzed, and interpreted. Simply plugging numbers into obscure formulae is undesirable. Students must appreciate the importance of numeric information in the world of science. Related skills such as estimating and approximating, rounding off, graphing, tabulating, calculating, using significant figures and scientific notation, should be developed in science.

Specific factors relating to the Common Essential Learning of Communication are not as easy to identify, with the notable exception of communicating (C2). The public/private nature of science (A1) reveals the underlying importance of communication in science. Scientists share their discoveries with others. This involves the use of language and of written and verbal communication. When students explore important scientific principles, and discuss their understandings orally or in writing, using their own language, their ability to communicate evolves. Skills which help to promote and develop effective communication need to be reinforced. They are important aspects of a good science program. Review the section in this Guide on **Science Writing and Reading.**

Values that Underlie Science (Dimension F) and Science-Related Interests and Attitudes (Dimension G) help to develop Personal and Social Values and Skills. Attaining the factors in these two Dimensions of Scientific Literacy can lead to positive attitudes about science. These Dimensions involve the affective domain. Other factors, such as working cooperatively with others (C4), scientists and technologists are human (D2), and the human/culture related nature of science (A9), further help to develop Personal and Social Values and Skills.

An activity-oriented science program will develop critical and creative thinkers. Among other things, scientific inquiry involves hypothesizing (C8), designing experiments (C16), observing and describing (C3), inferring (C9), arriving at conclusions, formulating scientific laws, developing or testing theories, etc. These kinds of activities require higher level thinking.

The emphasis on practical applications of science throughout the entire curriculum allows students to make meaningful connections with the real world, transferring their understanding of science to things which make their learning relevant. Problem solving activities and classroom outreach further develop the knowledge, values, skills, and processes related to Critical and Creative Thinking.

Considering controversial issues in science also leads students to develop Critical and Creative Thinking abilities when they analyze conflicting value positions. As they develop a knowledge base and begin to form their own value positions, Personal and Social Values and Skills are developed.

Independent Learning can also be developed well in science because of the emphasis being placed on variety in instructional approaches. By placing less emphasis on traditional lecture presentations, teachers transfer more of the responsibility for learning from themselves to their students. The student assumes a more active role in the classroom experience. The teacher assumes the role of the learning facilitator.

The science curriculum has the potential for developing Independent Learning. By pursuing topics of interest, with direction and encouragement from their teachers, students can become highly motivated and enthusiastic about science. Topics in the curriculum of contemporary interest require that students keep up to date with current affairs. They may need to do independent study, using a wide variety of resources and different types of media, to investigate topics of current interest. This lends itself well to Resource-Based Learning. As students examine issues and notice the effects that competing and conflicting points of view have on shaping those issues, an appreciation of the social impact of science will likely emerge. Making these connections helps students recognize that learning takes place throughout life, continuing after formal schooling has ended.

While some science content can be identified with specific Common Essential Learnings, quite often it can not. **The Common Essential Learnings developed in any given lesson do not depend solely upon content, but also upon teacher behaviour and modelling, and upon the processes which students experience**. The teaching strategies selected, through careful unit and lesson planning, are what determine which Common Essential Learnings will be developed, and how well they will be developed. The key point is that a conscientious effort to incorporate the Common Essential Learnings can make a tremendous impact on students.

For many topics in science, any of the Common Essential Learnings can be developed. Which ones are developed, and to what extent any Common Essential Learning is emphasized depends on the goals of the science curriculum, the needs of the students, and the foundational and learning objectives being addressed in the unit. Just as there are many different ways to teach a lesson, so too there are many different ways of incorporating the Common Essential Learnings into that lesson. What matters is that teachers develop the Common Essential Learnings effectively, with the specific interests and needs of their students in mind. The beauty of incorporating the Common Essential Learnings into science is that, as in other subject areas, the ways in which this can be done are dynamic and flexible. The methods used change as students' needs change.

Gender Equity

Saskatchewan Education, Training, and Employment is committed to providing quality education for all students in the K-12 system. Expectations based primarily on gender limit students' ability to develop to their fullest potential. While some stereotypical views and practices have disappeared, others remain. Where schools endeavour to provide equal opportunity for male and female students, continuing efforts are required to achieve equality of benefit or outcome. It is the responsibility of schools to create an educational environment free of gender bias. This can be facilitated by increased understanding and use of gender balanced material and non-sexist teaching strategies. Both female and male students need encouragement to explore nontraditional as well as traditional options.

In order to meet the goal of gender equity in the K-12 system, Saskatchewan Education, Training, and Employment is committed to bringing about the reduction of gender bias which restricts the participation and choices of students. It is important that Saskatchewan curricula reflect the variety of roles and the wide range of behaviours and attitudes available to all members of society. The new curricula strive to provide gender-balanced content, activities, and teaching approaches. It is hoped that this will assist teachers in creating an environment free of stereotyping, enabling both females and males to share in all experiences and opportunities which develop their abilities and talents to the fullest.

These suggestions for encouraging gender equity in science classrooms are adapted from *Gender Equity: A Framework for Practice* (Saskatchewan Education, 1992).

- Have equally high expectations for students of both genders.
- Provide opportunities for both female and male students to design and conduct their own science investigations.
- Select written material which is gender equitable, and bring to the attention of other staff gender biased portions of materials currently in use.
- Encourage and reward intellectual risk taking in science.
- Ask divergent questions.
- Ensure that both genders have comparable access to and time with laboratory equipment.
- Provide activities which have student-directed components.
- Encourage innovative solutions.
- Provide information about scientists of both genders.
- Support the participation of both genders in science fairs.
- Increase awareness about nontraditional careers for students of both genders.
- Have mixed gender groupings for projects and investigations.

Resource-Based Learning

Resource-based teaching and learning is a means by which teachers can greatly assist the development of attitudes and abilities for independent, life-long learning. Resource-based instruction involves units that integrate resources with classroom assignments, and teach students the processes needed to find, analyze, and present information. Teachers, teacher-librarians, and other professional staff may be involved in planning such units.

Resource-based instruction is an approach to curriculum that involves students with all types of resources. Some possible resources are: books, magazines, films, audiotapes and videotapes, computer software and databases, manipulable objects, commercial games, maps, people and community resources, museums, field trips, pictures and study prints, real objects and artifacts, and media production equipment.

Resource-based learning is student-centred. It offers students opportunities to choose, to explore, and to discover. Students who are encouraged to make choices, in an environment rich in resources where their thoughts and feelings are respected, are assisted to become autonomous learners.

The following points will help teachers use resource-based teaching and learning.

- Discuss the objectives for the unit with students. Focus the discussion on how the students can relate the objectives to their environment, different cultures and other factors which are appropriate to their situation. Correlate needed research skills with the activities in the unit, so that skills are always taught in the context of application. Work with your teacher-librarian, if one is available.
- Model for students a variety of ways to gather, organize, and share information.
- Plan in good time with the other school staff so that adequate resources are available, and decisions are made about shared teaching responsibilities, if applicable.
- Use a variety of resources in classroom teaching, showing students that you are a researcher who constantly seeks out sources of knowledge. Discuss with them the use of other libraries, government departments, museums, and various outside agencies in their research.
- Ask the teacher-librarian (if available) to provide resource lists and bibliographies when needed.
- Participate in, and help plan, inservice programs on using resources effectively.
- Continually request good curriculum materials for addition to the library collection.
- Support the essential role of the library resource centre and the teacher-librarian in discussions with colleagues, principals, and directors.
- Actively involve yourself and your students in evaluating the resources for bias.
- Make use of the **Innovators in the Schools** program.

More information on Resource-Based Learning may be found in *Science Program Overview and Connections K-12* and in *Resource-Based Learning: Policy, Guidelines and Responsibilities for Saskatchewan Learning Resource Centres* (Saskatchewan Education, 1987).

Indian and Métis Curriculum Perspectives

The integration of Indian and Métis content into the Kindergarten to Grade 12 curriculum fulfils a central recommendation of *Directions*. *The Five Year Action Plan for Native Curriculum Development* further articulates the commitment and process. In addition, the *1989 Indian and Métis Education Policy from Kindergarten to Grade 12* makes the statement:

> Saskatchewan Education recognizes that the Indian and Métis peoples of the province are historically unique peoples and occupy a unique and rightful place in society today. Saskatchewan Education recognizes that education programs must meet the needs of Indian and Métis peoples, and that changes to existing programs are also necessary to benefit all students. (p.6)

It is recognized that, in a pluralistic society, affirmation of culture benefits everyone. Its representation in all aspects of the school environment enables children to acquire a positive group identity. Instructional resources which reflect Indian and Métis cultures similarly provide meaningful and relevant experiences for children of Indian and Métis ancestry and promote the growth of positive attitudes in all students towards Indian and Métis peoples. Awareness of one's own culture, and the cultures of others, forms the basis for positive self-concept. Understanding other cultures enhances learning and enriches society. It also promotes an appreciation of the pluralistic nature of Canadian society.

Indian and Métis students in Saskatchewan have varied cultural backgrounds and come from geographic areas encompassing northern, rural, and urban environments. Teachers must be given support that enables them to create instructional plans relevant to meeting diverse needs. Varied social, cultural, and linguistic backgrounds of Indian and Métis students imply a range of strengths and learning opportunities for teachers to draw upon. Explicit guidance, however, is needed to assist teachers in meeting the challenge by enabling them to make appropriate choices in broad areas of curriculum support. Theoretical concepts in anti-bias curricula, cross-cultural education, applied socio-linguistics, first and second language acquisition, and standard and non-standard usage of language are becoming increasingly important to classroom instruction. Care must be taken to ensure teachers utilize a variety of teaching methods that build upon the knowledge, cultures, and learning styles students possess. All curricula need specific kinds of adaptations to classroom strategies for effective use.

The final responsibility for accurate and appropriate inclusion of Indian and Métis content in instruction rests on teachers. They have the added responsibility of evaluating resources for bias, and teaching students to recognize bias.

These points summarize expectations for Indian and Métis content and perspectives in curricula, materials, and instruction.

- Concentrate on positive and accurate images.
- Reinforce and complement beliefs and values.
- Include historical and contemporary insights.
- Reflect the legal, political, social, economic and regional diversity of Indian and Métis peoples.
- Affirm life experiences and provide opportunity for expression of feelings.

The following ideas can encourage integration of Indian and Métis perspectives in all science classrooms:

- Investigate phenomena and issues related to the students' environment.
- Encourage students to investigate their world, based on topics of interest to them.
- Use an activity-based hands-on approach to promote success and the development of a positive self-image.
- Use resources, both concrete and pictorial, with which the student is familiar and comfortable.
- Include student-focused projects.
- Provide opportunities for the collection of data.
- Demonstrate how science applies to other subject areas and to daily life.
- Provide opportunities for students to work together in cooperative groups of various sizes.
- Encourage students to present their ideas and the results of their investigations to their peers in both oral and written forms.
- Integrate scientific ideas associated with traditional Indian and Métis cultures.

The ways in which a people are referred to determine how they will be perceived by others. Terms evolve and may vary by location and in specific situations. The term "Indian" may be appropriate in some situations and not in others. People in the local community are often the best judge of what terms apply to groups of peoples. Consult ***Diverse Voices*** (p.3) for advice.

Instructional Approaches

The factors of scientific literacy and the Common Essential Learnings are the foundations of the K-12 Science program. In order to give students a chance to develop their understandings and abilities in these foundations, it is necessary for teachers to use a broad range of instructional approaches. *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) provides a framework to help teachers understand and implement a variety of methods of teaching. The science curriculum has been designed to support teachers in using such a broad-based approach in the classroom by making the curriculum flexible enough to accommodate their plans. Specific information on teaching science using a variety of strategies can be found in *Teaching Science Through a Science-Technology-Society-Environment Approach: An Instruction Guide* (SIDRU, 1988).

Ideas on adapting the curriculum to the classroom can be found on page 13 of this Guide, in the section titled **The Adaptive Dimension in the Middle Level Science Curriculum.**

When varying instructional approaches are used, evaluation techniques must be matched to the approaches. If students learn by doing, assessments may involve students showing what they can do.

Student assessment should reflect the methods of instruction. Figure 5 on page 20 outlines some of the relationships between instructional methods and assessment techniques.

The verbs of the **Learning Objectives** listed for the units suggest various approaches to instruction, and reiterate some processes of science. Note these examples:

- analyze
- assess
- classify
- compare
- create
- debate
- determine
- develop
- discuss
- distinguish
- examine
- explain
- explore
- identify
- investigate
- map
- recognize
- relate
- test
- use

If concept mapping has been used as a method to help students analyze the interrelationships inherent in a grassland community, then a concept map, essay, or mural might be appropriate ways of asking students to communicate what they have learned.

Figure 5: **Correlating Instruction, Evaluation, and Science Goals**

Instructional Strategies	**Some Important Instructional Methods for Science** (See p. 20, **Instructional Approaches: A Framework for Professional Practice**)	**Some Corresponding Assessment Techniques*** (See pages 23, 45 ***Student Evaluation: A Teacher Handbook***)	**DSL Major Emphasis** (See p. 1-2 this Guide)
Direct	• Demonstrations • Mastery Lecture • Structured Overview	• Group/Individual (Peer/Self): Performance Assessments, Written Assessments • Short-Answer Quizzes & Tests	B, E
Indirect	• Concept Mapping/Formation/ Attainment • Inquiry • Problem Solving	• Individual/Group: Presentations • Oral Assessments • Performance Assessments • Written Assignments	A-D
Experiential	• Conducting Experiments • Field Observations & Trips • Model Building • Simulations	• Group/Individual: Performance Assessments; Written Assignments; Presentations • Peer/Self: Oral Assessments • Technical Skills	B, C, E
Independent Study	• Computer Assisted Instruction • Essays & Reports • Homework • Research Projects	• Performance Assessments • Portfolios • Presentations • Quizzes • Written Assignments	All
Interactive	• Brainstorming • Co-operative Learning Groups • Discussion • Laboratory Groups	• Group/Peer: Oral Assessments • Written Assignments • Self-Assessment/Peer	All

* Ancedotal Records, Observation Checklists, and Rating Scales can be used as methods of data recording with all of the categories.

Some Adaptive Dimension Variables

Curriculum
- prior knowledge, skills
- topics
- materials
- evaluation

Instruction
- strategies, methods, skills
- pacing and time
- feedback, modification and reflection

Learning Environment
- classroom climate
- grouping
- support
- physical setting

Assessment and Evaluation

Why Consider Assessment and Evaluation?

Much research in education around the world is currently focusing on assessment and evaluation. It has become clear, as more and more research findings accumulate, that a broader range of attributes need to be assessed and evaluated than has been considered in the past. A wide variety of ways of doing this are suggested. Assessment and evaluation are best addressed from the viewpoint of selecting what appears most valid in allowing students to show what they have learned.

In *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991) the difference between the various forms of evaluation is explained. Student evaluation focuses on the collection and interpretation of data which would indicate student progress. This, in combination with teacher self-evaluation and program evaluation, provides a full evaluation.

Information in Saskatchewan Education, Training, and Employment documents should be used to help develop an overall evaluation plan.

Phases of the Evaluation Process

Evaluation can be viewed as a cyclical process including four phases: preparation, assessment, evaluation, and reflection. The evaluation process involves the teacher as a decision maker throughout all four phases.

- In the **preparation phase**, decisions are made which identify what is to be evaluated, the type of evaluation (formative, summative, or diagnostic) to be used, the criteria against which student learning outcomes will be judged, and the most appropriate assessment strategies with which to gather information on student progress. Decisions made during this phase form the basis for planning during the remaining phases.

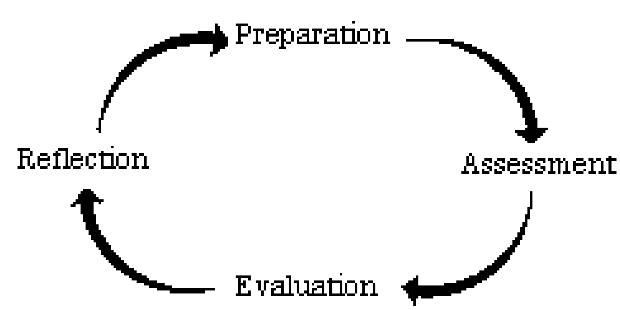
- During the **assessment phase**, identify information-gathering strategies, construct or select instruments, administer them to the student, and collect the information on student learning progress. The identification and elimination of bias (such as gender and culture bias) from the assessment strategies and instruments, and the determination of where, when, and how assessments will be conducted are important considerations .

- During the **evaluation phase**, the information gathered during the assessment phase is used to make judgements about student progress. Based on the judgements (evaluations), decisions about student learning programs are made and reported to students, parents, and appropriate school personnel.

- The **reflection phase** allows you to ponder the successes and shortfalls of the previous phases. Specifically, evaluate the utility and appropriateness of the assessment strategies used, and make decisions concerning improvements or modifications to subsequent teaching and assessment. *Science Program Overview and Connections K-12* contains questions that encourage reflection on student assessment, your own planning, and on the structure of the curriculum.

Formative, diagnostic, and summative evaluation processes each involve all four phases. The relationship of the phases is illustrated in Figure 3.

Figure 6: **Process of Student Evaluation**



Assessing Student Progress

Specific assessment techniques are selected in order to collect information about how well students are achieving objectives. Which assessment techniques are chosen depends on what the teacher wants the students to demonstrate, the capabilities of the students, and on what the students have been doing in class. The environment and culture of the students is also an important consideration.

Various assessment techniques are listed here for reference. Each teacher must exercise professional judgement in determining which techniques suit the particular purposes of the assessment. No two situations are identical so no two evaluation strategies should be identical. For further information on assessment strategies and on instruments to collect and record information about student learning, refer to the *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991).

Following is a list of specific student assessment techniques from the *Handbook*, page 13 .

Methods of organization
- assessment stations
- individual evaluations
- group evaluations
- contracts
- self- and peer-assessments
- portfolios

Methods of data recording
- anecdotal records
- observation checklists
- rating scales

Ongoing student activities
- written assignments
- presentations
- performance assessments
- homework

Quizzes and tests
- oral assessment
- performance tests
- extended open response items
- short answer items

Student Assessment in Science

At the start of any class, you, the teacher, have a group of new students. The students are new, even if they know each other or know you, because they will be dealing with different material, from a different point of view, within an evolving system of interactions. The factors of scientific literacy and the learning objectives for the curriculum become the criteria by which to assess the students' learning and progress. These may be easily attainable by the majority of students, but some will need extra support to reach their potential. Adaptations to materials or approaches will be required.

Graded teaching resources and standardized tests are built on what is accepted as normal or average for a student of that age group and often for a specific segment of society. **A standardized test assesses how a child matches culturally-biased standards over a narrow range of skills**. The results must be considered in that context. This measure may be unattainable by some students. Alternatively, some students may not reach full potential because they are not challenged but are allowed to remain at the "acceptable average". The Adaptive Dimension recognizes that the needs of all students must be considered for effective teaching and learning to occur.

In assessing the factors of scientific literacy, methods can be established for addressing knowledge (Dimensions A, B, D), values (Dimensions G and F), and abilities (Dimensions C and E) in ways that suit the nature of the factor. See Figure 7 on page 24.

The factors of scientific literacy in Dimensions A through E can be assessed through manipulation of factual knowledge. However, it is quite possible to assess only factual knowledge and this is a fault of much current student assessment. When examined, this assessment is often little more than simple recall or limited application of facts. When assessment does go further and appears to include abilities, often too much emphasis is still devoted to straight recall. **Students deserve to be assessed on the range of abilities they have been using and developing during instruction**. The overall assessment plan should reflect the students' different learning styles, their different ways of displaying their learning, and the nature of the abilities being assessed. Self-referenced assessment may be one aspect to investigate.

Assessment can be oral, written, practical, or some combination of these. Practical exercises are the best way to assess scientific and technical knowledge and skills (Dimension E). For example, reading a thermometer diagram is not the same as knowing how best to use and place the thermometer in order to measure temperature.

The best way to assess whether students can perform an activity is to observe them while they are actually performing the activity.

Ask them probing questions. The use of anecdotal records, observation checklists, and rating scales can assist in data collection as these observations are taking place.

The types of tasks and questions which students are expected to address influence their responses. When the tasks and questions are limited, so are the responses. Tasks and questions which elicit only one word or simple sentence answers usually test basic recall of factual knowledge. It is very important to consider that once students have, for example, formulated a model in a particular context during a science activity, if that exact same context is given in the assessment, the response is recall, and not a test of any conceptual or process ability. Valid assessment of the ability requires slightly different conditions so the ability is tested through a new set of events.

Good questioning is extremely important for effective teaching and testing. Avoid using only questions that have a single acceptable response. Structure questions so that some type of reasoning is required. **How..., why..., and explain... are stems you can use to create divergent questions**. Present problem solving activities. Develop critical and creative thinking. These ways promote and challenge higher level thinking. Ask yourself whether your questions to the students, and the students questions to each other and to you, require reporting knowledge, using knowledge, or creating knowledge. Try to ensure a good mix of question types.

Ask your students to interpret a graph or photograph, or to answer a question orally. Assessment does not have to consist totally of written work. Varied formats adapt to students' differing learning styles and allow students to show what they have learned.

Summative assessment items following the completion of a unit can cover more scope and depth than formative assessment items. Apart from the scope and depth of the activities selected, the format of summative assignments can be just as varied, including practical tasks (to reflect practical knowledge and abilities), interpretation of graphs and photographs, and investigative problems and assignments.

Multiple choice, true or false, or fill-in-the-blank tests usually assess only basic factual recall. Such tests should be used as little as possible and fewer "marks" should be awarded them in comparison with those items that require more complex abilities. Multiple choice questions which test higher levels abilities than recall can be constructed, but the process of construction is long and difficult.

Essay questions are useful tests of understanding and ability to synthesize and evaluate. They can indicate an understanding of all Dimensions of Scientific Literacy, and can be used in both formative and summative assessment. Students who have difficulty writing may be given the option of alternative forms of communication to express their understanding of the concepts. Illustrations or art projects, an oral report, a concept map, a project, journal writing, or some other challenging activity may serve as innovative alternatives to the written essay. Care must be taken to provide writing opportunities and guidance to improve their writingto students having difficulty with writing. Always keep in mind the importance of assessing understanding of the objectives, whichever format is used.

Projects are useful items for summative assessment. Students can explore a topic in depth, and use of a range of process abilities. If the project is a group effort, difficulties might arise in assessing the individual participation of each student if the project is a group effort. The contributions and participation of individuals within a group can often be determined by structuring the tasks, assigning roles, and observing the ways in which the group members interact with one another. Using student self-assessment is another avenue to determining individual contributions and participation. The number and type of assignments completed in a learning centre can be recorded as a summative assessment. Assessment stations are particularly useful for allowing students to demonstrate competence.

Assessing values is an emerging area of assessment and evaluation. At one time, values were not considered a part of the school's written curriculum. Parents and society certainly required that students develop acceptable behaviours and attitudes, but these were promoted through the "hidden curriculum" – the teachers' and school's influences.

Now, specific attitudes and values are to be openly promoted in students, so the teacher's influence must be directed to these objectives. Accordingly, they must be assessed. For further information on values review Chapter VI in *Understanding the Common Essential Learnings: A Handbook for Teachers* (Saskatchewan Education, 1988). Both in questioning and in the matter of values, there is a need for knowledge about the influence of culture on communications. Teachers must recognize, be sensitive to, and respect cultural differences. Values are a direct result of culture and as such, the connection between the two may need to be made explicit.

There are valid reasons to assess students' value and attitude outcomes at school and to attempt to promote these with effective teaching methods and individual student reflection. Since the values listed in Dimensions F and G of the factors of scientific literacy may be developed over time, teachers should be emphasizing many of the same values through the grades, but developing them to higher levels. This cumulative development helps to take students to a point where the level achieved may become a feature of their characters, and may continue to develop further in adult life.

Figure 7: **Including Dimensions of Scientific Literacy in Planning for Assessment**

	Possible evaluation techniques (abbreviation key below)												
DSL	% **wt.**	ar	co	lr	oc	or	pa	pf	pr	pt	rs	sa	wt
A. nature of science	**5-15**		x	x		x			x	x	x	x	x
B. key concepts	**25-40**	x	x	x		x		x	x			x	x
C. processes	**15-30**	x	x	x	x			x	x	x	x	x	x
D. STSE	**5-15**					x	x	x	x		x	x	x
E. skills	**5-15**	x			x		x		x	x	x		
F. values	**5-10**	x			x	x	x	x			x	x	x
G. attitudes	**5-10**	x			x	x	x	x		x	x		x

Key to abbreviations of evaluation techniques:

ar anecdotal record
co contract
lr laboratory report
oc observation checklist
or oral response
pa peer assessment
pf portfolio
pr project or written report
pt performance test
rs rating scale
sa self assessment
wt written test

An 'x' in a cell indicates a strategy that might be appropriate for assessing that Dimension of Scientific Literacy. The placement of an x in a cell is not definitive. You may not be able to use that technique to assess factors from the Dimension indicated. You may find that a blank cell represents a combination which is appropriate for use in your classroom. The terms for evaluation techniques are taken from *Student Evaluation: A Teacher Handbook*. Assistance in designing an evaluation plan that uses these techniques can be found in that document.

Summary of % weight by domains and DSLs:
- Cognitive knowledge (A, B, D, F) ~60%
- Cognitive process/skill (C, E) ~30%
- Affective (F, G) ~10%

Performance-Based Evaluation in Science

In a curriculum based on activity, it is essential that performance testing be used for a significant portion of student assessment. Performance testing can also be used to gauge the effectiveness and value of particular activities. Skills and abilities that are stressed in the activities should be the ones that are included in the performance assessment. Performance testing should be used when it can test factors or criteria which can not be assessed as well using solely a paper and pencil item. They can be done as individual tests or as group tests. Many activities described in activity books can be used as perfomance tests. If you pick one from an external source, make sure it relates to the objectives you have been stressing during instruction.

A significant portion of the grade for Middle Level science classes should be derived from performance-based evaluation.

The following is an example of a performance task. The criteria for assessing the task are included in the student instructions for the task so that the students are aware of the basis for their evaluation. They should be given or develop these criteria at the beginning of a section of study, and told that these criteria would be used to help assess their performance at the end of the unit.

Instructions for teacher

Materials (per individual or group)
- two 10 mL vials of soil, one labelled Y and the other labelled G
- two plastic funnels
- two pieces of circular filter paper
- two pieces of white paper, one labelled Y
- **Either** two 300 mL juice bottles to catch filtrate and access to a 25 mL cylinder for measuring volume
  or two 25 mL graduated cylinders
- yellow ice cream pail and a pail of another colour for disposal of wet soil

Use two distinct samples of soil for this activity. Try to obtain one with a fairly high percentage of clay, and one of sandy soil. Alternatively, a sample of local soil and a sample of bagged potting soil may be used. The critical thing is to get two samples with significant differences. When you travel to another part of the province, you may want to take along some ice cream pails and collect soil samples along the way.

Instructions to students

You will be evaluated according to the following criteria:
- Are your observations worded clearly and concisely?
- Are your observations organized so another person can look at them and follow what happened during your investigation?
- Are there enough details in the observations so that another person could visualize what was happening during the investigation?
- Is your workplace left in the same (or better) condition at the end of the investigation as it was at the beginning?
- Did you fold the filter paper for the funnel as you were instructed during previous classes?
- Did you make appropriate inferences and generalizations based on your data?
- Did you follow appropriate safety procedures?
- If you worked in a group during this task, did you
  -share tasks equitably
  -work cooperatively
  -remain on task

1. Dump the contents of each vial onto the corresponding sheet of paper.
2. Compare the samples. Record your observations in your lab journal. (To compare is to describe all the similarities and differences.)
3. Place the funnel into the jar or cylinder for support. At the outside edge of one piece of filter paper, use a ballpoint pen to label it Y.
4. Fold the filter paper marked Y and place it in one funnel. Fold the other piece of filter paper and put it in the other funnel.
5. Carefully transfer the soil from the sheet of paper marked Y to the filter paper marked Y. Transfer the other soil to the other filter paper.
6. Fill each vial with water. Add one vial of water to each funnel, bit by bit if necessary to prevent overflow.
7. When the water has flowed through each system, compare the filtrate in each bottle or cylinder.
8. Carefully remove the filter paper from each funnel. Place the filter paper labelled Y back on the sheet of paper labelled Y. Place the other filter paper on the other sheet.
9. Compare the wet soil samples.

10. Dispose of the soil sample marked Y in the yellow pail. Put the other sample in the other pail.
11. Answer the following questions. **Give your reasons for each answer**.
    - Would one of the samples be better for growing crops?
    - Would one of the samples hold rain water better than the other?
    - Which is most like the soil in your region?

Record-Keeping

To aid data collection so that the factors of scientific literacy are addressed in student assessment, checklists have been included in the *Science Program Overview and Connections K-12* and in this guide. Teachers should adapt these to suit their needs.

Teachers often differ in the way they like to collect data. Some prefer to have a single checklist, naming all the students in the class (or in one work group) across the top and listing the criteria to be assessed down the side. The students' columns are then marked if a criterion is met. In this case some information would have to be transferred later to a student's individual record.

Other teachers prefer to have one assessment sheet per student, which is forms part of the student's record. That sheet would list the factors for assessment down the side, but along the top might be a series of dates indicating when assessment took place. Such an individual file would illustrate development over the year. In this case, information might have to be transferred from the record to the official class mark book, as required.

Examples of these types of assessment sheets are also given in *Science Program Overview and Connections K-12*, and may be available from the Stewart Resource Centre at the Saskatchewan Teachers Federation offices in Saskatoon.

Program Evaluation

Program evaluation is a systematic process of gathering and analyzing information about some aspect of a school program in order to make a decision, or to communicate to others involved in the decision-making process. Program evaluation can be conducted at two levels: relatively informally at the classroom level, or more formally at the classroom, school, or school division levels.

At the classroom level, program evaluation is used to determine whether the program being presented to the students is meeting both their needs and the objectives prescribed by the province. Program evaluation is not necessarily conducted at the end of the program, but is an ongoing process. For example, if particular lessons appear to be poorly received by students, or if they do not seem to demonstrate the intended learnings from a unit of study, the problem should be investigated and changes made. **By evaluating their programs at the classroom level, teachers become reflective practitioners**. The information gathered through program evaluation can assist teachers in program planning and in making decisions for improvement. Most program evaluations at the classroom level are relatively informal, but they should be done systematically. Such evaluations should include identification of the areas of concern, collection and analysis of information, and judgement or decision making.

Formal program evaluation projects use a step-by-step problem-solving approach to identify the purpose of the evaluation, draft a proposal, collect and analyze information, and report the evaluation results. The initiative to conduct a formal program evaluation may originate from an individual teacher, a group of teachers, the principal, a staff committee, an entire staff, or central office. Evaluations are usually done by a team, so that a variety of background knowledge, experience, and skills are available and the work can be shared. Formal program evaluations should be undertaken regularly to ensure programs are current.

To support formal school-based program evaluation activities, the *Saskatchewan School-Based Program Evaluation Resource Book* (1989) has been developed to be used in conjunction with an inservice package. Further information on these support services is available from Evaluation and Student Records Division, Saskatchewan Education, Training, and Employment.

Curriculum Evaluation

During the decade of the 1990's, new curricula will be developed and implemented in Saskatchewan. Consequently, there will be a need to know whether these new curricula are being effectively implemented and whether they are meeting the needs of students. Curriculum evaluation, at the provincial level, involves making judgements about the effectiveness of provincially authorized curricula.

Curriculum evaluation involves the gathering of information (the assessment phase) and the making of judgements or decisions based on the information collected (the evaluation phase), to determine how well the curriculum is performing. The principal reason for curriculum evaluation is to plan improvements to the curriculum. Such improvements might involve changes to the curriculum document and/or the provision of resources or inservice to teachers. It is intended that curriculum evaluation be a shared, collaborative effort involving all of the major education partners in the province. Although Saskatchewan Education, Training, and Employment is responsible for conducting curriculum evaluations, various agencies and educational groups will be involved. For instance, contractors may be hired to design assessment instruments; teachers will be involved in instrument development, validation, field testing, scoring, and data interpretation; and the cooperation of school divisions and school boards will be necessary for the successful operation of the program.

In the assessment phase, information will be gathered from students, teachers, and administrators. The information obtained from educators will indicate the degree to which the curriculum is being implemented, the strengths and weaknesses of the curriculum, and the problems encountered in teaching it. The information from students will indicate how well they are achieving the intended objectives and will provide indications about their attitudes toward the curriculum. Student information will be gathered through the use of a variety of strategies including paper-and-pencil tests (objective and open-response), performance (hands-on) tests, interviews, surveys, and observation.

As part of the evaluation phase, assessment information will be interpreted by representatives of all major education partners including the Curriculum and Evaluation Division of Saskatchewan Education, Training, and Employment and classroom teachers. The information collected during the assessment phase will be examined, and recommendations, generated by an interpretation panel, will address areas in which improvements can be made. These recommendations will be forwarded to the appropriate groups such as the Curriculum and Instruction Division, school divisions and schools, universities, and educational organizations in the province.

All provincial curricula will be included within the scope of curriculum evaluation. Evaluations will be conducted during the implementation phase for new curricula, and regularly on a rotating basis thereafter. Curriculum evaluation is described in greater detail in the document *Curriculum Evaluation in Saskatchewan* (Saskatchewan Education, 1991).

Program Organization

Facilities and Materials

Facilities and materials, by themselves, do not create a science course. They are essential, but proper use of the facilities and materials with students is critical. Since a wide range of teaching strategies is desirable in this course, more flexible teaching areas are useful. This might be a well designed laboratory which can be reconfigured to accommodate small group discussions, small group and large group laboratory activities, lectures, research, or other activities. Or, it may be a combination of two or more existing rooms.

Below are some features of a good science laboratory/facility.

- Two exits, remote from each other.
- Master shut-off controls for the water, natural gas, and electrical systems. These should be easily accessible and easy to operate.
- Spacious activity area where students can work without being crowded or jostle.
- Safety equipment that is visible and accessible to all.
- Ventilation system which maintains negative pressure in the lab.
- Enough electrical outlets to make the use of extension cords unnecessary. The plugs should be on a ground fault interruptor system or individually protected.
- Emergency lighting.
- Separate, locked storage rooms and preparation rooms to which students' access is restricted.
- Adequate shelving so that materials do not have to be stacked, unless it is appropriate to store them that way.
- Separate chemical storage cabinet with provisions for proper storage of all classes of chemicals.
- Audiovisual storage area for charts, video and audio tapes, slides, and journals.
- Areas for plant and animal care.
- Storage area for student assignments.

Science equipment and supplies are valuable resources. Not only are they becoming more expensive, but they are also indispensable to the proper presentation of science. There are several reasons for having an efficiently operating inventory system. Such a system can prevent running short of a consumable supply, prevent ordering something already in adequate supply, and save time when ordering. It can act as a quick reference to determine whether a particular item is available. It may also be useful for insurance purposes.

In addition to inventory control, maintenance and storage are important considerations. A regular procedure for maintenance ensures that the equipment is ready for use when it is needed and is in safe operating condition. Adequate storage space ensures that the equipment can be preserved in good condition and that it is safely away from unauthorized use. It also helps convey the message that laboratory equipment and supplies are not toys, and that a lab is not a place to play with equipment.

Safety

Safety in the classroom is of paramount importance. Other components of education – resources, teaching strategies, facilities – attain their maximum utility only in a safe classroom. Safety is no longer simply a matter of common sense. **To create a safe classroom requires that a teacher be informed, be aware, and be proactive**. There are several ways the teacher can become informed. Check these reading materials.

- *Safety in the Secondary Science Classroom*. (1978). National Science Teachers Association, 1742 Connecticut Avenue North West, Washington, D.C. 20009.
- *A Guide to Laboratory Safety and Chemical Management in School Science Study Activities.* (Saskatchewan Environment and Public Safety, revised, 1992).

Safety sessions are often offered at science teachers' conventions. Many articles in science teachers' journals provide helpful hints on safety. Professional exchange may provide teachers with an outside viewpoint on safety.

Awareness is not something that can be learned as much as it is developed through a visible safety emphasis: safety equipment such as a fire extinguisher, a fire blanket, and an eye wash station prominently displayed; safety posters on the wall; a "safety class" with students at the start of the year; and regular emphasis on safety precautions while preparing students for activities.

Proaction is accomplished by acting on what is known and by being vigilant. Six basic principles guide the creation and maintenance of a safe classroom.

- Model safe procedures at all times.
- Instruct students about safe procedures at every opportunity. Stress remembering to use safe procedures when experimenting at home.
- Close supervision of students at all times during activities, along with good organization, can avert situations where accidents and incidents can occur. Inappropriate behaviours in a classroom, and more particularly in a laboratory, can result in physical danger to all present and destroy the learning atmosphere for the class.
- Be aware of any health or allergy problems that students may have.
- Display commercial, teacher-made, or student-made safety posters.
- Take a first aid course. If an injury is beyond your level of competence to treat, wait until medical help arrives.

To compile a complete list of safety tips is impossible. This list might be termed a "highlight" list. It does not cover all situations and events which might occur in a classroom. It is the responsibility of each teacher to be functioning at the highest level with respect to creating a safe classroom climate.

- Check your classroom for hazards on a regular basis.
- Create a bulletin board with a safety theme.
- Make a rule that all accidents must be reported to the teacher.
- In case of a serious accident, pick one person who is present and send that person for expert, professional, or additional help. Then, take action. Remember, you are in charge of the situation.
- Become familiar with the school division's accident policy.
- Do not give medical advice.
- Move an injured person as little as possible until the injury assessment is complete.
- Emphasize that extra caution is needed when using open flames in the classroom.
- Require the use of goggles when using open flames, corrosive chemicals, or other identifiable hazards.
- In case of fire, your first responsibility is to get students out of the area. Send **a specific person** to give an appropriate alarm. Then assess the situation and act.
- Avoid overloading shelves and window sills.
- Properly label all containers of solids, liquids, and solutions.
- Separate broken glass from other waste.
- Advise students not to touch, taste, or smell chemicals unless instructed to do so.
- Each laboratory should have one first aid kit which is not accessible to students, but is only for the teacher's or administrator's use.
- Master shut-off controls for gas, electricity, and water should be tested periodically to ensure that they are operable.
- Safety equipment such as fire extinguishers, fire blankets, eye wash stations, goggles, fume hoods, test tube spurt caps, and explosion shields must be kept in good order and checked regularly.
- Electrical cords must be kept in good condition, and removed from outlets by grasping the plug.
- Students should use safety equipment – protective eye wear, protective aprons or coats, fume hoods, etc. – whenever practical and necessary.
- Students should tie back long hair and refrain from wearing loose and floppy clothing in the laboratory.
- Students should not taste any materials, eat, drink, or chew gum in a laboratory.

- Students should follow recommended procedures and check with teachers before deviating from such procedures.

- Students should be required to return laboratory equipment to its proper place.

- Chemicals or solutions should never be returned to stock bottles.

- Pipetting should be done only with a safety bulb, never by mouth.

- Acids or oxidizers should never be mixed with compounds containing chlorine (e.g., bleach).

- Mercury thermometers should be replaced with alcohol thermometers.

- Asbestos centred wire mats should be replaced with plain wire mats or with ceramic centred mats.

- The use of human biological fluids in laboratory activities should be closely monitored.

  - Students should use only materials from their own body – saliva, epithelial cells – when doing lab activities requiring those materials.
  - Students should have no contact with bodily fluids from another student.
  - Alcohol prep pads should not be used more than once.
  - Students should wash their hands thoroughly with soap and water after handling any bodily fluids.

- Specimens for dissection, dissecting tools and equipment, and chemicals used in biology must be kept under locked storage.

- When field materials such as pond or slough water, plants, soil, or insects are collected, assume that they are contaminated by pathogens and treat them as such.

- Known pathogens should not be cultured. Exposure plates and culture plates with unknown bacterial colonies must be treated as though they are contaminated by pathogens until it can be shown otherwise.

- Make sure that autoclaves are in good operating condition.

- Adequate ventilation is essential when working with specimens preserved in formalin or formaldehyde.

- Proper care must be given to animals kept in a classroom. Refer to a good animal care book, if needed.

- Use rubber gloves and take great care when handling any plant growth hormones such as colchicine, gibberellic acid, indole acetic acid, or Rootone(TM).

- Many plants may contain toxins or allergens. Students should be cautioned not to taste or handle plants. Teachers are responsible for familiarizing themselves with any local, provincial, or federal legislation pertaining to plants and animals. If in doubt, inquire.

- Chemicals should be stored in a locked area, to which access is restricted.

- Be prepared to handle all chemical spills rapidly and effectively.

- Inspect glassware (e.g., beakers, flasks) for cracks and chips before using them to heat liquids or hold concentrated corrosive liquids or solutions.

- Chemical storage should be organized by groups of compatible compounds, rather than by alphabetical order. (Within a group of compatible compounds, alphabetizing can be used.)

- Electrical equipment (e.g., transformers, induction coils, electrostatic generators, oscilloscopes, discharge tubes, Crookes tubes, magnetic effects tubes, lasers, fluorescent effects tubes and ultraviolet light sources) must be kept in locked storage.

- Discharge tubes can produce x-rays which may penetrate the glass of the tube if operating voltages higher than 10 000 volts are used.

- Lasers are capable of causing eye damage. The lens of the eye may increase the intensity of light by 1 000 000 times at the retina compared to the pupil. To reduce risk, lasers rated at a maximum power of 0.5 mW should be used.

  - Lasers should be used in normal light conditions so pupils are not dilated.
  - Everyone should stay clear of the primary and reflected paths.

- Everyone should be alert to unintended reflections.

- Contact lenses complicate eye safety. Dust and chemicals may become trapped behind a lens. Gases and vapours may cause excessive watering of the eyes and enter the soft material of the lens. Chemical splashes may be more injurious due to the inability to remove the lens rapidly and administer first aid. The loss or dislodging of a contact lens may cause a safety problem if it happens at a crucial moment.

  On the other hand, contacts, in combination with safety eye wear, are as safe as eyeglasses in most cases. Contacts may prevent some irritants from reaching the cornea, thus giving the eye some measure of protection. The Saskatchewan Association of Optometrists feels that, as long as proper, vented safety goggles are worn, there is no greater risk in a lab situation for a person wearing contacts than for one not wearing contacts. The Association recommends that:

  - teachers know which students wear contact lenses;
  - teachers know how to remove contact lenses from students' eyes should the need occur;
  - there be access to adequate areas for the removal and maintenance of contact lenses; and,
  - contact lens wearers have a pair of eye glasses to use in case the contact lenses must be removed.

Disposing of Chemicals

Some precautions should be followed when disposing of chemicals.

- *A Guide to Laboratory Safety and Chemical Management in School Science Study Activities* categorizes all chemicals by disposal category. Disposal of liquid or aqueous wastes from categories 1 and 2 should involve dilution before pouring them down the drain, then running tap water down the drain to further dilute their strength.

- Solid wastes should be rinsed thoroughly with water. They should be disposed of in a specially marked waste container – not the general class waste basket. The janitor should be alerted to the existence of this container and be assured that none of the materials are hazardous.

If, for any reason, substitutions are made for materials, it is the responsibility of the teacher to research the toxicity, potential hazards, and the appropriate disposal of these substituted materials.

Federal, provincial, and municipal regulations regarding the labelling, storage, and disposal of hazardous substances should be followed. Under current Workplace Hazardous Materials Information System (WHMIS) regulations, all employees involved in handling hazardous substances must receive training by their employer. For more information, contact the Canadian Centre for Occupational Health and Safety, or Saskatchewan Human Resources, Labour and Employment.

A Broader Look at Safety

Normally, safety is understood to be concerned with the physical safety and welfare of persons, and to a lesser degree with personal property. The definition of safety can also be extended to a consideration of the well-being of the biosphere. The components of the biosphere – plants, animals, earth, air and water – deserve the care and concern which we can offer. From knowing whether wild flowers can be picked to considering the disposal of toxic wastes from Middle Level science rooms, the safety of our world and our future depends on our actions and teaching in science classes.

The Workplace Hazardous Materials Information System (WHMIS) under the **Hazardous Products Act** governs storage and handling practices of chemicals in school laboratories. All school divisions should be complying with the provisions of the Act.

Measurement

An understanding of the importance of measurement in science is critical for each student to acquire. The importance of measurement can be seen when it is viewed as one component of the Common Essential Learning of Numeracy. There is an implicit assumption in science, and in society, that quantitative statements are more authoritative than are qualitative statements. Yet, many important advances in science are made through intuition and through creative leaps. Advances in science are not restricted to data analysis. Students must see that measurement is important, but important in its context.

To make quantitative statements, measurements must be made. The accuracy of the measurements determines the confidence placed in the facts which are derived from the measurements. If the facts are represented as being accurate, the measurements must be equally accurate. But accuracy is not the only factor to consider when measurement is discussed.

The ability to make measurements depends on the technology available. A metre stick can be used to measure the length of a table. What technology is available to measure the diameter of an atom? Such measurements require a greater degree of faith in the technology. At the furthest reaches of scientific inquiry, technology must be devised so that the results of exotic experiments can be detected, measured, and interpreted. What is measured depends upon the assumptions made in the design, and on the limitations of the technology.

The ability to make measurements depends on the correct use of the technology. Proper procedures must be followed, even with the use of simple devices such as thermometers, if measurements which accurately represent the system under observation are to be made. In addition to proper procedures, the measurement devices must be used appropriately. Even though a thermometer has a ruled scale, to measure the length of a pencil in degrees Celsius is not a useful way to represent length.

There must be as little interaction as possible between the technology, or application of it, and the object being measured. If the device used to measure the temperature of a system changes the temperature of that system by a significant amount, how useful is the measurement? Heisenberg faced a similar problem in attempting to determine the momentum and the position of the electron in the atom. Precision in determining one results in less information about the other.

Before the matter of accuracy is addressed, the student must have an understanding of what technology is available, its appropriateness for the situation, the proper use of that technology, and the limits which are inherent in the technology. Once that is understood, the student can then manipulate the technology to give the most accurate and precise results.

One aspect of accuracy pertains to the matter of uncertainty in measurement. The percentage error in a measurement, or the absolute error, is a concept students must consider. No measuring instrument has zero margin of error. No operator is capable of using an instrument so that no measurement error is introduced. Measurement error exists and must be accounted for in recording and interpreting data. A particular balance may have an uncertainty of measurement of 0.01 g, for example, if the balance is levelled, properly adjusted, and working well. This balance has a suitable accuracy for measuring a mass of 142.87 g but not for measuring a mass of 0.03 g. Calculate the percentage error in each case and the point is clear. However, the 0.007% measuring error for the 142.87 g mass which is due to the balance may be made entirely insignificant by operator errors such as having the balance pan on the wrong hook, misreading the scale, not zeroing the balance before starting, stopping the oscillation of the beam with a finger, using a wet or dirty pan, and so on. **Accuracy requires both good technology and good technique.**

Another concern is that of significant figures. Measuring instruments can only supply a limited degree of accuracy. The problem most often encountered with students is to have them make use of the maximum precision possible, without having them overstate their case. If seven identical marbles have a total mass of 4.23 g, the average mass of a marble is not 0.604 285 714 g. A more reasonable report would express the average mass rounded off to two decimal places.

Many science texts have sections dealing with the reporting of uncertainty in measurement and significant figures. Each teacher should find an approach that is comfortable for both the teacher and the students and then adopt and emphasize that approach.

Data analysis is an important related topic. Often, in order to make sense of measurements, data must be organized and interpreted. Students must learn to organize their data collection and recording so that it is ready for analysis. Graphical analysis is often useful and should be stressed. The use of computer software is also an option for recording and analysis. Databases can be used to store and then manipulate large amounts of data. Spreadsheets are also useful for organizing data. Many database and spreadsheet programs, as well as integrated software packages, contain graphing utilities and may contain statistical analysis options. Graphing and statistical analysis packages may also be purchased as stand-alone software. The use of computer analysis should be encouraged wherever possible.

In addition to the use of computer analysis, hardware interfaces to allow the input of data through sensors, which the software then interprets as measurements, are a valuable addition to a science lab. It should be emphasized that the use of a computer does not mean that the results will be error free. Accuracy is mainly a function of the technician and, to a lesser degree, of the technology.

Measurements should be expressed using SI units, or SI acceptable units, whenever this is realistic or feasible to do so. Common non-metric units may be used if necessary. Conversion factors from non-SI to SI or within the non-SI units may be necessary. Each teacher should follow the recommendations of the Canadian Metric Commission with respect to the basic and derived units of measurement and the proper symbols for those units.

If detailed information is required, refer to the *Canadian Metric Practice Guide* (CAN3-Z234.1-79 from the Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3), the *International System of Units (SI)* (CAN3-Z234.2-76 from the CSA) or the *SI Metric Guide for Science* (Saskatchewan Education, 1978).

During grade 9, scientific notation should be used so that students become familiar with reading, manipulating, and writing numbers in that format. In addition to the value of SI-notation for ease in handling very large or very small numbers, students must be able to use this notation to express the number of significant figures in a large number, and to perform calculations using scientific notation.

Plant and Animal Care in the Classroom

Teachers are responsible for familiarizing themselves with any local, provincial, or federal statutes pertaining to the care of plants or animals. If in doubt, inquire. Pet shops or plant shops may have useful information. There are regulations preventing the picking of wild flowers, or the captive use of migratory birds or endangered species.

Involve students in helping to care for plants and animals; set up a daily schedule of things that have to be done. Rotating student responsibilities will involve more students. They should be able to discuss the kinds of things that plants and animals need to live and stay healthy. They can use these ideas to learn more about the plants and animals they are caring for.

Wear gloves when handling animals in the classroom. Overhandling can put the animals under excessive stress. Be wary of possible diseases that may be spread by the animals, or by people to the animals.

Inquire about specific feeding requirements for any classroom pets. Find out about the size of cage the animal needs, the type of nutritional requirements it has, whether or not it needs a separate container for water, and so on. Odour and lack of cleanliness will occur if animals are not maintained properly. Before you obtain an animal as a classroom pet, find out how much time and effort will be needed to care for it. Be prepared to make the necessary commitment if you have a pet in the classroom. Does the animal need a metal cage? Does it need an exercise wheel? Can it be stored in cardboard boxes, and if so, how often do the boxes have to be changed? These are the areas of concern when deciding on a type of pet to have in the classroom.

Poisonous animals, or other potentially dangerous animals such as venomous snakes and spiders should not be kept in the classroom.

The use of animals for purposes of experimentation has come under very close scrutiny in recent years. If an experiment can be performed in some other way than by using live or preserved specimens, then do so. Alternatives might include computer simulations and research projects.

Some people may have allergies to certain plants and animals. Be wary of any possible signs of allergic reactions among students. Some plants are toxic and should not be used in the classroom. If in doubt, check about the plant first, and keep it out of reach of children until you are sure that it is safe.

Keep plants fairly far apart, so that if mites infest one plant they will not spread to other plants.

Plants and animals have certain environmental conditions which must be maintained to ensure their welfare. Room temperature, exposure to sunlight, humidity, noise, dust, and other such factors may have an effect on them.

Make arrangements to have the plants and animals looked after on weekends and over holidays.

Aquaria in the Classroom

The following suggestions may be helpful in setting up aquaria.

- A glass container of any size can be used, from a large, well washed pickle jar to a 2 metre long tank.
- Rinse any container several times before it is used.
- Plan an appropriate environment for the fish.
- Use clean, aerated water at an appropriate temperature (21 °C to 27 °C)
- A source of diffused light over the tank is useful. Use full spectrum lighting if plants are growing in an aquarium.
- Bottom gravel, water plants, and hiding places enhance the environment.
- Plants can rarely supply enough oxygen for the fish.
- Treated tap water must be left 48 - 72 hours in an open container, so that the chlorine in the water diffuses into the air. Adjust water temperature before adding fish.
- When replacing water lost by evaporation, use water that has lost its chlorine and reached aquarium temperature.
- A lid prevents excessive evaporation losses.
- Indirect light, from a light in a lid or from the classroom, is better than direct sunlight.
- Get help from your supplier to select fish based on several factors: hardiness, compatibility, available space.
- Too few fish is better than too many.
- Select a proper food and feed the proper amounts. Children will tend to overfeed the fish, causing a food decaying problem, if allowed to feed the fish whenever they wish.
- Remove or treat diseased fish immediately.
- Teach the children to avoid activities which put additional stress on the fish, such as tapping on the walls of the aquarium, poking the fish with pencils, or dropping paper or chemicals into the water.

Reference books are available at pet stores and in libraries. Some databases which can be accessed by computers also have area reserved for hobbyists.

Terraria in the Classroom

A terrarium simulates a natural land environment.

- Use a large glass container - a pickle jar, fish bowl or aquarium.
- Place the soil in layers: rocks or pebbles covered by activated charcoal, covered by topsoil.
- Topsoil is a mixture of peat moss, potting soil, and sand, with proportions varying according to the environment you wish to create.
- Activated charcoal chips, available at stores with aquarium supplies, absorb decaying organic material from the soil and water.
- Completely moisten the soil before transplanting into it.
- Use a loose fitting lid for a moist environment terrarium (with mosses, ferns, *etc*.). No lid is necessary for a dry environment (cactus) system.
- Place moist environment terraria in indirect, but adequate, light. Dry environment terraria may be placed in direct sunlight.
- Use occasional misting to maintain the humidity level.
- If animals are added, you should ensure that they are not able to escape the terrarium and become a classroom nuisance.
- Reference books on starting a terrarium may be found in the library.

Organizing a Field Trip

Field trips can and should be valuable learning experiences which allow students to apply their classroom learnings to an actual or "real" situation. Field trips also allow students the opportunity to learn directly rather than indirectly. Learning is enhanced through direct experience. Field trips are fun for everyone involved!

The key to successful field trip experiences is careful and thorough planning. This planning takes time and patience. Make sure to check to see if the school division has any special policies regarding field trips.

The simplest approach when planning a field trip is to treat the experience like the writing of a newspaper article, using the five Ws and How!

Why do you want to take your class on this particular trip?
- Is this mainly a science activity or does it integrate activities in other subjects as well?
- Are the planned activities valid learning experiences?

What learnings do you expect your students to gain from and apply to this experience?
- Have objectives for the field trip been established?
- Have appropriate activities and instructional approaches been selected?
- Have you and your students done your background research?
- Are expectations about student behaviour on the trip clear and realistic?

Where do you plan to go with your class?
- Is it accessible to all students?
- Is permission of landowners or officials required in order to visit this site?
- Does the site have facilities such as bathrooms, lunch areas, shelters, appropriate emergency facilities, etc.?
- Is it possible for you to visit the site beforehand?
- Are locations established at which various activities will occur?

When do you plan to take this field trip?
- Is there adequate time to plan the trip?
- Will relevant information be provided to students **before** the field trip?
- Is there adequate time **after** the field trip to do a wrap-up?
- Are there any potential conflicts with the selected date?
- Does the selected date indicate the need for special clothing or supplies?
- Is there a contingency plan in case of bad weather?
- Has parental consent been obtained?

How are you going to get to the site?
- Will transportation be required?
- Is appropriate transportation available and affordable?
- Can the students be learning during the trip to the site?

How long will this particular trip be?
- Can time be used efficiently and effectively?
- Is there too much to do and too little time?
- How does the field trip affect the rest of the school?
- Will someone else have to do additional supervision duties?
- Will others have to change their planned activities?
- Will a substitute teacher be required?

Who is coming with you on the field trip?
- Are there sufficient supervisors for the number of students involved?
- Have the people in your community been utilized for their expertise?
- Has the class been divided into working groups?
- Have leaders responsible for coordinating the groups' activities been selected for the working groups?

Although this may seem like a great deal of work, planning should be done **before** embarking on a field trip. The more concrete and detailed the planning is, the more likely it is that the trip will be a success.

Once the groundwork has been set and administrative approval has been obtained, approach the parents and the students about the trip. It is advisable to send a letter home to the parents which details the proposed field trip. Include information on such things as the times of departure and return, the location of the field trip, the people responsible for supervision, clothing requirements, lunch plans, required materials, anticipated costs, and contingency plans. This letter could also include a request for parental help and a separate permission slip to be returned to the teacher. It is a good idea to have the letter signed by both the teacher and the principal before sending it to parents.

The parental consent form which follows serves as an example of one that could be used. Note that the use of a consent form does not remove the teacher or the school division from the possibility of incurring liability during the trip.

Sample Permission Form for Field Trips

Date:

Dear Parent/Guardian:

As a part of the school science program, we will be going on a field trip to ____________. This field trip will provide your child with the opportunity to experience the following: (provide a brief list of the activities you have planned).

An itinerary and a schedule of our proposed activities during the field trip is included for your information. Please review this material and contact the school if you have any questions about our plans.

Your child should bring the following supplies on the field trip: (list any special needs) ______________________ ______________________________. If your child has any special physical or medical problems (e.g., allergies), please bring this to our attention. Contact the school if you feel that these problems may interfere with your child's participation in this activity.

We would like you to come along on this exciting learning experience. We encourage you to sign up as a volunteer. Thank you for your cooperation.

________________ ________________
Teacher Principal

Consent Form

I will be able to take part in this field trip as volunteer.

Yes __ No __

Comments: ____

I permit my child to take part in the field trip described above. I have notified the school of any physical or medical problems which might interfere with my child's participation in this activity.

Date:

Signature:

Unit Planning Guide

There is no `one best way' to plan units. The only thing that is essential in all planned units is that the curriculum guide be open and consulted at all stages of the planning process.

Two possible strategies are described here. The first is a teacher-structured unit. The second is based on teacher/student collaborative planning. Each has been adapted from the discussion of planning found in *English Language Arts: A Curriculum Guide for the Elementary Level* (Saskatchewan Education, 1992).

The model units that follow are teacher-structured units. By its very nature, a teacher/student collaboration must be done in the classroom with the students as the unit develops.

Lesson planning

Lesson planning follows from the unit planning process. During unit planning, activities are selected, analyzed, and modified. An initial sequence of lessons is outlined. In essence, lesson planning involves an enhancement of the unit plan to make the day-to-day activities of the class flow more smoothly and produce maximum success.

For science in Saskatchewan schools, we advocate a four-phase lesson. The stages can be labelled engaging, exploring, evaluating, and extending. Activities must form the core of each phase in this lesson planning scheme.

Engaging ties the science curriculum to students' prior experiences, and to students' interests and needs. During this lesson phase, students' concepts are explored, clarified, and stated. Students are encouraged to share their ideas, understandings, and reactions with each other. Such peer interaction fulfills one of the basic needs of adolescents. The direction the next phases of the lesson take is determined by what is discovered and discussed during this phase.

Exploring involves the investigation of questions raised during the engaging phase of the lesson. The investigations may involve student-designed investigations or activities suggested by teachers. Students should be encouraged to identify and use both community and multimedia resources to further their investigation. Community resources may be persons with expertise, sites to visit, or people who can suggest where information can be obtained. Multimedia resources may be oral histories, written materials, CD-ROM information bases, computer networks, or audio-visual productions.

The **evaluation** phase involves two levels of evaluation. Students must evaluate the results of their research and investigations. Is the information valid and useful? In addition, they must evaluate their understanding of the concepts in light of the results of their explorations. This is a critical phase. In cooperative learning groups, students can challenge each others' explanations and ideas. The evaluation phase involves **student evaluation of concepts** and their notions of those concepts. This is when it is valuable for students to read explanations and illustrations of the concepts they have been studying. Various formative assessment instruments can be used during this phase.

Extending gives students a chance to take the results of their evaluation and put those results to the test. Follow-up of unanticipated discoveries or hypotheses enhances the understanding of what surrounds us. This phase gives students a chance to experience what science involves. The search for information and understanding inevitably raises new questions for research.

Depending on your experience, confidence with science and time available, the detail in the lesson plans you produce may vary from those examples that follow.

Structured unit

- Read the **Unit overview** and the **Concept development** sections. Develop an idea about the nature and scope of the unit, and how it fits into the Elementary and Middle Level Science program. Consider what sorts of experiences and abilities students will bring to this unit and determine their entry level.

- Consider how the unit focus relates to other subjects and how joint learning opportunities may be used to enhance students' experiences. Discuss the unit with colleagues to help identify links that can be made, and cooperation that can occur.

- Read the Foundational Objectives for the unit. All students in the classroom are to be given opportunities to experience or cultivate what is described by these statements. These statements form the basis for the common experience shared by all students in Saskatchewan schools. These are outcomes for students to achieve.

- Create an outline or a web that summarizes the unit. It should show the major concepts to be considered during the unit as well as associated subconcepts and links to other areas of study. Examples of webs are found on page 41 and page 56 of this Guide. (The production of such a web is an excellent introductory activity for a teacher/student collaboratively planned unit.)

- In light of what you understand about the unit and the nature of the students in the class, choose learning objectives that you feel are appropriate. Select objectives from the Curriculum Guide or other resources. Develop your own learning objectives in consultation with your students.

  Adapt curriculum objectives that you select so that they meet the needs of the students in your classroom. During the course of the unit, you may ask the students to contribute to the development of additional objectives or to the refining of the ones you select.

- Identify a variety of activities for use. Choose activities that introduce concepts and ideas, that require exploration of the concepts, and that encourage students to extend their understandings. Students may be involved in developing or selecting activities that they feel meet their needs for understanding the concepts.

  Ensure that there are activities that vary the instructional methods which will be used so that the different learning styles of individuals will be accommodated. Remember, too, that writing and reading, and science challenge activities are to be integrated into the activities of each unit, and that these can be incorporated into virtually any activity.

- Analyze the activities to determine how the factors of scientific literacy can be emphasized through the activities. You may choose to focus on one or two factors per activity, or on factors within one Dimension. Consider posting the names of factors identified for each activity on a poster or on the blackboard so that students can become accustomed with the terms. Also consider modifying the activity to include other Dimensions.

  Modify the activities to enhance their presentation of other initiatives of Core Curriculum – Common Essential Learnings, Indian and Métis Perspectives, Gender Equity, and agriculture in the classroom.

- Plan daily assessment strategies and record keeping procedures that are appropriate for the activities. Create a unit evaluation plan.

- Collect resources and supplies that will be needed to do the activities and achieve the Foundational Objectives. Consult *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* and *Science: A Bibliography for the Middle Level* for suggestions. Consider developing classroom displays around the theme of the unit. Determine what resources are available in your community.

- Plan an initial sequence of lessons. Leave the plan flexible enough so that student interests and opinions can help direct the progress of the unit. Outline other lessons that will be required to deal with the Foundational Objectives.

- Create a tentative time schedule.

Collaborative unit

- ♦ Students have understandings and interest in many of the topics studied in science. With this expertise, they can help plan units that are at the appropriate developmental level, that deal with things that are relevant to them, and that engage them. The processes that are involved in planning can also be useful learning experiences, helping to make the students more confident, active, independent learners.

- ♦ The following is taken from *English Language Arts: A Curriculum Guide for the Elementary Level* (Saskatchewan Education, 1992, page 73).

  Strategies that facilitate teacher-student planning include:
  - **brainstorming** lists of topics, possible projects, and resources
  - **categorizing** lists made during brainstorming
  - **mapping** or **webbing** what is known about the topic, possible unit subtopics, or directions
  - **discussions** to determine individual interests and awareness levels
  - **questioning** about what students want to find out about the topic and how they could find answers and solutions
  - **identifying** and **sequencing** activities and projects...

- ♦ Resources available will often influence the direction and extent of a unit. Students can be involved in identifying and gaining access to resources.

Unit planning checklist

- ♦ Have the factors of scientific literacy, the Foundational Objectives for the unit, and the Common Essential Learnings been incorporated in the plan?
- ♦ Have the other initiatives of Core Curriculum been incorporated?
- ♦ Have I identified the major concepts students will deal with?
- ♦ Have I considered the students' entry level, needs, interests, and abilities?
- ♦ Have I sought student input into the planning process, and considered their lives outside of the school context?
- ♦ Have I discussed with colleagues ways that this unit can be integrated with or support units of study in other areas?
- ♦ Have I selected or created appropriate learning objectives?
- ♦ Have I included Indian and Métis content and perspectives?
- ♦ Are there sufficient interesting, useful, and varied resources to support this unit?
- ♦ Is there an adequate supply of appropriate print material for incorporating reading activities and serving as models for writing activities?
- ♦ Are there a variety of instructional strategies, reading and writing activities, and hand-on investigations?
- ♦ Have I determined appropriate assessment and evaluation strategies?
- ♦ Does the plan allow for flexibility and adaptation?
- ♦ Have I provided opportunities for student input and collaboration?
- ♦ Is the time allotted realistic?
- ♦ Have I considered possible unit extensions?

Model unit: Energy in Our Lives

Unit overview

We all have had practical experience with energy since birth. Energy effects and use are so much a part of our lives that we often take them for granted. Most of us could give some sort of answer to questions about energy, based on our understandings of why things are the way they are. Why do gloves keep our hands warm? Why do mittens keep them warmer than gloves? Why do we see the flash of lightning before we hear the sound of the thunder it makes? Why does water flow downhill but not uphill? Each individual has created theories and understandings about how these effects are produced and why things work as they do.

During science classes, students should be given a chance to observe and describe phenomena under controlled conditions, search for explanations, and compare their explanations to those of their peers and of scientists. They should be given a chance to create hypotheses, make predictions, devise investigations, analyze results, and evaluate their positions. This unit builds upon understandings and abilities developed by students during elementary science, language arts, and social studies classes as well as from their extensive experience with energy in their daily lives.

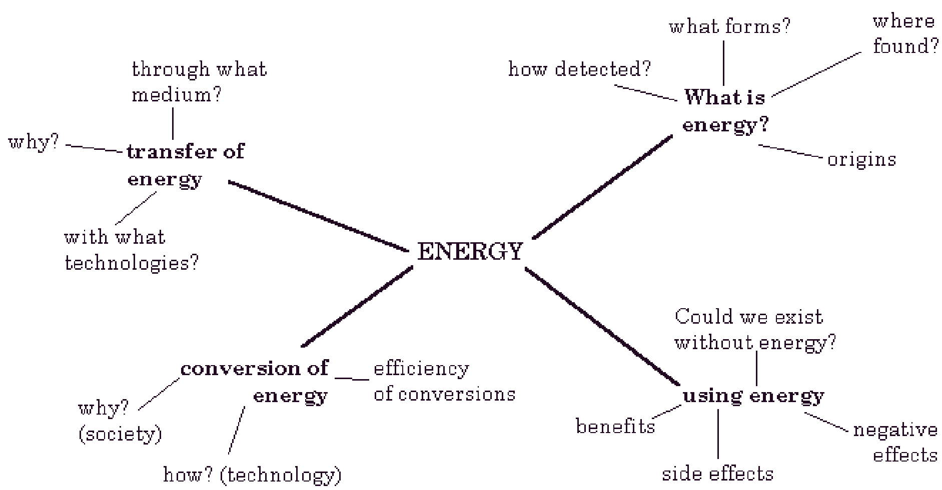
This unit has been written to illustrate how the Dimensions of Scientific Literacy and the Common Essential Learnings can be emphasized in an activity-based science classroom. Most of the activites used come from the Suggested Activities section of the Curriculum Guide. A variety of instructional methods and evaluation strategies are encouraged. There are opportunities for adapting the topics and teaching to the needs and interests of the students. Incorporating Indian and Métis perspectives in the classroom and encouraging participation in a variety of roles by both females and males is illustrated and encouraged.

Many of the goals expressed in the previous paragraph can be achieved through appropriate use of cooperative learning groups. Group activities require individual commitment to the task and a sustained, quality commitment to the group. There must be concrete, legitimate evaluation of the group's performance at specified intervals by each individual member of the group. This stimulates individuals to maintain a commitment to the group, and provides information for the group about their progress in the task and about their progress as a functional group. Ideas on cooperative group learning can be found in ***Together We Learn*** by Judy Clarke.

Benefits of cooperative group learning include:

- student-centred learning, with the teacher as a facilitator;
- the opportunity to use alternative, and several, types of evaluation; and,
- teachers and students experiencing methods from each of the five categories of instructional strategies.

Unit web



Resources

Books (See Bibliography for citations)

Journeys in Science 6 (1 book per group of four students)
- chapter 3 "How Energy Changes"
- chapter 4 "Energy Working For You"
- chapter 5 "Tomorrow's Energy"

Motion, Forces, and Energy (2 or 3 per class) (entire book)

Silver Burdett and Ginn Science 6 (1 book per group of two students)
- chapter 7 "Light Energy"
- chapter 8 "Sound Energy"
- chapter 9 "Using Electricity"

Sound and Light (2 or 3 per class)
(entire book)

Forms and Uses of Energy (2 or 3 per class)
(entire book)

Project WILD (1990) Activity Guide
"Flip a Switch for Wildlife", pages 337-339

Newspapers (Saskatchewan dailies are listed)

Moose Jaw Times Herald
Prince Albert Daily Herald
Regina Leader Post
Saskatoon Star Phoenix

Video (all available from Media House Productions)

Kidzone II – "Watt's Up?"

Science Edition Program 5 "Holograms"

Sound Advice

Materials

- broken appliances from home
- flashlights
- broken light bulbs
- paper drinking cones
- straight pins or needles
- cheap records
- balloons
- small plane mirrors
- converging mirrors
- diverging mirrors
- newspapers from home
- magnifying glasses (hand lenses)
- stereo microscopes
- large speakers
- modelling clay
- cardboard
- tape

Unit Schedule

Lesson	Description
4 weeks before start	ask students and parents for donations of complete newspapers, broken small appliances, burned-out light bulbs, flashlights
lesson 1	activity 1 – 20 to 30 minutes during initial class. 20 to 30 minutes to discuss definitions during next class period. activity 2 – introduce the concept
lesson 2	two 30 minute class periods
lesson 3	one 30 to 45 minute period
lesson 4	activity 1 – one 30 minute period, and continuing through as time permits over the next four periods activities 2 and 3 – two to three 30 minute periods
lesson 5	activity 1 – 30 minutes for video, 10 to 45 minutes for disucssion activities 2 and 3 – three 30 minute periods
lesson 6	5 to 10 minutes of brainstorming followed by 20 to 25 minutes of questions selecting and planning of research
lesson 7	one 30 minute period (continue lesson 6 research and writing)
lesson 8	activity 1 – 30 minutes activity 2 – from two to four 30 minute periods activity 3 – 15 minutes
lesson 9	two to four 30 minute periods
lesson 10	four 30 minute periods

Unit Evaluation Plan

Each lesson has one or two ideas for assessment. Some of these are student self-assessment. Student self-assessment can be used both by the student as formative evaluation and by the teacher as information for formative and summative evaluation. Group self-evaluation instruments are mainly formative assessment information for the group's internal use. Information from checklists and anecdotal records completed by the teacher can be used to create written reports or included in the student's portfolio. Some of the lesson assessment items may be reused on a unit end examination. Lessons 4, 7, and 9 contain examples. A concept map or web dealing with energy might also be a useful item on a unit-end test. Terms could be supplied for students to map (web) or students may be asked to supply their own terms related to the central concept.

Lesson 1

Factors of scientific literacy

A7 unique
B13 energy-matter
C2 communicating
C6 questioning
C19 consensus making
C20 defining operationally
F5 respect for logic
G8 explanation preference

Objectives

1.1 Identify various forms of energy.
4.3 Understand how knowledge is created and evaluated in science.

Resources

- *Forms and Uses of Energy*
- *Journeys in Science **6***
- *Motion, Forces and Energy*
- *Silver Burdett and Ginn Science **6***

Assessment

- Individual or group evaluations – checklist

  You might choose to use the "Observation of Group Behaviours" checklist found on page 93 of this Guide. Although you will not be able to complete it for each student or each group in the class, by more closely observing one or two students each time the class are involved a group activity, you will, over time, be able to gather infomation about each student.

  Alternatively you may wish to use or adapt the group self-evaluation checklist on page 88.

Activities

♦ Use a class discussion to generate a list of the forms of energy. Display the names of these forms on a large poster. Ask the students to do research before the next class to discover if there are any forms not listed.

Discuss the nature of definitions. Definitions can state significant or distinctive characteristics so that a concept can be recognized. For example we might say an acid is a chemical that tastes sour, reacts with limestone to form carbon dioxide, and causes some chemicals to change colour. This type of definition is called an **operational definition**. Or an acid may be defined in terms of why it works as it does. An acid releases hydrogen ions into a solution. This is an example of a **conceptual definition**.

For the most part, grade six students will be able to produce and understand operational definitions better than conceptual definitions. Assign one of the forms of energy to each group in the class. It is not important whether there are two or more groups with the same term as long as each term is assigned to at least one group. Ask the group to write a definition for that form. They may research their term using texts or dictionaries, but the definition they produce must be understandable to them and to the rest of the students in the class.

When each group has finished its definition, they will present it to the rest of the class. Any other groups with the same definition will also present their definition of that term to the class. Through a class discussion, the class will modify, clarify, and enhance the definitions presented to create a class definition. The definitions can be either operational or conceptual but should be more than an example. When the class has reached consensus on a definition, record that definition on a small poster. Do not include the name of the form on the sheet with the definition. Post these definition posters on the walls of the room. These posters become sort of a matching exercise, to match each definition with its corresponding name on the large poster.

♦ Start an energy question board. Whenever anyone comes up with a question that deals with energy, post it on the board. Create a supply of your own as idea starters or add an occasional extension question to get the students thinking along a new line. Keep a file from year to year. Here are some questions you may use as examples if the question board is slow to get started.

- How is the light of the *aurora borealis* produced? Is the light reflected light or light that is created in the sky? Is there a corresponding effect in the southern sky? Some people say that the northern lights make noise when they are especially bright. What is this noise like? In what way might the noise be generated? Is there any way we could use the energy of the northern lights? In what ways might the same process that produces them be useful to us?

- How is the light from the sun produced? Does the sun produce other forms of energy than heat? Will the sun keep on producing light forever?

- When you hold your hand in sunlight, why does your hand feel warmer? Does the heat travel from the sun along with the light?

- Why is it hot enough deep in the earth to melt rock to form lava? Where does the heat come from? Will the centre of the earth ever cool off so there is no more molten rock? What other phenomena would disappear along with lava flows if this happened?

- Have you ever been awakened by a big thunderstorm? What causes the lightning to produce thunder? Why don't we usually call them lightning storms? Where does the electrical energy for the lightning come from?

- Why does a magnet pick up some metals but not others? How do we know that the earth acts as a giant magnet? How can the earth act as a giant magnet? What effects would there be if, all of a sudden, the earth stopped being a big magnet?

- Where does the heat in a fire come from? Is fire the only way to release heat from flammable objects?

- How hot does iron have to be before it gives off light of its own? Does it have to be hotter than the boiling point of water? How do you know? Does it have to be hotter than the melting point of copper?

This list can become a source of research projects, from which ideas for science fair projects can come.

Lesson 2

Factors of scientific literacy

A9 human/culture related
B2 interaction
B13 energy-matter
C1 classifying
C2 communicating
C6 questioning
C15 analyzing
D2 scientists and technologists are human
D6 resources for science and technology
F3 search for data and their meaning
G4 media preference

Objectives

1.1 Identify various forms of energy.
3.2 Understand the social and cultural forces which underlay technological developments.
3.3 Appreciate how technological developments affect culture and society.

Resources

- one daily newspaper (different day) per group

Assessment

- Written assignment with ratings scale, student self-assessment

  Students who bring advertisements dealing with energy could be encouraged to write a brief commentary on the ad and include the note and the ad together in their portfolio.

Activities

♦ Distribute the word search puzzle found on page 633 of this Guide. The puzzle uses words that are related to a term or concept that is also a word in the puzzle. What is the key word? What is the phrase that the solution of the puzzle reveals?

♦ Save a daily newspaper for enough consecutive days so that each group in your class has one. Ask each group to go through one entire paper and highlight the location each time any form of energy is mentioned. Determine which form of energy is mentioned the most. (Use the forms listed on the large poster as groups). Ask them to finish this part of the assignment as homework, by dividing the pages yet to be analyzed among the persons in the group.

  During the next science class, discuss what they discovered about the references to energy. Then identify the references by section of the paper – news, display advertising, classified advertising, sports, entertainment, and so on. Which section has the most references? Rank order the sections of the paper by the number of references. In what other ways can you analyze the references?

  As an ongoing project, look for advertisements that encourage people to use more energy. Also look for those that encourage energy conservation. What techniques do the ads use to try to get their message across?

♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need them, here are two possible stems to suggest:
  - One thing I didn't realize about energy was...
  - What I'm still not sure about is...

Lesson 3

Factors of scientific literacy

B1 change
B5 perception
B15 model
B16 system
C2 communicating
C9 inferring
C15 analyzing
D1 science and technology
E3 using equipment safely
F1 longing to know and understand
G2 confidence

Objectives

1.4 Examine conversions of energy between forms.
1.5 Assess the efficiencies of conversions of forms of energy.
2.1 Investigate how these forms of energy are formed and transmitted.
3.1 Examine their experience with technologies involving light, sound and electricity.
4.1 Make careful observations during activities and discuss observations with others.
4.2 Strengthen perceptual abilities through concrete experiences.

Resources

- *Forms and Uses of Energy*
- *Journeys in Science 6*
- *Silver Burdett and Ginn Science 6*
- *Sound and Light*
- other print materials in the resource centre

Materials

- incandescent light bulbs with glass removed
- dry cell in holder
- two 15 cm pieces of copper wire
- flashlight bulb

Assessment

- Assessment stations – performance assessments

  This lesson can be a source of performance assessment items. One could involve a demonstration of how to apply electricity to a bulb to make it light. Another might involve tracing the path of electricity through a bulb or a model or diagram of a bulb.

- Individual evaluations - short answer test items

  An example of a test item based on this lesson is:
  Look at the diagram of the bulb. Would the bulb would work if it was put together as shown in the diagram? Explain why.

Activities

♦ Using a dry cell in a holder, two pieces of wire and a flashlight bulb, discover where the wires have to be touching the bulb in order to get the bulb to light. Encourage both boys and girls to participate on equal terms in manipulating equipment and recording observations during science activities.

Carefully remove the glass from an incandescent light bulb. Is the filament still completely or partially intact? If it is completely absent find out where it goes by inspecting a new clear glass bulb. Trace the path of electricity in the bulb. What are the uses of the structures that aren't part of the circuit in the bulb? How does a light bulb produce light? Draw a diagram of a light bulb.

♦ Find out how light is produced in a fluorescent tube. Compare this method to how light is produced in an incandescent bulb. What are the advantages of each type of light production?

Why is it dangerous to break a fluorescent tube? Are there other ways to produce light? How many ways of producing light can you discover? (Teacher's note: These questions may be assigned for homework. Ask students to bring back answers for next class. One question might be assigned to the students from each group. Make sure to emphasize that it is dangerous to break fluorescent tubes. Let them do the research to find out why.)

♦ Encourage students to investigate these questions and create more:
- Which gets hotter when it is on: An incandescent bulb or a fluorescent tube?
- What is the purpose of these bulbs: to produce light or produce heat?
- How could you test which bulb (or light source) produces the most light per unit of electricity used?
- How do low-energy lightbulbs save energy over regular bulbs?

Lesson 4

Factors of scientific literacy

- A1 public/private
- A5 empirical
- B1 change
- B3 orderliness
- B14 cycle
- B16 system
- C4 working cooperatively
- C8 hypothesizing
- C13 formulating models
- D5 public understanding gap
- E3 using equipment safely
- E7 manipulative ability
- F1 longing to know and understand
- F7 demand for verification
- G3 continuous learner

Objectives

- 1.4 Examine conversions of energy between forms.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 3.1 Examine personal experiences with technologies involving light, sound, and electricity.
- 3.3 Appreciate how technological developments affect culture and society.
- 4.1 Make careful observations during activities and discuss observations with others.
- 4.2 Strengthen perceptual abilities through concrete experiences.

Materials

- flashlights
- toasters or other small appliances
- small screwdrivers of various types (Phillips, slot, Robertson)
- baby food jars to hold screws, small pieces
- tray (food tray, cookie sheet) to hold large pieces

Assessment

- Individual evaluations – written assignments

  Ask the students to write a paragraph describing what they have learned or what they understand about a flashlight (or other appliance) as a result of having taken it apart. This paragraph could be done in class, outside of class time, or on a test. If done in class or outside of class time, some students may wish to include the paragraph as part of their portfolio.

  Their diagrams and explanations of their concept of a clothes dryer may also be graded. If this is to be done, the students should be given the critieria for grading before they start the project. Some critieria might be:
  - description worded clearly and concisely
  - description organized so that a reader can easily follow it
  - diagrams large enough to be understood

Activities

♦ How does a flashlight work? Obtain some flashlights and ask the students to take them apart to determine how they work. The best kind of flashlights for this activity is the small keychain flashlight not much bigger than two AA cells side by side. When you open the battery compartment, the circuits are visible.

Ask each group to draw a diagram of the path electricity would take through the flashlight, and then write a story pretending they are an electron in one of the dry cells, getting ready to embark on the voyage through the bulb and back to the cell.

Encourage students to work cooperatively in the prewriting stage, when they are generating and organizing ideas. During the drafting and postwriting stages encourage them to work both individually and in groups as appropriate, using a word processor program if possible. Investigate how you can make word processors available and useful to your students. For a further explanation of the stages of the writing process consult *English Language Arts: A Curriculum Guide for the Elementary Level*.

- ♦ How does a toaster work? Obtain some old non-working toasters and ask the students to take them apart to determine how they work. It would be a good idea to cut the electric cord about 2 cm from where it enters the toaster so that no one is tempted to plug it in. Ask them to draw a diagram of the path electricity would take through the toaster, and then write a story pretending they are an electron in the house circuits which encounters the plug of a toaster. What adventures would the electron encounter going through the toaster?

  Repeat this activity with other small appliances, but not with old television sets. The coil in a television set may be charged with up to 25 000 volts.

- ♦ Think about an electric clothes dryer, the kind that is about 1 m by 1 m by 1 m. How does it work? What are its components? Discuss this problem with your partners and draw some annotated diagrams that explain to someone reading them your ideas about the design of the inside of a clothes dryer.

  What are some alternative ways of drying clothes? What are some advantages and disadvantages of each?

- ♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need them, two possible stems to suggest:
  - Diagrams are helpful because...
  - I would like to find out about...

Lesson 5

Factors of scientific literacy

- B2 interaction
- B5 perception
- B15 model
- B27 amplification
- C9 inferring
- C11 controlling variables
- C14 problem solving
- C16 designing experiments
- D3 impact of science and technology
- E1 using magnifying instruments
- E7 manipulative ability
- F3 search for data and their meaning
- G8 explanation preference

Objectives

- 1.2 Compare and contrast forms of energy.
- 1.3 Demonstrate how we recognize the presence of energy in a system.
- 1.4 Examine conversions of energy between forms.
- 2.1 Investigate how these forms of energy are formed and transmitted.
- 3.1 Examine personal experiences with technologies involving light, sound, and electricity.
- 3.3 Appreciate how technological developments affect culture and society.
- 4.2 Strengthen perceptual abilities through concrete experiences.

Materials

- stiff paper cones (homemade or purchased)
- straight pins or needles
- records
- record turntable
- balloons
- stereo system with speakers

Assessment

- Individual assessments – written assignments

  Write a review of the video **Sound Advice** for grading and for possible inclusion in a portfolio. Criteria for grading should be available to students before they write their review.

Activities

♦ Discuss with the class the question: What is sound? Record their ideas. Produce a class concept map. Watch the video **Sound Advice**. After this viewing, discuss any changes or additions they may wish to make to the concept map.

♦ Build a record player with a needle and drinking cone (Sno-Kone holder) or other stiff paper cone. Use a magnifying glass or a stereo microscope to look at record grooves. A supply of records for this use can be obtained relatively cheaply from garage sales or record store clearance bins. Put the record on a turntable and place the pin in the groove. Turn on the player and adjust the pressure on the cone and pin so that sound is reproduced.

  How do the grooves, pin and cone each contribute to the production of sound? Why don't you have to move the pin (or the needle of a regular pick-up) from track to track on the record to play the whole record?

  How do our vocal cords produce sound? When we whistle how is the sound produced? How does holding a blade of grass flat between the two thumbs cause a sound when one blows into the gap between the thumbs? Do birds have vocal cords to produce their sounds? When an object is going very quickly through the air, why does it make a whistling sound? What do all these ways of making sound have in common. What is a siren disk? What are other ways of making sound?

♦ Use a balloon inflated to its limit as a vibration detector in front of large speakers. How sensitive are the balloon-detectors? How do distance, amount of inflation, size, colour, shape, thickness of walls, and other factors you can identify affect the performance of the balloon as a vibration detector?

  If you put a string on the balloon, will the vibrations cause the string to vibrate. What type of sound (rock, classical, jazz) or instrument (clarinet, tuba, piano) cause the most or best vibrations?

♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need them, here are two possible stems to suggest:
  - The type of sounds that make me feel relaxed are...
  - Something I can't figure out is...

Lesson 6

Factors of scientific literacy

- A2 historic
- A3 holistic
- B12 conservation
- B13 energy-matter
- C2 communicating
- C12 interpreting data
- C20 defining operationally
- D3 impact of science and technology
- E4 using audiovisual aids
- F3 search for data and their meaning
- F5 respect for logic
- G4 media preference

Objectives

- 1.4 Examine conversions of energy between forms.
- 2.1 Investigate how these forms of energy are formed and transmitted.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 3.1 Examine their experience with technologies involving light, sound and electricity.
- 3.3 Appreciate how technological developments affect culture and society.

Resources

- *Forms and Uses of Energy*
- *Journeys in Science 6*
- *Motion, Forces and Energy*
- *Silver Burdett and Ginn Science 6*
- *Sound and Light*
- resources centre

Assessment

- Self-assessment – rating scale

  Each student should complete the checklist on page 89 with respect to their activity within the group.

  The group may also be assigned a grade based on their presentation. Criteria for marking might be:
  - organization of materials
  - organization and flow of presentation
  - involvement of audience in presentation
  - clarity of posters, graphs, and charts (Can they be seen from the back of the room? Are they neat and uncluttered? Are they visually attractive?)
  - utility of posters (Do they add information to the presentation?)

Activities

- ♦ Brainstorm to produce a list of electricity questions. Post all questions on the board or on large sheets of paper. (This activity might be started a week or so in advance of the actual lesson time for the research.) Examples of questions are:
  - How does a dry cell produce electricity?
  - Why do dry cells run down? What is the difference between a dry cell and a battery?
  - How many cells are there in a car battery?
  - What produces the electricity in a car battery?
  - How does an alternator or a generator in a vehicle produce electricity?
  - How do rechargeable cells and batteries get recharged?
  - How is electricity produced at Boundary Dam?
  - How is it produced at Coteau Creek and at Island Falls?
  - How are these processes similar to that used in a car battery? in a car alternator or generator? How are the processes different?
  - What effects on the body does an electrical shock have? Why do paramedics use electric shock to restart a stopped heartbeat?
  - How does a pacemaker work? Does a healthy heart generate electrical impulses on its own?

  When there are sufficient questions, ask each group to pick one question and answer it. They should prepare posters, graphs, charts, notes, or whatever is necessary to communicate their discoveries and explanations to the rest of the class. The presentations can be posted on a bulletin board, made orally, or both.

  The question list could be expanded to include questions about light and sound as well. This activity is intended to be done over the course of 1 to 2 weeks, as other lessons are progressing, as an ongoing research project.

- ♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need one, a possible stem to suggest is:
  - What I would like to learn during science is...

Lesson 7

Factors of scientific literacy

- A9 human/culture related
- B12 conservation
- C1 classifying
- C6 questioning
- C15 analyzing
- C19 consensus making
- D4 science, technology, and the environment
- F2 questioning
- G2 confidence

Objectives

- 1.4 Examine conversions of energy between forms.
- 1.5 Assess the efficiencies of conversions of forms of energy.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 2.3 Prioritize energy use in our lives.
- 3.3 Appreciate how technological developments affect culture and society.

Assessment

● Individual evaluations – anecdotal records, open response test items

Since this is a whole class discussion, anecdotal records written immediately after class may be useful. The topic may serve as a source of questions for open response test items. An example of such an item is: "The class agreed that light bulbs give off heat that is often wasted. Suggest two things that can be done to reduce the waste heat produced by lighting."

Activities

♦ Bring the forms of energy poster to the attention of the class. Brainstorm as a class to list all ways energy is converted from one form to another. For example, electricity is converted to light by a camera flash attachment. After one minute of brainstorming, stop and categorize each example according to whether it is a useful conversion or not. Resume brainstorming for another two minutes with the concept "useful conversions" and then a further two minutes on the concept "not useful conversions".

Analyze the list of useful conversions. Are there trends which can be determined? Does one form of energy appear more often than others? Are there some conversions that are useful but not essential?

Repeat with the list of "not useful" conversions. If the conversions are not useful, what effect do they have on us and on the way we live our lives? Does not useful mean the same as not essential? Which of the conversions classified as not useful could be easily dispensed with?

♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need them, here are two possible stems to suggest:

- One way I could use less energy is...
- The most important thing about energy conversion is...

Lesson 8

Factors of scientific literacy

- A3 holistic
- B2 interaction
- B10 cause-effect
- C1 classifying
- C8 hypothesizing
- C13 formulating models
- D3 impact of science and technology
- F2 questioning
- F5 respect for logic
- G8 explanation preference

Objectives

- 2.1 Investigate how these forms of energy are formed and transmitted.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 2.3 Prioritize energy use in our lives.
- 3.1 Examine personal experiences with technologies involving light, sound, and electricity.
- 3.3 Appreciate how technological developments affect culture and society.

Assessment

- Group self-assessment – rating scale

  Each lab group should complete the group self-assessment on page 88 with respect to their investigation about colour.

Activities

♦ Brainstorm to produce a list of all uses of all types of light. Identify any uses that are essential to life. Ask each group to choose one use that has been identified as essential. What type of adaptations would be necessary for organisms that now depend on this light to succeed in its absence?

  If each group has a different use, ask them to present their ideas orally to the whole class. An alternative way to present their ideas might be to create a story describing life that has adapted to no light or draw a mural depicting such adaptations.

♦ In pairs, ask the students to study pages 158 to 167 in **Silver Burdett and Ginn Science 6**. Are there are other uses of light mentioned there, or does the discussion help them think of any other uses, that were not listed in the initial class brainstorming session? Record any such uses and share them with the class. Devise an investigation to study the effect of the colour of light on the colour an object appears to be. Why is this effect important if you are shopping for clothes? What would be the effect of using sodium vapour lighting (the orange street and yard lights) in stores?

♦ Watch the segment on holograms on the video **Science Edition Program 5**. Some students may want to do additional research into how holograms are produced and used. Other research topics involving the use of some part of the electromagnetic spectrum in a technological application include: compact disc players; radar speed guns; microwave ovens; X-ray machines; polarizing lenses; infrared detectors; night-vision binoculars; and, ultraviolet absorbers and blockers (sunscreens, glasses and other applications).

♦ Take 5 to 10 minutes at the end of the class to give each student an opportunity to write reflectively. For those who need them, here are two possible stems to suggest:

- Light is important to me because...
- I wonder about...

Lesson 9

Factors of scientific literacy

- A4 replicable
- A5 empirical
- B3 orderliness
- B6 symmetry
- B11 predictability
- C3 observing and describing
- C10 predicting
- C11 controlling variables
- C16 designing experiments
- C18 using time-space relationships
- D1 science and technology
- E3 using equipment safely
- F3 search for data and their meaning
- G3 continuous learner

Objectives

- 2.1 Investigate how these forms of energy are formed and transmitted.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 3.1 Examine personal experiences with technologies involving light, sound, and electricity.
- 4.1 Make careful observations during activities and discuss observations with others.
- 4.2 Strengthen perceptual abilities through concrete experiences.
- 4.3 Understand how knowledge is created and evaluated in science.

Resources

- *Silver Burdett and Ginn Science 6*
- *Sound and Light*
- print materials in the resource centre

Materials

- rectangular pieces of mirror, various sizes, from 2 cm square to 4 cm by 6 cm
- modelling clay to support mirrors vertically
- cardboard for model building
- tape for model building

Assessment

- Individual or peer assessment – anecdotal records

  If students draw diagrams of devices that use mirrors, the diagrams can be analyzed to determine whether the devices would work as indicated. Peer evaluation could be used for these diagrams.

- Assessment stations – performance assessments

  A station could be created with a light source, two mirrors and a target. The task would be to get the light to bounce off both mirrors and then hit the target.

Activities

♦ List as many devices as possible which use mirrors as essential components. Draw diagrams to show how mirrors are used in each case, and build models of the devices if that is practical.

Experiment with how plane mirrors reflect light. Can you state a rule that describes how light reflects from a plane mirror?

♦ A converging mirror can be used to reflect light to create an image on a card held between the object and the mirror. Experiment with images formed in and by converging mirrors. What characteristics do the images have? In what devices are converging mirrors used?

See if the same type of image formation is possible with a diverging mirror. (These are the mirrors that say on them: "Warning! Objects may be closer than they appear.")

Lesson 10

Factors of scientific literacy

- A9 human/culture related
- B1 change
- B7 force
- B10 cause-effect
- B15 model
- C6 questioning
- C13 formulating models
- C15 analyzing
- D3 impact of science and technology
- F6 consideration of consequence
- G6 response preference

Objectives

- 1.2 Compare and contrast forms of energy.
- 2.2 Recognize how individuals use and depend on these forms of energy.
- 2.3 Prioritize energy use in our lives.
- 3.1 Examine personal experiences with technologies involving light, sound, and electricity.
- 3.2 Understand the social and cultural forces which underlay technological developments.
- 3.3 Appreciate how technological developments affect culture and society.

Activities

♦ Working in groups of three or four, reach a consensus about which form of energy is most important to our lives: light, sound, or electricity? Which is second most important? Ask each group to report their decision to the class. Is their unanimity?

Individually, pick one of the forms and visualize a life without that form of energy? How would you adapt to survive? What other forms of energy or what changes in behaviour would help you accommodate the loss of use of the form you have chosen?

Write a short story that describes the ideas you have about how your life, and life in general, would change without that form of energy. Share your story with the other members of your group after you have completed the drafting process. Use their reactions and input during the postwriting process. If word processing programs are available for you to use at home or in school, use them for this assignment.

Assessment

- Individual evaluations – written assignments

The short stories produced can be included in individual student portfolios.

Model unit: Risks and Limits

Unit overview

Often we live lives of contradictions. We demand zero risk from pesticide residues on fruits and vegetables or from `second-hand' cigarette smoke, but take a large risk quite voluntarily when we don't fasten the seat belt in our car.

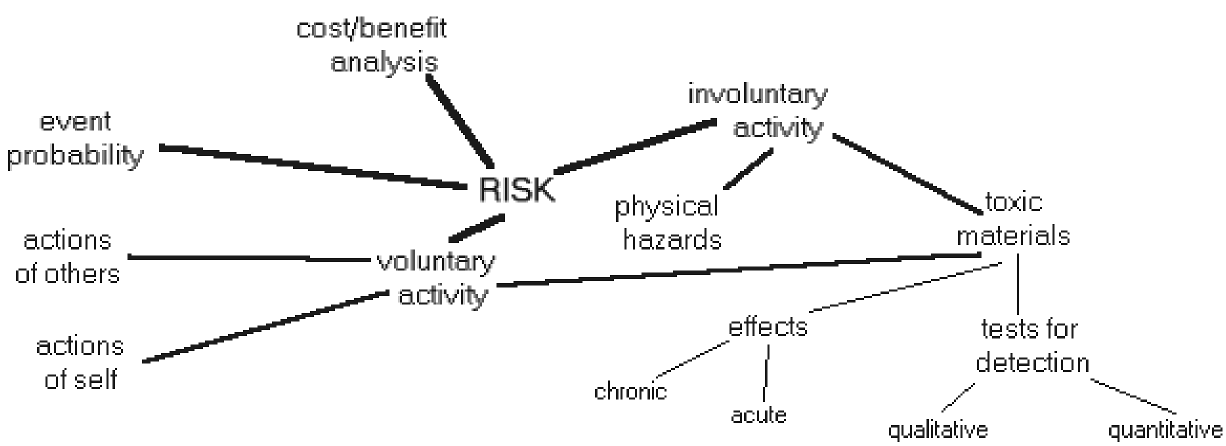
How are the risks of activities assessed? How do we decide whether a risk is unacceptable? How do we determine what risks are present? This unit gives students a chance to consider these questions in the context of issues and events important in their lives and the lives of those around them.

This unit is based on two key resources: *Risk Comparison* and *Determining Threshold Limits*. If you are going to use the model unit, you will need one copy of each of these modules. The activities selected from these modules and from the Suggested Activities section of this Guide present the concepts of science in the context of their application in society and their implications for society.

The activities utilize a variety of instructional methods. Suggestions for evaluation strategies accompany the lessons, and can be incorporated into an overall evaluation plan for the unit and the year. When moving away from a `text for each student' model of science education, as this unit does, two things are especially important. One is that the evaluation techniques used must complement the instructional methods. For example, to use at the end of this model unit a single exam with questions stressing only ability to recall information as the sole evaluation technique would be a mismatch between the instruction and evaluation. To use such an exam in combination with several or many of the strategies suggested in the lesson outlines, and to add questions involving application, analysis, or evaluation to the exam would be a more valid assessment of student abilities.

While Indian and Métis curriculum perspectives and concerns of Gender Equity have been included while writing this unit, look for ways that more sensitivity to these important principles can be expressed in your classroom.

Unit web



Resources

Materials

- one coin per four students
- one die per four students
- six coloured marbles per four students (if use of dice in the classroom raises objections)
- sodium chloride (reagent grade or pickling salt)
- household ammonia solution
- phenolphthalein solution
- potassium chromate
- silver nitrate
- vinegar
- dropper bottles (e.g. Boreal #68593-02)
- one sheet of glass or acrylic (10 cm by 15 cm) per group

Books (See *Key Resource Correlations* for citations.)

- *Determining Threshold Limits* (1 book per school)
- *Risk Comparison* (1 book per school)

Video (see citation in the reference list on page 102)

- *What's Killing the Children?* (optional)

Unit schedule

This schedule is based on 45 minute class periods.

Lesson	# of periods
1	3-4
2	1
3	2-3
4	2
5	1
6	1
7	3
8	3-4
9	2

Unit Evaluation Plan

Ideas for continuous assessment are outlined with each lesson overview. The information from these activities would be combined with a unit end examination. Questions for this exam would be drawn from the evaluation sections on pages 45 to 47 of *Determining Threshold Limits* and pages 43 to 44 of *Risk Comparison*, from the discussion questions that accompany the activities in these modules, and from questions raised and considered in class.

Lesson 1

Factors of scientific literacy

- A5 empirical
- A7 unique
- B3 orderliness
- B6 symmetry
- B11 predictability
- B19 probability
- B29 gradient
- C7 using numbers
- C14 problem solving
- F3 search for data and their meaning
- F5 respect for logic
- G3 continuous learner

Objectives

1.1 Understand and demonstrate the concepts of probability and chance.

Resources

- *Risk Comparison* (CEPUP module)
- one coin per four students
- one die per four students

Assessment

- Individual evaluations – written assignments, short answer test items

  Use the "Going Further" section on pages 3 and 4 of the Risk Comparison module as homework or in-class assignments to be marked for credit. Question (c) can be changed by including or substituting the statistic that in 1991, when our population was approximately 990 000, 170 people were killed in motor vehicle accidents in Saskatchewan. Another statistic is that in Canada in 1990, 3 957 persons were killed in motor vehicle accidents.

  The questions from this section can also be used as models for questions on a unit exam.

- Peer assessment
  The second activity involves peer assessment of the spinners produced. Copies of the testing report might be included in the testers' portfolios as well as being submitted to the creators of the spinner.

Activities

♦ Follow the activity as outlined on pages 1 to 5 of the *Risk Comparison* module. Student Sheet 1·1 on page 5 need not be duplicated for each group. Rather the instructions for the activity and the data collection charts could be given orally or on an overhead transparency. One idea is to give the students a concept of the data to be collected, let them discuss in pairs how to organize the data, and then have a class discussion to discuss their solutions.

If there are objections to using a die in the classroom, a toque or hat containing marbles of six different colours could be substituted for the die. Mix by shaking, draw a marble, record the colour, replace the marble and repeat. A key can be used to convert data from colours to numbers if you want to use the data for calculations. (For example red=1, green=2, and so on.)

♦ Design and produce an unbiased spinning wheel for use in games. The wheel must produce an equal probability of stopping in any of the eight (or some other number you select) sectors marked at the edge of the wheel. Trade your spinner for one another group made. Test the spinner you received from them to determine if it is unbiased. Write a report, complete with statistics, outlining your findings.
Create a game based on the use of this spinner. Experiment with altering the spinner to make it biased.

♦ If two dice are rolled, what is the range of possible outcomes? What is the most likely outcome? Use a chart or tree diagram to show all outcomes. Highlight the most likely outcomes. What happens if three dice are used? What is the most likely total to represent the sum of the dots on three rolled dice? Explain how you discovered this answer.

♦ Consider the game paper-scissors-stone. What strategies work best for playing the game? Why are these strategies the best? What strategy is best for playing X and O (tic-tac-toe) if you have the first play? if you have the second play? Is there a strategy to use to help you win if you are rolling two dice with a friend to see who can roll a sum of seven?

Discuss the difference between independent events based on pure probability (whether a flipped coin comes up heads or tails) and dependent events that involve probability, such as in paper-scissors-stone outcomes.

Lesson 2

Factors of scientific literacy

- A2 historic
- A9 human/culture related
- B5 perception
- B10 cause-effect
- B18 population
- B19 probability
- C10 predicting
- C12 interpreting data
- D5 public understanding gap
- D8 limitations of science and technology
- F5 respect for logic
- G8 explanation preference

Objectives

- 1.2 Relate the concept of probability to the concept of risk.
- 1.3 Compare risks of various voluntary and involuntary activities.
- 3.3 Explore how moral values influence behaviour and assessment of risk and benefit.
- 3.4 Recognize the importance of fact-finding, prior experience, and open dialogue in the development of reasoned arguments.

Materials

- student sheet 2·1 from *Risk Comparison*

Assessment

- Individual evaluations – rating scales

  Each student's role in the group discussions of answers can be assessed by using a rating scale or checklist to structure and record observations. An example of such an instrument is found on page 85 of *Student Evaluation: A Teacher Handbook*. This instrument may also be adapted for use in student self-assessment.

Activities

♦ Distribute "Injection Problem Story" found on Student Sheet 2·1. These sheets can be collected after this activity for reuse with another class. Following individual student completion of the questions at the end of the story, ask students to form groups of two or three to compare their answers, formulate improved responses, and prepare for a class discussion of the questions.

Lesson 3

Factors of scientific literacy

- A6 probabilistic
- B5 perception
- B11 predictability
- B15 model
- B19 probability
- C7 using numbers
- C12 interpreting data
- C15 analyzing
- D5 public understanding gap
- F3 search for data and their meaning
- G8 explanation preference

Objectives

- 1.2 Relate the concept of probability to the concept of risk.
- 1.3 Compare risks of various voluntary and involuntary activities.
- 2.1 Consider how risk is assessed.
- 2.4 Discuss how the value one places on an activity influences the amount of risk one is willing to accept.
- 3.4 Recognize the importance of fact-finding, prior experience and open dialogue in the development of reasoned arguments.

Resources

- copies of pages 923 to 926 in the Curriculum Guide

Assessment

- Individual evaluations – written assignments

  Write a paragraph on the topic "There is no such thing as a risk-free life." A good paragraph will:
  - be well-organized (Are ideas linked and coherent?)
  - support arguments with examples or evidence
  - have minimal mistakes in sentence structure, grammar and word usage

- Group evaluations – data tables may be marked for accuracy of results

Activities

♦ Distribute one copy of the "Rank the risk of death..." form (see page 923) to each student. Ask the students to work individually to rank the risks from greatest (#1) to least (#9). Page 923 has three copies of the form so you need only photocopy one-third as many copies of that page as you have students. Create a class data chart where they can enter the rank number for each risk. Total the class data to produce a class ranking.

Distribute the Risk Data sheet (page 924). Calculate the numerical risk per 100 000 persons, using the Statistics Canada data given. Rank the hazards according to the risk as expressed by this number. Compare this ranking with the rankings done in the first part of this activity.

Why isn't the estimated population at risk the same value for each risk listed?

Heart disease is a lower risk for the 10-19 year age group than for the population as a whole. What other event or activities might pose a lower risk for this age group? Which might pose a higher risk? Be prepared to give reasons to support your statement.

♦ Complete the blank Numerical Risk chart on page 925 using data from the completed charts on page 924.

Discuss the reasons for the variations which show up in the Risk chart. Suppose that the numerical risk of injury from jumping from a car moving at 30 kph is expressed as 50 000 in 100 000. Express that risk as a probability for each person jumping from the car.

Numerical risks that are expressed in the form "1 chance in 2" are called risk probabilities. They can be calculated from the numerical risk data. Calculate risk probabilities to fill in the Risk Probability chart, using data from the Numerical Risk chart. Several cells are completed for you to be able to check your method of calculation.

- Of 6 651 persons injured while riding in motor vehicles involved in accidents during 1990, 5 053 were wearing seat belts. 1070 were not wearing seat belts. It is not known whether the other 528 people were wearing seat belts or not. The estimated compliance rate with the mandatory seat belt use law in Saskatchewan in 1990 was 94%. Could these statistics be used to argue that wearing seat belts causes people who are in motor vehicle accidents to be injured?

  The injuries to these people were categorized as minor, moderate, or major. Of those injuries to people wearing seatbelts, 1 750 were minor, 2 824 were moderate, and 479 were major. Of those injuries to people not wearing seatbelts, 214 were described as minor, 549 as moderate, and 307 as major. Present this data in a table showing both absolute numbers of casualties and the risk probability statistics for each group of people.

  Write a paragraph summarizing your conclusions and recommendations from analysis of this data.

- Discuss the concept of cost-benefit analysis in making decisions about what activities to participate in and how to conduct our lives. Compare the benefits and costs of an activity they voluntarily assume, such as riding in or driving a motor vehicle or playing a sport. Discuss how the number and relative worth of costs and benefits can be changed.

  Then compare the costs and benefits of an involuntary activity such as the risk of homicide. How can the number and relative worth of the costs and benefits be changed?

Lesson 4

Factors of scientific literacy

A2 historic
A5 empirical
B5 perception
B15 model
B18 population
C9 inferring
C14 problem solving
C19 consensus making
D8 limitations of science and technology
F5 respect for logic
F6 consideration of consequence
G6 response preference

Objectives

1.3 Compare risks of various voluntary and involuntary activities.
2.1 Consider how risk is assessed.
2.4 Discuss how the value one places on an activity influences the amount of risk one is willing to accept.
3.2 Understand the potential narrowness in adopting a single perspective in judging the impact or influence of objects, experiences or events.
3.3 Explore how moral values influence behaviour and assessment of risk and benefit.
3.5 Establish arguments based upon human rights, human needs or needs of the environment when examining social issues.

Activity

♦ Use Activity 4 in the *Risk Comparison* module. Reformat the student sheets so that the reading and questions for part 1 appear on one sheet of paper, omitting the space for students to answer each question. Students may recopy the question and write their answer in their notebook. Do the same for parts 2, 3, and 4. Collect the pages from the students for reuse with subsequent classes. Consider laminating these pages if you estimate that to be cost effective.

Resources

- student readings and questions, adapted from Student Sheets 4·1, 4·2, and 4·3 in the *Risk Comparison* module.

Assessment

- Individual evaluations – extended open response test items, written assignments

  Questions 1-9 may be adapted as items for a unit test, as may the swine flu story, and questions presented in the "Going Further" section on pages 23 and 24. Alternatively, the swine flu example may be given to students (as individuals or groups) as a homework assignment.

Lesson 5

Factors of scientific literacy

A9 human/culture related
B2 interaction
B10 cause-effect
B14 cycle
B31 significance
C9 inferring
C15 analyzing
C15 analyzing
D4 science, technology, and the environment
F5 respect for logic
G8 explanation preference

Objectives

2.1 Consider how risk is assessed.
2.2 Assess significance of contaminants in water supplies.
3.1 Understand the natural environment and the conditions putting it at risk.
3.4 Recognize the importance of fact-finding, prior experience, and open dialogue in the development of reasoned arguments.

Activities

♦ Use Activity 5 from the *Risk Comparison* module. As in Activity 4, reformat the student sheets so that the reading and questions for Part 1 are on one sheet of paper, with the spaces to answer the questions on the sheet removed. Reformat Part 2 so that it is on another sheet of paper. Collect these student sheets for reuse with subsequent classes.

♦ The video "What's Killing the Children?" from the NOVA series on PBS describes how a scientist named David Fleming used the techniques of epidemiology amd the technology of modern medicine to identify a new disease during the 1980's. The video shows that the principles that Edward Jenner, Peter Boylston, John Snow, and other early scientists used to identify and control smallpox and cholera are still used today.

Resources

- student sheets 5·1 and 5·2, reformatted

Assessment

- Individual evaluations – anecdotal records

  Anecdotal records of student cooperation and performance during the class discussions of the questions can be recorded during or after the class period.

Lesson 6

Factors of scientific literacy

- A4 replicable
- B5 perception
- B8 quantification
- B29 gradient
- C11 controlling variables
- C20 defining operationally
- F3 search for data and their meaning
- G1 interest

Objectives

- 2.2 Assess significance of contaminants in water supplies.
- 3.4 Recognize the importance of fact-finding, prior experience and open dialogue in the development of reasoned arguments.

Resources

- *Determining Threshold Limits* module
- salt solutions (see page 53 for preparation instructions)

Activity

♦ Use Activity 1 from the *Determining Threshold Limits* module. This is a rare activity in that it asks students to taste salt solutions to experience the concept of threshold limits of detection. Make sure that all droppers and beakers used in this activity are absolutely clean. It would be a good idea to use a new box of droppers and some drinking glasses for the solutions each time this activity is repeated. Instructions for making the salt solutions are found on page 53 of the module. Pickling salt (non-iodized sodium chloride) can be used instead of reagent grade sodium chloride.

Assessment

- Individual evaluations – short answer test items

  Create data from imaginary threshold limit determinations similar to this activity to use in questions that ask students to analyze the results of investigations. An example is given in the next paragraph.

  Suppose that in a test to determine the threshold of taste sensitivty to grapefruit juice, 6 people reported that they could detect it at a dilution of 1 part grapefruit juice in 8 parts water, two reported that they could detect the taste at a dilution of 1 part grapefruit juice in 10 parts water, and one person reported detecting the taste when it was diluted to 1 part grapefruit juice in 12 parts water.

  a) Draw a bar graph showing the data collected.
  b) Write a general statement about the outcome of this test.
  c) What factors or conditions might influence the outcome of this test?

Lesson 7

Factors of scientific literacy

A4	replicable
A5	empirical
B2	interaction
B9	reproducibility of results
B16	system
B29	gradient
C3	observing and describing
C11	controlling variables
C15	analyzing
C20	defining operationally
D4	science, technology, and the environment
E3	using equipment safely
E13	using quantitative relationships
F5	respect for logic
G2	confidence

Objectives

2.2 Assess significance of contaminants in water supplies.

3.4 Recognize the importance of fact-finding, prior experience, and open dialogue in the development of reasoned arguments.

Resources

- solutions of salt, ammonia, phenolphthalein, potassium chromate, silver nitrate, acetic acid in dropper bottles
- 10 cm by 15 cm sheet of glass or acrylic
- Student Sheets 2·1, 2·3, 3·1 adapted

Assessment

- Assessment stations, individual or group checklists, self and peer-assessments

Since this is an activity involving active investigations, it is ideally suited for performance assessment. After the activity, stations can be set up where students individually or in groups go to investigate a different system (calcium chloride, sodium carbonate, potassium chloride) that produces a precipitate. Alternatively the activity outlined on Student Sheet 2·3 could be used as a performance assessment instrument if not used during this lesson.

Checklists such as the one on page 74 of *Student Evaluation: A Teacher Handbook* can be adapted for use with this activity. Another model of a checklist is found on page ?? of this Guide, as are sheets for use in self-assessment.

Activity

♦ Use Activities 2 and 3 from the *Determining Threshold Limits* module. Potassium chromate, phenolphthalein, and silver nitrate must all be ordered from a chemical supply company. Instructions for making the solutions of these chemicals are found on page 53 of the module. (From 5 to 6 mL of the silver nitrate solution, about 1 mL of the potassium chromate solution and 0.5 mL of the phenolphthalein solution will be needed for each group to do Activities 2 through 5.)

Lesson 8

Factors of scientific literacy

A2 historic
A9 human/culture related
B5 perception
B8 quantification
B11 predictability
B18 population
B31 significance
C6 questioning
C9 inferring
C13 formulating models
D9 social influence on science and technology
E9 measuring volume
F7 demand for verification
G7 vocation

Objectives

2.3 Recognize how scientists estimate toxicity levels from experimental data.
2.4 Discuss how the value one places on an activity influences the amount of risk one is willing to accept.
3.1 Understand the natural environment and the conditions putting it at risk.
3.2 Understand the potential narrowness in adopting a single perspective in judging the impact or influence of objects, experiences or events.
3.3 Explore how moral values influence behaviour and assessment of risk and benefit.

Activity

♦ Use Activities 4 and 5 from the *Determining Threshold Limits* module. Student Sheet 5·1 could be adapted so it would fit on on sheet of paper. The materials list could be on the board or an overhead transparency for everyone to see and the questions condensed by removing the spaces for answers. These sheets can be collected for use with another class.

Resources

- same solutions as in previous activities
- Student Sheets 4·1, 5·1 (adapted)

Assessment

- Individual assessments – short answer test items

  The evaluation section on pages 45 to 47 has a number of multiple choice and open-ended questions that could be used as is or as models for questions you develop. Questions 4 and 13 are examples of multiple choice questions that require an application of knowledge.

Lesson 9

Factors of scientific literacy

A6 probabilistic
B4 organism
B10 cause-effect
B16 system
C4 working cooperatively
C9 inferring
C12 interpreting data
C19 consensus making
D8 limitations of science and technology
F1 longing to know and understand
F8 consideration of premises
G1 interest

Objectives

2.3 Recognize how scientists estimate toxicity levels from experimental data.
2.4 Discuss how the value one places on an activity influences the amount of risk one is willing to accept.
3.3 Explore how moral values influence behaviour and assessment of risk and benefit.
3.5 Establish arguments based upon human rights, human needs or needs of the environment when examining social issues.

Activities

♦ Use Activity 6 from the *Determining Threshold Limits* module.

♦ Read the article titled "Study Claims" (Guide, page 926). Write a two paragraph review of this article. Find a magazine article or advertisement to use to illustrate some of the ideas presented in this article. Analyze the presentation in the advertisement.

Resources

- Student Sheets 6·1, 6·2 (adapted)

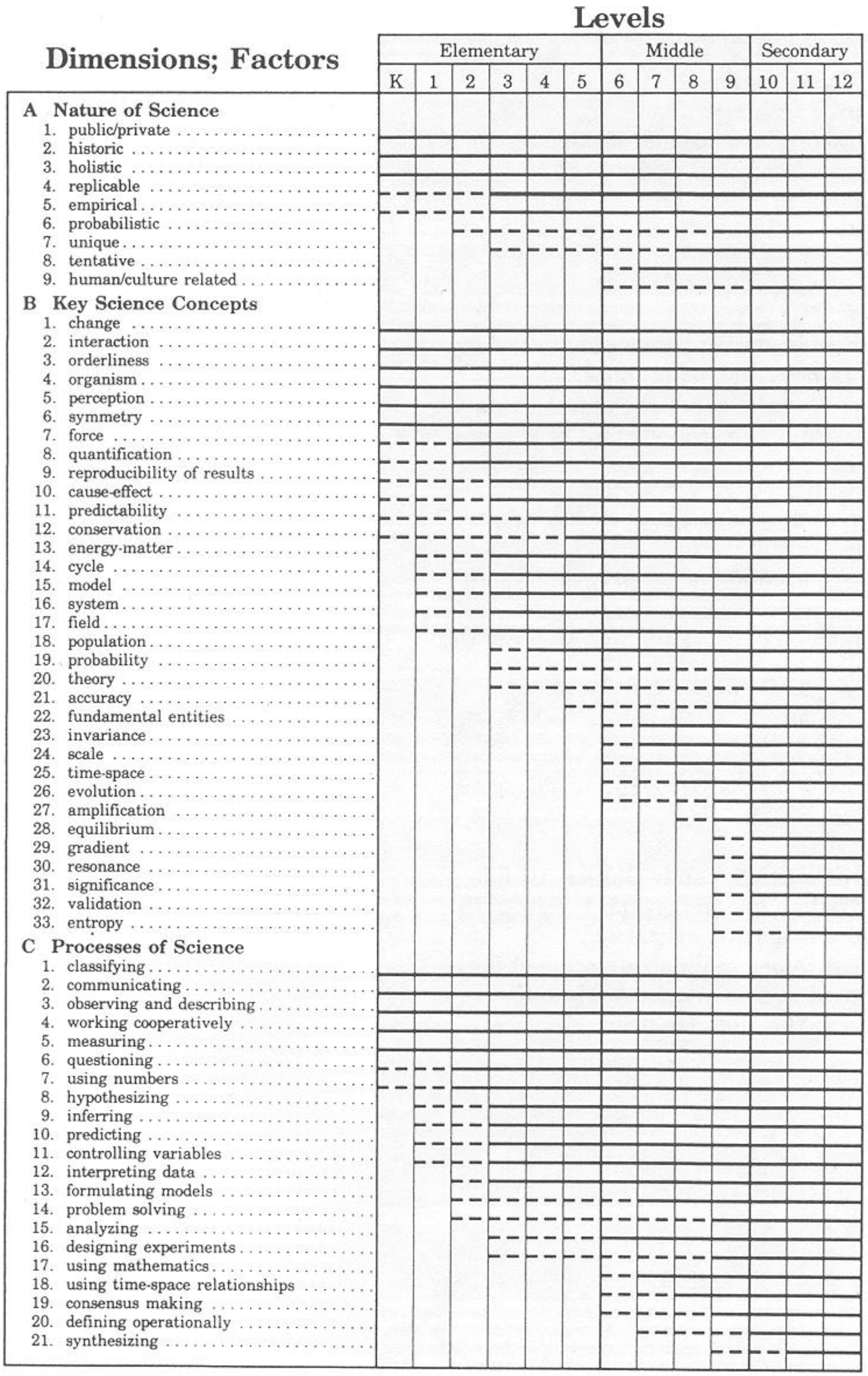
Assessment

- Individual evaluations – extended open response test items

  Questions such as 5 on page 43 and 3 on page 44 (Student Sheets 6·1 and 6·2) of *Determining Threshold Limits* could be repeated on a unit test, even if they are discussed in class as part of this lesson.

Aids for Planning

Scope and Sequence of the Factors Forming the Dimensions of Scientific Literacy[1]



[1]Adapted from: Hart, E.P. (1987). *Science for Saskatchewan Schools: Proposed Directions. Field Study, Part B. A Framework for Curriculum Development.* A Saskatchewan Instructional Development Research Unit project funded by Saskatchewan Education.

Dimensions; Factors	Levels												
	Elementary						Middle				Secondary		
	K	1	2	3	4	5	6	7	8	9	10	11	12
D Science-Technology-Society-Environment Interrelationships													
1. science and technology	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
2. scientists and technologists are human		- -	- -	- -	- -	- -	- -	—	—	—	—	—	—
3. impact of science and technology				- -	- -	- -	—	—	—	—	—	—	—
4. science, technology, and the environment				- -	- -	- -	—	—	—	—	—	—	—
5. public understanding gap				- -	- -	- -	- -	- -	- -	—	—	—	—
6. resources for science and technology				- -	- -	- -	- -	- -	- -	—	—	—	—
7. variable positions				- -	- -	- -	- -	- -	- -	- -	—	—	—
8. limitations of science and technology							- -	- -	- -	—	—	—	—
9. social influence on science and technology								- -	- -	- -	—	—	—
10. technology controlled by society										- -	—	—	—
11. science, technology, and other realms										- -	—	—	—
E Scientific and Technical Skills													
1. using magnifying instruments	—	—	—	—	—	—	—	—	—	—	—	—	—
2. using natural environments	—	—	—	—	—	—	—	—	—	—	—	—	—
3. using equipment safely	—	—	—	—	—	—	—	—	—	—	—	—	—
4. using audio-visual aids	—	—	—	—	—	—	—	—	—	—	—	—	—
5. computer interaction	—	—	—	—	—	—	—	—	—	—	—	—	—
6. measuring distance	- -	- -	—	—	—	—	—	—	—	—	—	—	—
7. manipulative ability	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
8. measuring time		- -	—	—	—	—	—	—	—	—	—	—	—
9. measuring volume		- -	—	—	—	—	—	—	—	—	—	—	—
10. measuring temperature		- -	—	—	—	—	—	—	—	—	—	—	—
11. measuring mass			- -	—	—	—	—	—	—	—	—	—	—
12. using electronic instruments						- -	- -	- -	- -	—	—	—	—
13. using quantitative relationships						- -	- -	- -	- -	- -	—	—	—
F Values That Underlie Science													
1. longing to know and understand	—	—	—	—	—	—	—	—	—	—	—	—	—
2. questioning	—	—	—	—	—	—	—	—	—	—	—	—	—
3. search for data and their meaning	—	—	—	—	—	—	—	—	—	—	—	—	—
4. valuing natural environments	—	—	—	—	—	—	—	—	—	—	—	—	—
5. respect for logic	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
6. consideration of consequence	- -	- -	- -	- -	- -	- -	—	—	—	—	—	—	—
7. demand for verification				- -	- -	- -	—	—	—	—	—	—	—
8. consideration of premises										- -	—	—	—
G Science-Related Interests and Attitudes													
1. interest	—	—	—	—	—	—	—	—	—	—	—	—	—
2. confidence	—	—	—	—	—	—	—	—	—	—	—	—	—
3. continuous learner	—	—	—	—	—	—	—	—	—	—	—	—	—
4. media preference	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
5. avocation				- -	- -	- -	—	—	—	—	—	—	—
6. response preference				- -	- -	- -	—	—	—	—	—	—	—
7. vocation				- -	- -	- -	- -	- -	- -	—	—	—	—
8. explanation preference							- -	- -	- -	- -	—	—	—
9. valuing contributors							- -	- -	- -	- -	—	—	—

KEY: - - - - Preparation. Emerging in these grades. Limited focus.
—— Development. Addressed in full, and appropriate to the grade level. Emphasized.

Explanations of the Factors in the Dimensions of Scientific Literacy

A. Nature of Science

The scientifically literate person understands the nature of science and scientific knowledge.

Science is both public and private. Science experiences should introduce students to the private and intuitive aspects of scientific inquiry and discovery as well as to the more formal public aspects of science.

The nature of scientific knowledge is such that it is:

A1 public/private D(K-12)

Science is based on evidence, developed privately by individuals or groups, that is shared publicly with others. This provides other individuals with the opportunity to attempt to establish the validity and reliability of the evidence.

Examples:

After scientists have gathered and organized evidence for their ideas, they publish the evidence and the methods by which it was obtained, so that other scientists may test the validity and reliability of the evidence.

Students carry out their investigations and then report to the class the results of their studies.

A2 historic D(K-12)

Past scientific knowledge should be viewed in its historical context and not be degraded on the basis of present knowledge.

Examples:

Each refinement of the model of the atom by Thompson, Rutherford, Bohr, and the quantum theorists has relied on the previous work of others.

Selective breeding of corn by the Indian peoples of North America produced a high quality food plant.

A3 holistic D(K-12)

All branches of science are interrelated.

Example:

The structure of molecules is a topic of interest for physicists, chemists, and biologists.

A4 replicable P(K-2), D(3-12)[1]

Science is based on evidence which could be obtained by other people working in a different place and at a different time under similar conditions.

Examples:

Any procedure which is repeated should give similar results.

A group of students all perform the same experiment and discover similarities in their results.

A5 empirical P(K-2), D(3-12)

Scientific knowledge is based on experimentation or observation.

Examples:

The gravitational field strength of the Earth can be determined in the laboratory.

Scientific theories must always be tested experimentally.

[1] The code **P(K-2)** means that preparation for development of this factor is to take place from kindergarten until grade 2. Development, coded **D(3-12)**, of the factor takes place from grades 3 to 12. **Preparation** involves such things as the teacher using the term or its concepts and the students being exposed to phenomena which illustrate or involve the factor. **Development** occurs when students are encouraged to use the term or its related concepts correctly.

A6 probabilistic **P(2-8), D(9-12)**

Science does not make absolute predictions or explanations.

Examples:

An electron orbital is a region in space where there is the greatest likelihood of finding an electron.

A weather forecaster predicts a 20% chance of precipitation tomorrow.

A7 unique **P(3-7), D(8-12)**

The nature of scientific knowledge and the procedures for generating new scientific knowledge are unique and different from those in other fields of knowledge such as philosophy.

Examples:

Compare the methods used for weather forecasting by meteorologists and those used by the people producing the forecasts for the Farmer's Almanac.

Compare Galileo's experimental approach to investigating the rate at which heavy and light objects fall and Aristotle's approach, based on reason alone.

A8 tentative **P(6), D(7-12)**

Scientific knowledge is subject to change. It does not claim to be truth in an absolute and final sense. This does not lessen the value of knowledge for the scientifically literate person.

Example:

As new data become available, theories are modified to encompass the new and the old data. Our understanding of atomic structure has changed considerably for this reason.

A9 human/culture related **P(6-9), D(10-12)**

Scientific knowledge is a product of humankind. It involves creative imagination. The knowledge is shaped by and from concepts that are a product of culture.

Examples:

Vertebrates, and specifically humans, are regarded as being at the pinnacle of evolution by some people.

The use of biotechnology has resulted in changes in rapeseed to remove erucic acid. This has led to the development of improved varieties of canola oil for human consumption.

B. Key Science Concepts

The scientifically literate person understands and accurately applies appropriate science concepts, principles, laws, and theories in interacting with society and the environment.

Among the key concepts of science are:

B1 change **D(K-12)**

It is the process of becoming different. It may involve several stages.

Examples:

An organism develops from an egg, matures, and eventually dies.

B2 interaction **D(K-12)**

This happens when two or more things influence or affect each other.

Example:

Within an ecosystem some animals have to compete for available food and space.

B3 orderliness D(K-12)

This is a regular sequence which either exists in nature or is imposed through classification.

Examples:

Crystal structures can be identified by diffraction techniques because of the regular arrangement of their atoms.

The periodic table of the elements displays an orderly arrangement of elements.

B4 organism D(K-12)

An organism is a living thing or something that was once alive.

Examples:

Whether or not a virus is a living organism is an interesting topic for scientific scrutiny.

Fossils found in sedimentary rock provide evidence of organisms which became extinct a long time ago.

B5 perception D(K-12)

Perception is the interpretation of sensory input by the brain.

Example:

Jet lag may impair the judgement of pilots during landing and takeoff.

B6 symmetry D(K-12)

This is a repetition of a pattern within some larger structure.

Example:

Some molecular structures and living organisms exhibit properties of symmetry.

B7 force P(K-1), D(2-12)

It is a push or a pull.

Example:

The weight of an object decreases at higher altitudes.

B8 quantification P(K-1), D(2-12)

Numbers can be used to convey important information.

Example:

The gravitational force of attraction between two objects can be calculated by using Newton's Law of Universal Gravitation.

B9 reproducibility of results P(K-2), D(3-12)

Repetition of a procedure should produce the same results if all other conditions are identical. It is a necessary characteristic of scientific experiments.

Example:

Heating a pure sample of paradichlorobenzene should cause it to melt at about 50 °C

B10 cause-effect P(K-2), D(3-12)

It is a relationship of events that substantiates the belief that natural phenomena do not occur randomly. It enables predictions to be made. The advent of chaos theory has caused some rethinking of this principle.

Examples:

The acceleration of a cart depends on the unbalanced force acting upon the cart.

Every event has a cause. It does not happen by itself.

B11 predictability P(K-3), D(4-12)

Patterns can be identified in nature. From those patterns inferences can be made.

Example:

When sodium metal reacts with water, the resulting solution turns red litmus paper blue.

B12 conservation **P(K-4), D(5-12)**

An understanding of the finite nature of the world's resources, and an understanding of the necessity to treat those resources with prudence and economy, are underlying principles of conservation.

Examples:

Insulating a home may reduce the amount of energy needed to heat it in the winter.

Smaller, more efficient internal combustion engines can be designed to use less fuel.

B13 energy-matter **P(1-2), D(3-12)**

It is the interchangeable and dependent relationship between energy and matter.

Example:

When a candle burns, some of the energy stored in the wax is released as heat and light.

B14 cycle **P(1-2), D(3-12)**

Certain events or conditions are repeated.

Examples:

The water cycle, nitrogen cycle, and equilibrium all serve as examples of cycles.

Change occurring in cycles or patterns is one of the twelve principles of Indian philosophy.

B15 model **P(1-2), D(3-12)**

It is a representation of a real structure, event, or class of events intended to facilitate a better understanding of abstract concepts or to allow scaling to a manageable size.

Example:

Watson and Crick developed a model of the DNA molecule which allowed people to gain a better understanding of genetics.

B16 system **P(1-2), D(3-12)**

A set of interrelated parts forms a system.

Example:

Chemical equilibrium can be established only in a closed system.

B17 field **P(1-2), D(3-12)**

A field is a region of space which is influenced by some agent.

Examples:

Similarly charged objects have a tendency to repel one another when they are in close proximity.

The sun is the source of a gravitational field which fills space. The Earth's motion is affected by the influence of this field.

B18 population **P(3), D(4-12)**

A population is a group of organisms that share common characteristics.

Example:

Wildlife biologists monitor white tail deer to determine the number of permits for hunting that will be issued in a particular zone.

B19 probability **P(3-8), D(9-12)**

Probability is the relative degree of certainty that can be assigned to certain events happening in a specified time interval or within a sequence of events.

Example:

The probability of getting some types of cancer increases with prolonged exposure to large doses of radiation.

B20 theory **P(3-9), D(10-12)**

A theory is a connected and internally consistent group of statements, equations, models, or a combination of these, which serves to explain a relatively large and diverse group of things and events.

Example:

As new experimental evidence becomes available, atomic theory undergoes further change and refinement.

B21 accuracy **P(5-8), D(9-12)**

Accuracy involves a recognition that there is uncertainty in measurement. It also involves the correct use of significant figures.

Example:

A stopwatch which measures to the nearest 1/10th of a second would be an inappropriate instrument for determining the duration of a spark discharge.

B22 fundamental entities **P(6), D(7-12)**

They are units of structure or function which are useful in explaining certain phenomena.

Examples:

The cell is the basic unit of organic structure.

The atom is the basic unit of molecular structure.

B23 invariance **P(6), D(7-12)**

This is a characteristic which stays constant even though other things may change.

Example:

Mass is conserved in a chemical reaction.

B24 scale **P(6), D(7-12)**

Scale involves a change in dimensions. This may affect other characteristics of a system.

Example:

A paper airplane made from a sheet of notebook paper may fly differently than a plane of identical design made from a poster-sized sheet of the same paper.

B25 time-space **P(6-7), D(8-12)**

It is a mathematical framework in which it is convenient to describe objects and events.

Examples:

An average human being has an extension in one direction of approximately 1 3/4 metres and in another direction of about 70 years.

According to general relativity, gravity is not a force, but a property of space itself. It is a curvature in time-space caused by the presence of an object.

B26 evolution **P(6-8), D(9-12)**

Evolution is a series of changes that can be used to explain how something got to be the way it is or what it might become in the future. It is generally regarded as going from simple to complex.

Example:

Organic evolution is thought to progress in small, incremental changes. Similarly, scientific theories undergo change to accommodate new data as they become available.

B27 amplification **P(8), D(9-12)**

Amplification is an increase in magnitude of some detectable phenomenon.

Example:

A loudspeaker produces an amplification of sound.

B28 equilibrium **P(9), D(10-12)**

Equilibrium is the state in which there is no change on the macroscopic level and no net forces on the system.

Examples:

Chemical equilibrium exhibits no change on the macroscopic level.

A first class lever in a condition of static equilibrium remains at rest. The sum of all of the moments of the forces acting is zero.

B29 gradient **P(9), D(10-12)**

A gradient is a description of a pattern or variation. The description includes both the magnitude and the direction of the change.

Examples:

Light intensity decreases in a predictable manner as the distance from the light source increases.

On a mountain, the direction in which the change of slope is smallest is the most desirable route to build a railroad line.

B30 resonance **P(9), D(10-12)**

It is an action within one system which causes a similar action within another system.

Examples:

The hollow body of a guitar amplifies the sound of the vibrating guitar strings.

A wine glass can be made to shatter by sound vibrations due to mechanical resonance.

B31 significance **P(9), D(10-12)**

It is the belief that certain differences exceed those that would be expected to be caused by chance alone.

Example:

An analysis of Brahe's data led to the development of Kepler's First Law.

B32 validation **P(9), D(10-12)**

Validation is a belief that similar relationships obtained by two or more different methods reflect an accurate representation of the situation being investigated.

Example:

Carbon-14 dating can be used to check the authenticity of archaeological artifacts.

B33 entropy **P(9-10), D(11-12)**

Entropy is the randomness, or disorder, in a collection of things. It can never decrease in a closed system.

Example:

When solid sodium chloride dissolves in water, its particles are dispersed randomly.

C. Processes of Science

The scientifically literate person uses processes of science in solving problems, making decisions, and furthering understanding of society and the environment.

Complex or integrated processes include those which are more basic. Intellectual skills are acquired and practised throughout life so that eventually some control over these processes can facilitate learning.

This can provide information processing and problem solving abilities that go beyond any curriculum.

Process skills such as accessing and processing information, applying knowledge of scientific principles to the analysis of issues, identifying value positions, and reaching consensus are believed to include the more basic processes of science.

The basic processes of science are:

C1 classifying D(K-12)

Classifying is a systematic procedure used to impose order on collections of objects or events.

Example:

Grouping animals into their phyla or arranging the elements into the periodic table are examples of classifying.

C2 communicating D(K-12)

Communicating is any one of several procedures for transmitting information from one person to another.

Example:

Writing reports, or participating in discussions in class are examples of communicating.

C3 observing and describing D(K-12)

This is the most basic process of science. The senses are used to obtain information about the environment.

Example:

During an investigation, a student writes a paragraph recording the progress of a chemical reaction between hot copper metal and sulphur vapour.

C4 working cooperatively D(K-12)

This involves an individual working productively as a member of a team for the benefit of the team's goals.

Example:

Students should share responsibilities in the completion of an experiment.

C5 measuring D(K-12)

An instrument is used to obtain a quantitative value associated with some characteristic of an object or an event.

Example:

The length of a metal bar can be determined to the nearest millimetre with an appropriate measuring device.

C6 questioning P(K-1), D(2-12)

It is the ability to raise problems or points for investigation or discussion.

Example:

A student should be able to create directed questions about observed events. When migratory birds are observed, questions such as, "Why do birds flock to migrate?", "Do some birds migrate singly?", and "How do birds know where to go?" should direct further inquiry.

C7 using numbers P(K-1), D(2-12)

This involves counting or measuring to express ideas, observations, or relationships, often as a complement to the use of words.

Example:

1 litre contains 1 000 millilitres.

C8 hypothesizing P(1-2), D(3-12)

Hypothesizing is stating a tentative generalization which may be used to explain a relatively large number of events. It is subject to immediate or eventual testing by experiments.

Example:

Making predictions about the importance of various components of a pendulum which may influence its period is an example of hypothesizing.

C9 inferring P(1-2), D(3-12)

It is explaining an observation in terms of previous experience.

Example:

After noticing that saline sloughs have a different insect population than fresher sloughs, one might infer that small changes in an environment can affect populations.

C10 predicting P(1-2), D(3-12)

This involves determining future outcomes on the basis of previous information.

Example:

Given the results of the hourly population counts in a yeast culture over a 4 hour period, one could attempt to predict the population after 5 hours.

C11 controlling variables P(1-2), D(3-12)

Controlling variables is based on identifying and managing the conditions that may influence a situation or event.

Examples:

If all other factors which may be important in plant growth are identified and made similar (controlled), the effect of gibberellic acid can be observed.

In order to test the effect of fertilizer on plant growth, all other factors which may be important in plant growth must be identified and controlled so that the effect of the fertilizer can be determined.

C12 interpreting data P(2), D(3-12)

This important process is based on finding a pattern in a collection of data. It leads to a generalization.

Example:

Concluding that the mass of the pendulum bob does not affect the period of a pendulum might be based on the similarity of periods of 100 g, 200 g, and 300 g pendulums.

C13 formulating models P(2-6), D(7-12)

Models are used to represent an object, event, or process.

Example:

Vector descriptions of how forces interact are models.

C14 problem solving P(2-8), D(9-12)

Scientific knowledge is generated by, and used for, asking questions concerning the natural world. Quantitative methods are frequently employed.

Example:

A knowledge of genetics and the techniques of recombinant DNA are used to create bacteria which produce insulin.

C15 analyzing P(3-5), D(6-12)

It is examining scientific ideas and concepts to determine their essence or meaning.

Examples:

Determining whether a hypothesis is tenable requires analysis.

Determining which amino acid sequence produces insulin requires analysis.

C16 designing experiments P(3-8), D(9-12)

Designing experiments involves planning a series of data-gathering operations which will provide a basis for testing a hypothesis or answering a question.

Example:

Automobile manufacturers test seat belt performance in crash tests.

C17 using mathematics P(6), D(7-12)

When using mathematics, numeric or spatial relationships are expressed in abstract terms.

Example:

Projectile trajectories can be predicted using mathematics.

C18 using time-space relationships P(6-7), D(8-12)

These are the two criteria used to describe the location of things or events.

Example:

Describe the migratory paths of the barren lands caribou.

C19 consensus making P(6-8), D(9-12)

Consensus making is reaching an agreement when a diversity of opinions exist.

Examples:

A discussion of the disposal of toxic waste, based on research, gives a group of students the opportunity to develop a position they will be using in a debate.

C20 defining operationally P(7-9), D(10-12)

It is producing a definition of a thing or event by giving a physical description or the results of a given procedure.

Example:

An acid turns blue litmus paper red and tastes sour.

C21 synthesizing P(9-10), D(11-12)

Synthesizing involves combining parts into a complex whole.

Examples:

Polymers can be produced through the combination of simpler monomers.

A student essay may involve the synthesis of a wide variety of knowledge, skills, attitudes, and processes.

D. Science-Technology-Society-Environment Interrelationships

The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each other.

Some of the factors involved in the interrelationships among science, technology, society, and the environment are:

D1 science and technology P(K-2), D(3-12)

There is a distinction between science and technology, although they often overlap and depend on each other. Science deals with generating and ordering conceptual knowledge. Technology deals with design and development, and the application of scientific or technological knowledge, often in response to social and human needs.

Example:

The invention of the microscope led to new discoveries about cells.

D2 scientists and technologists are human P(1-6), D(7-12)

Outside of their specialized fields, scientists and technologists may not exhibit strong development of all or even most of the Dimensions of Scientific Literacy. Vocations in science and technology are open to most people.

Example:

By researching the biographies of famous scientists, students can begin to appreciate the human elements of science and technology.

D3 impact of science and technology P(3-5), D(6-12)

Scientific and technological developments have real and direct effects on every person's life. Some effects are desirable; others are not. Some of the desirable effects may have undesirable side effects. In essence, there seems to be a trade-off principle working in which gains are accompanied by losses.

Example:

As our society continues to increase its demands on energy consumption and consumer goods, we are likely to attain a higher standard of living while allowing further deterioration of the environment to occur.

D4 science, technology, and the environment P(3-5), D(6-12)

Science and technology can be used to monitor environmental quality. Society has the ability and responsibility to educate and to regulate environmental quality and the wise usage of natural resources, to ensure quality of life for this and succeeding generations.

Example:

Everyone should share in the responsibility of conserving energy.

D5 public understanding gap P(3-8), D(9-12)

A considerable gap exists between scientific and technological knowledge, and public understanding of it. Constant effort is required by scientists, technologists, and educators to minimize this gap.

Examples:

Some people mistakenly believe that irradiation causes food to become radioactive.

Buttermilk is often mistakenly regarded as having a high caloric content.

Folklore has it that the best time to plant potatoes in the spring is during the full moon.

Many believe that technology is simply applied science.

D6 resources for science and technology **P(3-8), D(9-12)**

Science and technology require considerable resources in the form of talent, time, and money.

Example:

Further advances in space exploration may require the collective efforts of many nations working together to find the necessary time, money and resources.

D7 variable positions **P(3-9), D(10-12)**

Scientific thought and knowledge can be used to support different positions. It is normal for scientists and technologists to disagree among themselves, even though they may invoke the same scientific theories and data.

Examples:

The debate about the possibility of cold fusion illustrated variable positions among scientists.

There is a debate about whether or not controlled burning techniques should be used in national parks.

D8 limitations of science and technology **P(6-8), D(9-12)**

Science and technology can not guarantee a solution to any specific problem. In fact, the ultimate solution of any problem is usually impossible, and a partial or temporary solution is all that is ever possible. Solutions to problems can not necessarily be legislated, bought, or guaranteed by the allocation of resources. Some things are not amenable to the approaches of science and technology.

Example:

The solutions that technology now proposes for nuclear waste storage often have significant limitations and are, at best, only short-term solutions until better ones can be found.

D9 social influence on science and technology **P(7-9), D(10-12)**

The selection of problems investigated by scientific and technological research is influenced by the needs, interests, and financial support of society.

Example:

The race to put a person on the moon illustrates how priorities can determine the extent to which the study of particular scientific and technological problems are sanctioned and thus allowed to be investigated.

D10 technology controlled by society **P(9), D(10-12)**

Although science requires freedom to inquire, applications of scientific knowledge and of technological products and practices are ultimately determined by society. Scientists and technologists have a responsibility to inform the public of the possible consequences of such applications. A need to search for consequences of scientific and technological innovations exists.

Examples:

Einstein's famous letter to President Roosevelt, warning about the possibility of developing nuclear weapons, and his pacifist views, illustrate the responsibility that scientists must have as members of society.

D11 science, technology, and other realms **P(9), D(10-12)**

Although there are distinctive characteristics of the knowledge and processes that characterize science and technology, there are many connections to, and overlaps with, other realms of human knowledge and understanding.

Example:

The Uncertainty Principle in science, the Verstehen Principle in anthropology, and the Hawthorne Effect in social psychology all express similar types of ideas within the realm of their own disciplines.

E. Scientific and Technical Skills

The scientifically literate person has developed numerous manipulative skills associated with science and technology.

The list of skills that follows represents manipulative skills important to the achievement of scientific literacy:

E1 using magnifying instruments D(K-12)

Some magnifying instruments include the magnifying lens, microscope, telescope, and overhead projector.

Examples:

Fine dissections of earthworms are done with the aid of stereoscopic microscopes.

A student uses a microphone to make an announcement to a large group over the public address system.

E2 using natural environments D(K-12)

The student uses natural environments effectively and in appropriately sensitive ways (e.g., collecting, examining, and reintroducing specimens).

Example:

Students can do a study of the margin of a pond by observing and describing a particular section at two week intervals for three months. After they collect and examine specimens, they should reintroduce them to their natural environment.

E3 using equipment safely D(K-12)

The student demonstrates safe use of equipment in the laboratory, in the classroom, and in everyday experiences.

Example:

A student recognizes a situation where goggles should be worn, and puts them on before being instructed to wear them.

E4 using audiovisual aids D(K-12)

The student independently uses audiovisual aids in communicating information. (Audiovisual aids include such things as: drawings, photographs, collages, televisions, radios, video cassette recorders, overhead projectors.)

Examples:

A student shows the teacher how to operate the VCR.

A student uses a camera to record natural phenomena.

E5 computer interaction D(K-12)

The student uses the computer as an analytical tool, a tool to increase productivity, and as an extension of the human mind.

Examples:

Computer software can be used to simulate a natural event or process which may be too dangerous or impractical to perform in the laboratory.

E6 measuring distance P(K-1), D(2-12)

The student accurately measures distance with appropriate instruments or techniques such as rulers, metre sticks, trundle wheels, or rangefinders.

Examples:

The length and width of a room can be determined using a metre stick.

Large distances can be determined using parallax or triangulation methods.

E7 manipulative ability P(K-2), D(3-12)

The student demonstrates an ability to handle objects with skill and dexterity.

Example:

A student uses a graduated cylinder to measure 35 mL of liquid. The liquid is then transferred into a flask and heated.

E8 measuring time **P(1), D(2-12)**

The student accurately measures time with appropriate instruments such as a watch, an hourglass, or any device which exhibits periodic motion.

Example:

A student uses an oscilloscope to measure a short time interval accurately.

E9 measuring volume **P(1), D(2-12)**

The student measures volume directly with graduated containers. The student also measures volume indirectly using calculations from mathematical relations.

Examples:

The volume of a graduated cylinder is read at the curve inflection point of the meniscus.

Archimedes' principle is used to determine the volume of an irregular solid.

E10 measuring temperature **P(1), D(2-12)**

The student accurately measures temperature with a thermometer or a thermocouple.

Example:

Thermometers must be properly placed to record accurate measurements of temperature.

E11 measuring mass **P(2), D(3-12)**

The student accurately measures mass with a double beam balance or by using other appropriate techniques.

Example:

Balances may be used to determine the mass of an object, within the limits of the precision of the balance.

E12 using electronic instruments **P(5-8), D(9-12)**

The student can use electronic instruments that reveal physical or chemical properties, or monitor biological functions.

Example:

Following the recommended procedures allows an instrument to be used to the maximum extent of its precision (e.g., ammeter, oscilloscope, pH meter, camera).

E13 using quantitative relationships **P(5-9), D(10-12)**

The student uses mathematical expressions correctly.

Examples:

To calculate instantaneous acceleration, find the slope at one point on a velocity versus time graph.

Calculate the volume of a cube given the length of one side.

F. Values That Underlie Science

The scientifically literate person interacts with society and the environment in ways that are consistent with the values that underlie science.

The values that underlie science include:

Fl longing to know and understand D(K-12)

Knowledge is desirable. Inquiry directed toward the generation of knowledge is a worthy investment of time and other resources.

Example:

A group of four students asks the teacher if they can do a Science Challenge project on a topic that they are all interested in.

F2 questioning D(K-12)

Questioning is important. Some questions are of greater value than others because they lead to further understanding through scientific inquiry.

Example:

Students ask questions which probe more deeply than the normal class or text presentation.

F3 search for data and their meaning D(K-12)

The acquisition and ordering of data are the basis for theories which, in turn, can be used to explain many things and events. In some cases these data have immediate practical applications of value to humankind. Data may enable one to assess a problem or situation accurately.

Example:

In a **Science Challenge** activity, a group of students asks a question about a natural occurrence. They then design an experiment in an attempt to answer the question. Variables which may influence the results of the experiment are controlled. Careful observations are made and recorded. Data are collected and analyzed to test the hypothesis that is under scrutiny. Further testing then takes place.

F4 valuing natural environments D(K-12)

Our survival depends on our ability to sustain the essential balance of nature. There is intrinsic beauty to be found in nature.

Example:

On a field trip the actions of the participants should be considerate toward and conserving of all components of the ecosystem.

F5 respect for logic P(K-2), D(3-12)

Correct and valid inferences are important. It is essential that conclusions and actions be subject to question.

Example:

Errors in logic are recognized. Information is viewed critically with respect to the logic used.

F6 consideration of consequence P(K-5), D(6-12)

It is a frequent and thoughtful review of the effects that certain actions will have.

Example:

Experimental procedures can affect the outcome of an experiment.

Transporting oil by tankers might cause an oil spill with very serious environmental consequences.

F7 demand for verification P(3-5), D(6-12)

Supporting data must be made public. Empirical tests must be conducted to assess the validity or accuracy of findings or assertions.

Example:

Media reports and research are reviewed critically and compared to other sources of information before being accepted or rejected.

F8 consideration of premises P(9), D(10-12)

A frequent review should occur of the basic assumptions from which a line of inquiry has arisen.

Examples:

In a lab investigation into the rate of chemical reactions, the control of variables is examined.

A critical examination is made of the factors under consideration in explaining the extinction of dinosaurs.

G. Science-Related Interests and Attitudes

The scientifically literate person has developed a unique view of science, technology, society and the environment as a result of science education, and continues to extend this education throughout life.

Science-related interests and attitudes include:

G1 interest D(K-12)

The student exhibits an observable interest in science.

Example:

Students and teachers who spend a great deal of time outside of class on science fair projects exhibit a keen interest in science.

G2 confidence D(K-12)

The student experiences a measure of self-satisfaction by participating in science and in understanding scientific things.

Example:

Students and teachers read science literature and are interested in discussing with others what they read.

G3 continuous learner D(K-12)

The individual has gained some scientific knowledge and continues some line of scientific inquiry. This may take many forms.

Example:

A person joins a natural history society to learn more about wildlife.

G4 media preference P(K-2), D(3-12)

The student selects the most appropriate media, depending on the information needed, and on his or her present level of understanding.

Examples:

Students and teachers who watch science-related television programs demonstrate a real interest in science.

When researching a science project, a student might have to determine which sources of information are most appropriate. The choice could include such things as television programs, newspaper articles, books, public displays, and scientific journals.

G5 avocation P(3-5), D(6-12)

The student pursues a science-related hobby.

Example:

By pursuing a hobby such as bird watching, astronomy, or shell collecting, a student demonstrates a keen interest in science.

G6 response preference P(3-5), D(6-12)

The way in which people behave can be an indication of whether or not they are striving to attain scientific literacy.

Example:

In an election, voters might consider the candidates' positions on environmental issues.

G7 vocation P(3-8), D(9-12)

The student considers a science-related occupation.

Example:

By modelling appropriate behaviours, teachers can encourage their students to become interested in science education or other science-related fields.

G8 explanation preference P(6-9), D(10-12)

The student chooses a scientific explanation over a nonscientific explanation when it is appropriate to do so. The student also recognizes that there may be some circumstances in which it may not be appropriate to select a scientific explanation.

Example:

By resorting to logic in a debate, students demonstrate logical thinking similar to that used in science.

G9 valuing contributors P(6-9), D(10-12)

The student values those scientists and technologists who have made significant contributions to humanity.

Examples:

A person wears a T-shirt bearing the image of some famous scientist.

Some students may hold the science teacher in very high regard.

Templates for Assessment and Evaluation

Rating Scale Template

____
____
____

1) ____________________ 1 2 3 4 5

2) ____________________ 1 2 3 4 5

3) ____________________ 1 2 3 4 5

4) ____________________ 1 2 3 4 5

5) ____________________ 1 2 3 4 5

6) ____________________ 1 2 3 4 5

7) ____________________ 1 2 3 4 5

8) ____________________ 1 2 3 4 5

9) ____________________ 1 2 3 4 5

10) ____________________ 1 2 3 4 5

11) ____________________ 1 2 3 4 5

12) ____________________ 1 2 3 4 5

13) ____________________ 1 2 3 4 5

14) ____________________ 1 2 3 4 5

Checklist of Laboratory Procedures

________________ ________
Name Date

____
Activity

Key: 1 = Rarely 2 = Occasionally 3 = Frequently

	1	2	3
Instructions followed	___	___	___
Safety precautions observed	___	___	___
Equipment handled correctly	___	___	___
Equipment cleaned thoroughly	___	___	___
Equipment stored properly	___	___	___
Lab area kept clean	___	___	___
Spills cleaned promptly	___	___	___
Chemical disposed of properly	___	___	___
Cooperation with others	___	___	___
Improvisation	___	___	___
Appropriate use of time	___	___	___
Observations noted and recorded	___	___	___
Other: ______________	___	___	___
______________	___	___	___

Group Self-Assessment of Laboratory Activities

Group ____________________ Date ____________

Activity ______________________________

Use these descriptors to assess how effectively your group performed a specific activity. Choose one or several numbers from the list of criteria.

1 = yes **2 = no** **3 = we think so**

4 = needs improvement **5 = satisfactory** **6 = excellent**

Things to consider	
Did we develop a clear plan before we began?	
Did each group member have specific things to do?	
Were we able to work together as a team?	
Did we discuss the purpose for doing the activity?	
Was a hypothesis developed and recorded?	
How well did we predict what took place?	
Were instructions followed correctly?	
How well did we use equipment and materials?	
Did we observe all safety precautions?	
Were measurements made accurately?	
How well were data recorded?	
Did we clean up thoroughly after the activity?	
Were the data examined closely to search for meaning?	
Did we use accepted techniques for data analysis?	
Were the conclusions consistent with the data?	
Did we re-examine our initial hypothesis?	
Did we account for experimental error?	
Was relevant research used to support our work ?	
Other:	

Self-Assessment of Performance as a Group Member

Your name ____________________ Topic ____________________

Group Members ____________________ Date ____________________

Circle the following on working within the group. Additional written responses may be included.

1. I encouraged others.	Seldom	Sometimes	Often
2. I shared ideas and information.	Seldom	Sometimes	Often
3. I checked to make sure that others in the group knew what they were doing.	Seldom	Sometimes	Often
4. I was willing to help others.	Seldom	Sometimes	Often
5. I accepted responsibility for completing the work properly and on time.	Seldom	Sometimes	Often
6. I was willing to listen to others in the group.	Seldom	Sometimes	Often
7. I was willing to receive help from others in the group.	Seldom	Sometimes	Often
8. I offered encouragement and support to others in the group.	Seldom	Sometimes	Often
9. Others in the group shared ideas and information.	Seldom	Sometimes	Often
10. The group checked with the teacher to make sure we knew what we were supposed to be doing.	Seldom	Sometimes	Often
11. All members of the group contributed equally to this project.	Seldom	Sometimes	Often

Answer the following questions about working in a group.

12. How did you distribute the workload within your group?

13. What problems, if any, arose within your group?

14. What would you do differently next time?

15. How is working in a group different from working by yourself?

Science Report Evaluation Form*

Name: Date:

Activity:

Written Presentation	Weight	Score
Title Page	5	
Introduction	10	
Body	30	
Conclusion	20	
Supporting References	5	
Neatness	10	
Organization	20	
Content		
Communication Skills	25	
Originality	25	
Accuracy	20	
Appropriateness	30	
Creativity	25	
Overall Impression	10	
Total Score	185	

Other Comments:

* Criteria for an oral presentation may be developed. Teachers are encouraged to develop criteria for each element on this page (e.g, Title page must include title centered left/right and vertically, student's name and class number) and share those with the students before they do their report.

Laboratory Report Evaluation

______________________ ___________
Name Date

____
Activity

	Excellent	Good	Satisfactory	Unsatisfactory
Completeness				
Accuracy				
Organization				
Presentation				

Comments: ____

____

____

____

____

____

____

Overall Report Grade: _________

Data Collection/Notebook Checklist*

_________________________ ___________

Name Date

A checkmark indicates that the criterion is satisfactory. No mark indicates that the criterion is either missing or unsatisfactory.

Documentation is complete.	
The information or data collected is accurate.	
Written work is neat and legible.	
Tables and diagrams are completed neatly.	
Each new section begins with an appropriate heading.	
Errors are crossed out but not erased.	
Spelling and language usage are edited and corrected.	
Information is recorded in a logical sequence.	
Technological aids are used appropriately.	
Notes are collected in a folder or binder.	
Colour or graphics are used to enhance the appearance.	
Rough work is done separately.	

Comments/Overall Impressions:

* This checklist may be used by teachers, or by students for self-evaluation. It may be used to evaluate notebooks, laboratory data collection done during investigations, or more formal written laboratory reports. Students should be made aware of these criteria at the start of the term.

Observation of Group Behaviours

____
Student or Group

Activities:

a ______________________________

b ______________________________

c ______________________________

d ______________________________

e ______________________________

f ______________________________

1 = rarely 2 = occasionally 3 = frequently 4 = consistently

	a	b	c	d	e	f
Remains on task						
Follows directions						
Exhibits leadership						
Respects the ideas of others						
Works cooperatively						
Communicates effectively						
Shares tasks equitably						
Works safely						
Handles equipment correctly						
Displays initiative						
Exhibits scientific curiosity						

Science Challenge Suggested Marking Scheme

____
Name

____
Description of Activity

____

____

____

____
Due Date

	Weight	Score
Content		
Accuracy	5	____
Completeness	10	____
Range of coverage	10	____
Concept attainment	30	____
Presentation of Material		
Layout	5	____
Neatness	5	____
Organization of ideas	10	____
Language usage	10	____
Originality	10	____
Sources acknowledged	5	____
Graphs, tables, and charts	10	____
Supporting exhibits (models, etc.)	10	____
Deadline met	5	____
Interest level	10	____
	____	____
Oral Report	25	
	____	____
Bonus (submitted before due date)	**5**	____
Total		____

Factors of Scientific Literacy Developed in Middle Level Science

These checklists may be used in a variety of ways. Teachers may wish to use them to determine which factors have been covered throughout the entire year to ensure that adequate coverage has been provided for them. The checklists could also be used when covering a particular topic. Once factors which have not been emphasized in that topic have been identified, teachers can then use that information in their planning of subsequent topics to ensure that all of the factors have been given sufficient coverage by the end of the course. Columns for core and optional units are shown.

Dimension A Nature of Science

Factors								
1. public/private								
2. historic								
3. holistic								
4. replicable								
5. empirical								
6. probabilistic								
7. unique								
8. tentative								
9. human/culture related								

Dimension B   Key Science Concepts

Factors								
1. change								
2. interaction								
3. orderliness								
4. organism								
5. perception								
6. symmetry								
7. force								
8. quantification								
9. reproducibility of results								
10. cause-effect								
11. predictability								
12. conservation								
13. energy-matter								
14. cycle								
15. model								
16. system								
17. field								
18. population								
19. probability								
20. theory								
21. accuracy								
22. fundamental entities								
23. invariance								
24. scale								
25. time-space								
26. evolution								
27. amplification								
28. equilibrium								
29. gradient								
30. resonance								
31. significance								
32. validation								

Dimension C Processes of Science

Factors								
1. classifying								
2. communicating								
3. observing and describing								
4. working cooperatively								
5. measuring								
6. questioning								
7. using numbers								
8. hypothesizing								
9. inferring								
10. predicting								
11. controlling variables								
12. interpreting data								
13. formulating models								
14. problem solving								
15. analyzing								
16. designing experiments								
17. using mathematics								
18. using time-space relationships								
19. consensus making								
20. defining operationally								

Dimension D Science-Technology-Society-Environment Interrelationships

Factors								
1. science and technology								
2. scientists and technologists are human								
3. impact of science and technology								
4. science, technology, and the environment								
5. public understanding gap								
6. resources for science and technology								
7. variable positions								
8. limitations of science and technology								
9. social influence on science and technology								
10. technology controlled by society								
11. science, technology, and other realms								

Dimension E Scientific and Technical Skills

Factors								
1. using magnifying instruments								
2. using natural environments								
3. using equipment safely								
4. using audiovisual aids								
5. computer interaction								
6. measuring distance								
7. manipulative ability								
8. measuring time								
9. measuring volume								
10. measuring temperature								
11. measuring mass								
12. using electronic instruments								
13. using quantitative relationships								

Dimension F Values that Underlie Science

Factors								
1. longing to know and understand								
2. questioning								
3. search for data and their meaning								
4. valuing natural environments								
5. respect for logic								
6. consideration of consequence								
7. demand for verification								
8. consideration of premise								

Dimension G Science-Related Interests and Attitudes

Factors								
1. interest								
2. confidence								
3. continuous learner								
4. media preference								
5. avocation								
6. response preference								
7. vocation								
8. explanation preference								
9. valuing contributors								

References

Aikenhead, G.S. (1988). *Teaching Science Through a Science-Technology-Society-Environment Approach: An Instruction Guide*. Saskatchewan Instructional Development and Research Unit. Report #12: University of Regina.

Clarke, Judy. (1990). *Together We Learn*. Scarborough, ON: Prentice-Hall.

Etobicoke Board of Education. (1987). *Making the Grade*. Scarborough, ON: Prentice-Hall.

Francis, Neil. (1988). *Super Flyers*. Toronto: Kids Can Press.

Gartrell, Jack Jr. (1989). *Methods of Motion: An Introduction to Mechanics (Book One)*. Washington, DC: National Science Teachers' Association.

Gartrell, Jack Jr. and Larry Schafer. (1990). *Evidence of Energy: An Introduction to Mechanics (Book Two)*. Washington, DC: National Science Teachers' Association.

Gordon, Anthony. (1979). *Geology of Saskatchewan: A Historical Approach*. Saskatoon: Western Extension College Educational Publishers.

Hart, E.P. (1987). *Science for Saskatchewan Schools: A Review of Research Literature, Analysis, and Recommendations*. Saskatchewan Instructional Development and Research Unit. Report #7: University of Regina.

Hawking, Stephen. (1988). *A Brief History of Time*. Toronto: Bantam Books.

Hazen, Robert and James Trefil. (1991). *Science Matters*. Toronto: Doubleday.

Hummell, Monte (ed.). (1989). *Endangered Spaces: The Future for Canada's Wilderness*. Montreal: Key Porter Books.

National Science Teachers Association. (1978). *Safety in the Secondary Science Classroom*. Washington, D.C. 20009.

Novak, J. and D. Gowin. (1984). *Learning How to Learn*. New York: Cambridge University Press.

Richards, J. and K.I. Fung. (1969). *Atlas of Saskatchewan*. Saskatoon: University of Saskatchewan.

Saskatchewan Education. (1993). *Science: A Bibliography for the Middle Level*. Regina.

Saskatchewan Education. (1993). *Science (Middle Level): An Information Bulletin for Administrators*. Regina.

Saskatchewan Education. (1993). *Science: An Information Bulletin for the Middle Level – Key Resource Correlations*. Regina.

Saskatchewan Education. (1992). *English Language Arts: A Curriculum Guide for the Elementary Level*. Regina.

Saskatchewan Education. (1992). *Diverse Voices: Selecting Equitable Resources for Indian and Métis Education*. Regina.

Saskatchewan Education. (1992). *The Adaptive Dimension in Core Curriculum*. Regina.

Saskatchewan Education. (1991). *Curriculum Evaluation in Saskatchewan*. Regina.

Saskatchewan Education. (1991). *Gender Equity: A Framework for Planning*. Regina.

Saskatchewan Education. (1991). *Instructional Approaches: A Framework for Professional Practice*. Regina.

Saskatchewan Education. (1991). *Selecting Fair and Equitable Learning Materials*. Regina.

Saskatchewan Education. (1991). *Student Evaluation: A Teacher Handbook*. Regina.

Saskatchewan Education. (1989). *Indian and Métis Education Policy from Kindergarten to Grade 12*. Regina.

Saskatchewan Education. (1989). *Science Program Overview and Connections K-12*. (Draft) Regina.

Saskatchewan Education. (1989). *Saskatchewan School-Based Program Evaluation Resource Book*. Regina.

Saskatchewan Education. (1988). *Understanding the Common Essential Learnings: A Handbook for Teachers*. Regina.

Saskatchewan Education. (1987). *Resource-Based Learning: Policy, Guidelines and Responsibilities for Saskatchewan Learning Resource Centres*. Regina.

Saskatchewan Education. (1987). *Core Curriculum: Plans for Implementation*. Regina.

Saskatchewan Education. (1986). *Program Policy Proposals*. Core Curriculum Advisory Committee. Regina.

Saskatchewan Education. (1984). *Directions: The Final Report*. Regina.

Saskatchewan Education. (1978). *SI Metric Guide for Science*. Regina.

Saskatchewan Environment and Public Safety. (1987). *A Guide to Laboratory Safety and Chemical Management in School Science Study Activities*. Regina.

Storer, J. (1989). *Geological History of Saskatchewan*. Regina: Museum of Natural History.

What's Killing the Children? (This video is from the NOVA series produced by WHDH, Boston, and is available from Coronet (Prentice-Hall) or Media House Productions.)

Youth Science Foundation. (1990). *Science Fairs: Organization, Regulations, Judging and Project Ideas*. Ottawa, ON.

Science 6

Chemicals and Reactions

Unit overview

Chemistry involves the study of the composition, structure, and properties of matter and its reactions. During this unit, the emphasis should be on directly observing a wide variety of chemicals and their reactions. Encourage the students to identify patterns and trends in their findings, and search for generalizations that emerge from their investigations.

Limit the depth of study of this unit. Writing chemical equations and depicting the configurations of atoms in molecules are topics which should not be covered. Do not attempt, through lectures or detailed explanantions, to impart to students principles beyond those which they are able to observe through activities and in their experiences. Turning science at the Middle Level into an abstract set of principles and theories divorced from what can be observed gives students an inappropriate view of science.

The suggestions given for activities in this unit are the means by which important concepts are developed. Terminology and mathematical relationships should be used to describe concepts which have already been encountered and clarified in the students' minds, rather than memorized in order to be able to describe what they see.

Many of the activities suggested in this unit involve the use of readily available household substances. Teachers who do not have a background in chemistry may wish to consult with Secondary Level chemistry teachers regarding some other chemical reactions which might be investigated in this unit. Chemical reagents and special apparatus for performing some other chemical reactions might have to be obtained from a high school chemistry lab.

Safety precautions are important when performing investigations involving chemical reactions. Teachers should be alert to such considerations at all times.

In this unit as in all others, two additional emphases are important. **Science writing and reading**, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers, and reporting science activities in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A1 public/private
A4 replicable

B1 change
B2 interaction
B9 reproducibility of results
B10 cause-effect
B11 predictability
B13 energy-matter

C3 observing and describing
C6 questioning
C9 inferring
C10 predicting
C11 controlling variables
C12 interpreting data

D1 science and technology

E3 using equipment safely

G1 interest

Concept development

grades 1 and 2
- investigating matter and its properties

grade 3
- characteristics and requirements for combustion

grade 4
- chemical reactions convert chemical energy into heat, light, and electricity
- regular arrangements of crystalline form of matter
- regularities of chemical properties

grade 5
- temperature change is one indication that a chemical change has occurred
- most chemical reactions that involve the combustion of fossil fuels are not reversible
- energy flow is one way so energy can't be recycled

grade 6
- energy changes take place during all chemical reactions

grade 8
- measuring, estimating, and reporting strengths of aqueous solutions
- characteristics of solutions and colloids

grade 9
- everything is composed of chemicals
- variables which influence chemical reactions
- communicating information about chemical reactions through chemical equations

grade 10
- variables which influence chemical reactions
- communicating information about chemical reactions through chemical equations

Foundational and learning objectives for Science and the Common Essential Learnings

1. Appreciate the diversity of chemical substances.
   - 1.1 Understand that all substances and organisms are composed of chemicals.
   - 1.2 Categorize substances as pure substances or as mixtures.
   - 1.3 Identify components of various types of mixtures.

2. Investigate the characteristics of elements.
   - 2.1 Describe chemical and physical properties of some elements.
   - 2.2 Discover similarities among the properties of the elements.
   - 2.3 Explain why symbols are used to represent elements.
   - 2.4 Identify names and symbols of elements.
   - 2.5 Recognize the distinction between elements and compounds.

3. Distinguish between chemical and physical properties of compounds.
   - 3.1 Observe or measure some physical properties of chemical elements and compounds.
   - 3.2 Demonstrate safe handling of chemicals.
   - 3.3 Investigate the chemical properties of chemical compounds.
   - 3.4 Design some ways to monitor the progress of chemical reactions.
   - 3.5 Devise some process which makes use of the products or effects of a chemical reaction.
   - 3.6 Understand how symbols and equations are used to communicate chemical information.

4. Understand and use the vocabulary, structures, and forms of expression related to atoms and reactions. (COM)
   - 4.1 Gradually incorporate the vocabulary used to describe chemicals and reactions into written and spoken language.
   - 4.2 Recognize symbols used to represent chemicals.

5. Strengthen both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and objects in meaningful contexts. (CCT)
   - 5.1 Generate, classify, and explore rules underlying categories of chemicals.
   - 5.2 Propose generalizations which explain relationships.
   - 5.3 Describe how patterns and regularities are useful in understanding chemicals.

Suggested Activities

Note: Emphasize safety precautions whenever chemicals are used. The chemicals should never be handled with bare hands or tasted. Safety glasses or goggles should be worn. (Various reference materials on laboratory safety are available. Consult these to familiarize yourself with important aspects of safety.)

Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Ask each student group to place a variety of substances in water and observe how they behave. Remind them to record all observations. (Note: **Always add the substances to water**. Not only does this aid mixing of powders but it may be an important safety precaution. Some acids react violently when water is added to them, but when they are added to water, since they are more dense than water, they mix more easily.)

  Some examples of things they might add to the water include: candle wax, steel wool, rubbing alcohol, laundry soap, vinegar, baking soda, corn starch, flour, sugar, paint thinner (use this in a well ventilated area), Alka Seltzer™ tablets, cooking oil, salt crystals, Tang™ crystals. Most of these are commonly available household substances.

  Emphasize safety precautions whenever chemicals are used.

  After each substance has been tested, the container used for testing should be rinsed out thoroughly before the next test. Proper disposal methods should be used for each of the substances tested. The disposal method varies, depending on the substance used. For example, the candle wax should not be poured down the drain, but can be placed in ordinary waste containers. A guide for disposal of chemicals, *A Guide to Laboratory Safety and Chemical Management in School Science Activities*, is available from Saskatchewan Environment and Public Safety in Regina.

  Once all of the substances have been tested, students should discuss which tests might have involved a chemical reaction. A class discussion could be held as part of the follow-up to reach a consensus on those conclusions. During the discussion, students should be prepared to support their opinions, indicating what things were observed which lead them to believe that chemical changes had or had not taken place in each test.

  In many cases, the difference between a chemical reaction and a physical change is not obvious. In these instances, a distinction between these two different types of phenomena need not be made.

  Ensure that both girls and boys are encouraged to be involved in these activities.

  Factors: A1, A4, B1, B2, B9, B13, C3, C6, C9, C11, C12, E3, G1
  Objectives: 3.1, 3.2, 3.3, 5.1
  Assessment Techniques: observation checklists, rating scales, assessment stations, written assignments
  Instructional Methods: cooperative learning groups, inquiry

- Mix equal amounts of oil and water. Cover the container and shake. Baby food jars or pill vials work well for this investigation. Observe the liquids and record observations. Sketch pictures of what the system looks like at various stages. Set the container aside and use it for comparison during the next procedures.

  Repeat, mixing egg whites and water. Shake well. Observe, record, and compare with the control. Try using egg yolks and water. Compare this with the results obtained using egg whites.

  Repeat, adding some liquid detergent to an oil and water mixture. Shake and observe. Repeat again, adding egg white to the oil and water mixture. Compare all results.

  Factors: A4, B1, B2, B9, B10, C3, C6, C9, C11, C12, E3, G1
  Objectives: 1.2, 1.3, 3.1, 3.2
  Assessment Techniques: anecdotal records, self and peer evaluation, assessment stations
  Instructional Methods: conducting experiments, problem solving

- Use a ball point pen to draw a line along the length of a piece of white paper towel. Add drops of water, salt water, rubbing alcohol, cooking oil, and paint thinner (the low odour type), placing the drops so that they make contact with the line, but not with the other drops.

  The tests can be repeated using crayon, pencil, or marking pen impressions on the paper towel. For each test performed, students should observe the way the liquid interacts with the mark on the paper towel. Evidence which indicates that a chemical reaction might have occurred should be noted.

  A colour change in this activity does not necessarily indicate that a chemical change has taken place. Different substances may be migrating at different rates through the paper. This is similar to what happens in paper chromatography. Dilution may also be responsible for the change in colour.

  Factors: A4, B1, B2, B9, B10, C3, C6, C12, E3, G1
  Objectives: 1.3, 3.1, 3.3, 5.2
  Assessment Techniques: observation checklists, rating scales, oral tests, written reports
  Instructional Methods: conducting experiments, discussion

- An invisible writing activity can be used to show students how phenolphthalein indicator changes from colourless to pink.

  Obtain a small sample of phenolphthalein indicator. A little bit goes a long way. It can be obtained from a chemistry lab. Ex-lax™ is another source. Add Ex-lax to water and filter to obtain a phenolphthalein solution.

  Use a fountain pen or pen nibs to write with the phenolphthalein solution on a sheet of paper. Allow the liquid to dry. Mist the sheet of paper with an ammonia solution from an atomizer. The indicator will turn pink in a basic solution.

- Steel wool (iron) often comes with a coating of grease to prevent it from rusting.

  Take four samples of steel wool. Soak two in alcohol. Remove the samples and allow them to dry. Place one original and one alcohol-soaked sample in separate containers of water. Repeat with the other two samples, using salt water. Label all containers. Have students predict what will happen to each sample.

  Allow all samples to remain in the water for three days. Observe and compare the results. Make generalizations about the factors that contribute to the corrosion of iron.

  Twin with a Secondary Level class. Arrange to have students in the senior class take slides of evidence of corrosion in the community. They can receive credit for their projects based on criteria established by their teacher at the Secondary Level. Use the slides to observe how metals corrode. Make some generalizations about things that contribute to the corrosion of metals.

- Compare some crystals to the products formed when chemical reactions occur. Dissolve some epsom salts in water. Pour off some of the solution into an evaporating dish and allow the liquid to evaporate. Add ammonia to the remaining epsom salt solution. Allow the mixture to settle. Decant the clear liquid and allow it to evaporate. Compare the ammonium sulphate crystals formed with the original epsom salts.

  Repeat, replacing epsom salts with alum. Add vinegar to the precipitate. Evaporate and compare the product to the powder produced when an alum solution is allowed to evaporate.

- Make saturated salt solutions. Use sodium chloride (table salt), potassium chloride (salt substitute), and powdered alum.

  Hang a weighted string in the salt solutions. As evaporation occurs, top up by adding more saturated salt solution. Once the crystals have grown for several weeks, remove and dry them. Observe them carefully with a hand magnifier. Draw the shape of the crystals. Have students discuss the observations.

- Add some table salt to vinegar. The solution will clean pennies. After a number of pennies have been cleaned using the solution, add a nail to the solution and observe what happens.

  Add some baking soda to hot water and dissolve. Pour the mixture into an aluminum tray. Put a tarnished piece of silverware into the tray and let it stand for about an hour. Remove the silverware, rinse with tap water, and dry it. Compare it to another tarnished piece of silverware which did not receive this treatment.

Many commercial processes involve chemical reactions. Products can be purchased for cleaning copper and removing tarnish from silver. Most of these products have been developed using an understanding of chemistry. The products have important applications in our lives.

This activity takes some of the mystery out of how these products work. It also helps to show students that inexpensive alternatives can sometimes be found to replace expensive products which essentially do the same thing. This helps to develop a sense of consumer awareness to help the environment.

- Pour about 30 mL of vinegar into a pop bottle. Put some baking powder in a balloon. Tap the baking powder so that it goes down to the bottom of the balloon.

  Fit the opening of the balloon over the mouth of the pop bottle. Lift the balloon and shake the contents into the pop bottle. When the baking powder and the vinegar mix, a chemical reaction takes place. Gas is released. The balloon expands. Do this on a mass balance to show that mass is conserved during a chemical reaction.

  Limewater (saturated calcium hydroxide solution, available from a chemistry lab) can be used to test the gas. Remove the balloon without allowing the gas to escape. Place a straw over the end of the balloon. Then place the straw in the limewater to allow the carbon dioxide gas from the balloon to mix with the limewater. Limewater turns cloudy in the presence of carbon dioxide gas.

  Using a straw, exhale into the limewater. Where does the carbon dioxide in the exhaled breath come from? (Extend this into Health, discussing human respiration.)

- Collect samples of chemical elements. Some should be easy to find – copper, iron, aluminum – and others more difficult. Some periodic tables have pictures of the elements. One such item is #60451 from

  Boreal Laboratories
  1820 Mattawa Avenue
  Mississauga, ON
  L4X 1K6

  Have each group of students select one of the elements to research. They should try to find out: its symbol; when it was discovered; the name of the scientist who first discovered or identified it; the physical and chemical properties of the element; the uses of the element; the names of other elements that have similar chemical properties.

  Groups could prepare a poster summarizing the results of their findings or report their findings in a story or poem, a song, or an interview with a group member playing the part of the element.

  Have the entire class attempt to develop a classification scheme for the elements that have been investigated, based on their physical and chemical properties. Because only a small number of elements were researched, the classification extension of this activity is analogous to early attempts at classifying elements based on their periodicity.

  The public nature of science is revealed through the activity. Many scientific findings have been published in a variety of resources and are available for people to use. Everyone benefits when scientific information is disclosed in this way.

  Correlate this activity with the display of the table of elements at the Saskatchewan Science Centre in Regina.

- Place a variety of symbols on small index cards. Some examples are Roman and Arabic numerals, syllabics, characters from English, French, or other alphabets, symbols of elements, and flags. Pass them around. Tell the students that they all have something in common. Try to establish that they are all symbols, used to represent something else. Brainstorm and list of some of the reasons why symbols are used.

  Develop the connection of the symbols used and the elements they represent. Explain that some symbols are used to simplify notation. Write down the names of a few chemical compounds. Show how symbols are used to represent them. Establish that using symbols makes it easier for people to communicate in written form. To reinforce this, show how two 4-digit numbers would be expressed in Arabic and Roman numerals. (Some methods for expressing things in written form are more cumbersome to use than others.)

Write the following descriptive sentence down on the blackboard:

> Magnesium metal reacts with oxygen gas to produce magnesium oxide and heat.

Write the chemical equation for this underneath the sentence:

> $2Mg + O_2 \text{--->} 2MgO + \text{heat}$

Compare the written description of the chemical reaction with its symbolic description as a chemical equation. **Note**: To demonstrate this chemical reaction in class, obtain a small piece of magnesium ribbon. Hold one end of the magnesium ribbon with metal tongs. Light the free end of the ribbon. A bright flame will result. The magnesium ribbon will change to a fine white powder. **Caution: This reaction produces heat. If the burning magnesium falls, it could severely burn anything it touches. Perform this demonstration over a protective mat.**

Science relies heavily on the use of symbols and symbolic representations in order to convey information. Chemical and mathematical equations are common examples. Browsing through an advanced science textbook reveals the use of a wide variety of other symbols. Without the use of these symbols, communicating scientific information in written form would be very awkward and time-consuming.

♦ Play a game of chemical bingo. Place the symbols of some elements in the cells of a grid to make up the bingo cards. Prepare enough cards so that each student, or each group, gets a card. Call out the name of an element. If the symbol of that element is on the card, it is covered, as in regular bingo.

♦ Drop a sugar cube into a glass of cold water. Observe the sugar cube for about 10 to 15 minutes. Many changes take place. Have students observe and record the changes that are noted.

Repeat a second time, using a glass of cold water and a glass of hot water. Simultaneously drop a sugar cube in each. Observe and record all changes that take place. Discuss the differences between how the sugar cube behaves in cold water and in hot water. Have students make inferences about why the sugar cube behaves differently depending on the temperature of the water.

This activity helps to reinforce ideas about how molecules behave. The rate at which the sugar cube dissolves can also be related to collisions. The average water molecule is moving more rapidly in hot water than in cold water. This allows the sugar cube to dissolve faster in hot water. The fact that water and sugar "combine" easily implies the existence of attractive forces between them.

Some students may find that recording all observations in this activity is tedious. So many different things are happening, and it is not easy to record these events descriptively. Emphasize the importance of careful recording. Certain observations should not be dismissed as being less significant than others. One never knows which observations may turn out to be the critical ones in a scientific investigation.

♦ Reuse a number of used metal containers with lids, such as coffee cans. Tape heavy objects inside some of the containers, in different positions. Put sand in another container, gravel in another, and marbles in yet another. Number each container.

Working in groups, have students perform experiments in order to try to develop and test an hypothesis about what might be inside each container. The first test they do would serve to establish an hypothesis. Predictions can then be made about how the can might behave when subjected to another test. The second and any subsequent tests help to refine or replace that hypothesis, based on the new evidence. If the predictions are an accurate reflection of what takes place, then the initial hypothesis has been further substantiated.

Some examples of the types of tests that they might decide to use could be: shake the can; tip the can upside down; roll the can down an inclined plane; roll the can along the floor. Emphasize that all of the tests should be nondestructive -- that is, the containers cannot be opened or damaged when tests are performed on them.

Make sure that each group gets to test all of the numbered containers. Once this has been done, hold a "symposium," at which representatives from each group present their findings. See if consensus can be reached regarding the most likely contents of each can. Whether or not consensus is reached, have students discuss what they have learned about how investigations are carried out, and how results are shared.

Discuss the use of nondestructive observation in science. There are many examples that can be used to illustrate this. The use of exploratory techniques in medicine, such as ultrasound, x-rays, CAT scans, or fibrescopes, serve as good illustrations. Emphasize some of the reasons why the need exists for nondestructive testing.

♦ Set up the following demonstration when students are not present. Tie a magnet to the end of a string. Attach the end of the string to a ruler, and tape the ruler securely to a desk, so that the end on which the string is tied is suspended over the edge. The magnet should hang down on the string, forming a pendulum. Adjust the length of the string so that the magnet is suspended a few centimetres above the floor.

  Beneath the pendulum-magnet, place a few disk magnets in an irregular pattern on the floor. Cover those magnets with a piece of cloth or a large piece of paper.

  With the students watching, swing the pendulum back and release it. Observe the motion of the pendulum. See if they can suggest what is causing the pendulum to behave erratically. If they are able to propose that other magnets under the cloth or paper might be causing the interaction, have them consider the system further to determine if similar or opposite magnetic poles are influencing the motion of the magnet.

  This is an example of making inferences about unseen objects and forces from observations. Similar inferences must be made about atoms, since although we can't see them, we make assumptions about where they are and how they act based on chemical reactions.

♦ Fill one glass with cold water and another glass with hot water. Place both glasses on a flat surface. Put a drop of food colouring into a glass of cold water. Place another drop of food colouring into a glass of hot water. Make sure that the glasses are not shaken. Observe the way the food colouring disperses throughout the water. This activity can be really dramatic when done in petri dishes on the overhead projector.

  Use the observations to make inferences about what might be different at the molecular level in the water in order to cause the drop of food colouring to diffuse more rapidly in the warm water.

  A variation of this activity is to use tea bags in equal amounts of hot and cold water. Gently place the bag on the surface of each. Do not stir. Observe each for a period of about 10 minutes. Compare what happens.

♦ Half-fill one beaker or jar with ice water (below 5°C), another with water at about 25°C and a third with water at about 50°C. (50°C is a typical hot tap water temperature.) Predict what will happen when ¼ of an Alka-Seltzer™ tablet is dropped into each beaker. How will the reaction times vary? Complete the investigation and record the results in a chart? Why did the results occur as they did?

  What time would be required for a whole tablet to react in 25°C water? What would the time be for ¼ tablet to react in 12°C water or in 40°C water? If a second ¼ tablet is put in a jar where one tablet has already reacted, does it take the same time as the first tablet? What are other things to investigate about this system?

Earthquakes and Volcanoes

Unit overview

Although earthquakes and volcanoes are violent events capable of causing much destruction and terror, there is a fascination about them that makes this an interesting area of study. The use of videotape, pictures, and newspaper accounts can help bring to life some aspects of these phenomena, which, fortunately, are unknown to most Saskatchewan students.

In this unit, students consider the causes and effects of earthquakes and volcanoes. In grade 8, the evidence for the plate tectonic theory, including earthquake and volcano zones, will be considered in more depth. Discuss with the students the use of historical evidence as well as data collected today in understanding earthquakes and volcanoes, but don't deal at length with plate tectonics. Review the unit outline and the objectives of the grade 8 unit **The Moving Crust** before planning this unit.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing advertisements, letters to parents, and newspaper editorials about the activities and discoveries of science class are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word. Activities including writing components are found in the **Suggested activities** section of this unit.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

The activity involving Alka-Seltzer™ in water in the Suggested activities section of the grade six **Chemicals and Reactions** unit is an excellent one for a science challenge activity. Several challenging extensions are suggested at its end. Building a papier-maché model of a volcano is probably not a challenge activity. Investigating the case for climate change induced by continental drift as a cause for dinosaur extinction would be a challenge activity.

Factors of scientific literacy that should be emphasized

A1 public/private

B1 change
B2 interaction
B7 force
B10 cause-effect
B11 predictability

C1 classifying
C10 predicting
C15 analyzing

D4 science, technology and the environment

E4 using audio-visual aids
E7 manipulative ability

F6 consideration of consequence

G1 interest

Concept development

grade 4

- geothermal energy
- formation of igneous and sedimentary rocks

grade 6

- satellite remote sensing of information about the surface of the Earth and other celestial bodies
- uses of geothermal energy

grade 8

- plate tectonic theory
- Pangaea and continental drift
- Saskatchewan's latitude through the ages

Foundational and learning objectives for Science and the Common Essential Learnings

1. Explain the causes and effects of earthquakes.
   - 1.1 Examine the causes of earthquakes.
   - 1.2 Describe the effects of earthquakes.
   - 1.3 Recognize that earthquakes occur frequently in some regions.
   - 1.4 Describe the shock waves produced by earthquakes.
   - 1.5 Relate the effects of an earthquake to the amount of energy released.
   - 1.6 Interpret the meaning of numbers on the Richter scale.
   - 1.7 Explain safety procedures during an earthquake.
   - 1.8 Examine methods of predicting earthquakes.

2. Explain the causes and effects of volcanoes.
   - 2.1 Examine the causes of volcanoes.
   - 2.2 Describe the effects of volcanoes.
   - 2.3 Locate the Pacific Rim of Fire.
   - 2.4 Classify volcanoes according to their method of formation.
   - 2.5 Explain how magma can emerge as volcanic flow.

3. Investigate the theory of plate tectonics.
   - 3.1 Consider earthquakes and volcanoes as direct evidence of crustal movement.
   - 3.2 Recognize that forces within the Earth can produce folds and faults.
   - 3.3 Use models to explain how the forces of compression, tension, and shearing contribute to the production of earthquakes.
   - 3.4 Compare the forces involved in mountain building to those involved in earthquakes.
   - 3.5 Examine some indirect evidence of crustal movement.
   - 3.6 Use models to illustrate the theory of plate tectonics.
   - 3.7 Relate plate tectonic theory to continental drift theory.

4. Use a wide range of possibilities for developing students' knowledge of earthquakes and volcanoes. (COM)
   - 4.1 Discuss, describe, and write about their ideas about earthquakes and volcanoes using their own language.
   - 4.2 Construct concept webs, diagrams, and models to show their understanding.
   - 4.3 Compose divergent questions about earthquakes and volcanoes and discuss possible responses to those questions.
   - 4.4 Rephrase or outline what they have heard and read about earthquakes and volcanoes.

5. Understand how knowledge is created, evaluated, refined and changed within this area of science. (CCT)
   - 5.1 Appreciate the use of models, computer simulations, and indirect evidence in an area not amenable to direct experimentation.
   - 5.2 Focus attention on their own knowledge and gaps in knowledge in this area.
   - 5.3 Identify gaps in scientist's understanding of these phenomena.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level –Key Resource Correlations* describe activities or ideas for activities.

- The Chinese are the first people on record to invent a device for determining the intensity of an earthquake, and the direction of origin. Have students research this device and compare it to modern seismographs. Consider similarities between the ancient and modern devices, as well as their differences.

  Divide the class into two groups. In the library, ask one group to research ancient means of earthquake detection, while the second group researches modern techniques. Develop visual charts showing examples of modern and ancient methods. Compare the methods.

  Factors: A1, B1, B2, B7, B10, D4, E4, G1
  Objectives: 1.2, 1.4, 1.8, 4.2, 5.3
  Assessment Techniques: group evaluations, portfolios, presentations, extended open response test items
  Instructional Methods: cooperative learning groups, reports

- Supply groups of students with a hard boiled egg, a leather soccer ball, a globe, and cutout shapes representing each of the continents.

  As in any group situation, encourage students to work cooperatively during the tasks. Assign people in each group to be responsible for manipulating equipment, observing, recording, and reporting. Ask students choose different roles during subsequent activities.

  Emphasize that each of the objects they have acts as a model to help understand continental drift. Ask the groups to create analogies that show how each object can represent the Earth.

  The hard boiled egg has a thin outer shell. This is analogous to the Earth's crust. The egg white represents the mantle, and the yolk the core. By cracking the shell, students might convey the idea that the crust can be thought of as consisting of sections, rather than continuous, undisturbed matter.

  The soccer ball can reinforce that concept about the Earth's crust. The sections of the ball are all joined together. These are analogous to the plates on the crust.

  The globe provides a reference for considering the other objects. If the globe has relief contours on it, those might indicate where regions of the plates meet, similar to the boundaries between two connected patches on the soccer ball.

  Finally, the shapes of the continents can reinforce the idea of continental drift. Have students arrange the continents on a surface, using the globe to place the shapes in their relative positions. Ask them to try to move the continents together, as if they were moving the pieces in a large jigsaw puzzle until they find the best fit. Once they have the best fit, have them slowly return the continents back to their original position, noting the direction that each one moves. According to the theory of continental drift, forces within the Earth cause the continents to move in this way, .

  Factors: B1, B2, B7, B10, B15, C15, E4, E7, G1
  Objectives: 1.1, 2.1, 3.1, 3.2, 3.6, 3.7, 4.1, 5.2
  Assessment Techniques: presentations, oral assessment, group evaluations
  Instructional Methods: synectics, simulations

- Build a model to illustrate the working of a seismograph. Just under the rim of an ice cream pail, cut a round hole large enough for a drinking straw to go through without any friction. Attach a cork or small styrofoam block to one of a straw with a straight pin. Fill the pail with water so that the cork floats when the straw is inserted through the hole. Lengthen the straw on the outside of the pail by adding another straw to its end.

  Alternatively, tape a mirror to the surface of a table or desk. Shine a beam of light on the mirror so that it reflects onto a wall.

  In either case, shake the table on which the model is supported and observe the effects on the straw or on the reflected light, respectively.

  Factors: A1, B1, B2, B7, B10, B11, D4, E4, E7, F6, G1
  Objectives: 1.2, 1.4, 1.8, 5.1, 5.2
  Assessment Techniques: anecdotal records, presentations, oral assessment
  Instructional Methods: model building, inquiry

- Arrange several coloured layers of modelling clay into long, narrow strips. Lay one layer on top of the other. Hold the stack of clay stacks at each end and push the centre down quickly. Observe what happens. Using a second similar stack, warm the stack very gradually in a hot water bath. Again grasp the stack at both ends and press down very slowly and gently. Observe what happens and compare it with what occurred the first time.

  Repeat the tests, placing different kinds of forces on both ends of the stack. Try pulling both ends apart, pushing both ends together, or twisting both ends in opposite directions. In each case, observe and record the pattern produced. Examine diagrams of folding, bending, and rifting in rock formations. Try to simulate those formations using the layered modelling clay.

  Any other objects that can be pressed into distinct layers can be used. Carpet samples, towels, or even a layered chocolate bar would work. Slow, gradual pressure results in folding. Rapid changes in pressure causes cracking.

- Examine photographs of celestial bodies taken during space missions. Look for evidence on the surface of the body which might indicate the presence of a crater. Is there any way to tell if the crater was formed by a meteorite or volcanic activity? An interesting model to examine this is to bring a pot of Cream of Wheat™ to a boil. Examine the action on the surface. Drop some marbles in and observe the patterns formed when they strike the surface. Look for any similarities and differences. **Caution: The hot material could cause severe burns**. Have everyone stand back when observing this. Avoid splattering or set up a safety shield when dropping marbles into the pot. Don't try to remove the marbles while the Cream of Wheat is still hot.

  Look as well for evidence of earthquakes. See if there might be ways that those patterns could be scrutinized closely to make sure they were not caused by erosion. Is there any evidence of plate tectonics elsewhere in our Solar System?

- Examine maps which show the regions on Earth where earthquake epicentres most frequently occur, and regions where volcanic activity is most prevalent. Look for patterns, similarities, and differences. Compare these with another map which outlines the boundaries of the Earth's plates. What inferences can be drawn about any regions where similarities exist?

- Place a bag of ice cubes at one end of a shallow, transparent baking dish. Fill the tray with hot water. Wait several minutes before proceeding to the next step.

  Add a few drops of food colouring, drop by drop. Add them just below the surface of the water, near the centre of the pan. Avoid stirring, in order that the mixing is done as much by convection currents as possible. Observe the motion of the food colouring as convection currents develop.

  Use this activity to illustrate movement within the Earth caused by convection.

  Another illustration of convection is the type of decorative table lamp that was quite popular in the late 1970s. These lamps contained two different kinds of liquids in them. One formed thick globs which moved up when heated by the bulb at the bottom of the lamp. The globs would hover in the coloured liquid they were in, forming some interesting patterns. As the globs cooled down, they would begin to fall back to the bottom of the lamp.

- Have students keep a scrap book on earthquakes and volcanoes. They can include any clippings of articles from newspapers and magazines that they happen to notice throughout the school year. News stories about the effects that earthquakes and volcanoes have on people would be especially interesting in order to establish the concern that society must develop a better understanding of these phenomena. Art work, diary entries, poems, and other information could be created in the journals as well. These could be group or individual projects. Throughout the year, students could share what they have in their scrap books with other students.

  Remember, the school resource centre is a source of current information.

- Have students research famous earthquakes or volcanoes, finding out as much as they can about them. Along with this, it would be interesting if they could place the event within its historical context. Other scientific developments, as well as major world events could be described. This would help to integrate Science with Social Studies. Some good connections could be made with Unit 1, dealing with the physical geography of location, and Unit 2 dealing with the historical geography of interaction in the grade 6 Social Studies curriculum.

Below are some famous earthquakes and volcanoes from more recent times.

Some famous earthquakes:

Date	**Place**
1737	Calcutta
1755	Lisbon
1811/12	New Madrid, Missouri
1906	San Francisco
1964	Anchorage
1989	San Francisco

Some famous volcanoes:

Date	**Place**
79	Mount Vesuvius, Italy
1783	Volcano Laki, Iceland
1815	Sumbawa, Indonesia
1883	Krakatoa
1902	Mount Pelée, Martinique
1980	Mt. Saint Helens
1985	Nevada del Ruiz (Amero, Columbia)
1986	Lake Nyos, Cameroon
1991	Pinatubo, Phillipines
1993	Mayon, Phillipines

♦ On February 4, 1975, prior to the onset of a major earthquake in Haicheng, China, people noticed strange behaviour in animals. Pets would suddenly disappear. Frogs and fish broke through ice-covered rivers. Farm animals would make strange noises and behave in unusual ways. Similar accounts of strange animal behaviour prior to earthquakes have been made in North America. Jim Berkland, a geologist and researcher, claims to have found a correlation between the occurrence of an earthquake and the number of missing pet announcements that appear in the local newspaper prior to the earthquake. (See *Woman's World*, January 16, 1990.) He claims that the number of missing pet announcements in the classified sections increased for a few days prior to a major earthquake. (He uses other information, such as tidal forces and geyser gaps in addition to "*gone gatos*". Los gatos is Spanish for cats.) Could this suggest that animal behaviour may be a clue to a new way of predicting earthquakes and warning people of the impending danger?

Develop an activity to investigate this idea further. Research accounts of strange animal behaviour prior to earthquakes. Try to develop (and test, if possible) a hypothesis which might account for the strange animal behaviour.

Alternatively, investigate the claims about a correlation between missing pet announcements in the classified ads and the onset of a major earthquake. Obtain back issues of newspapers from an area which was struck by an earthquake, such as San Francisco on October 17, 1989. Get several copies of newspapers from San Francisco a few months before the earthquake, the few days in succession leading up to the earthquake, and several months after the earthquake. Local or regional libraries may be able to obtain this information through inter-library loan.

Collect all missing pet information from the classified ads and analyze the information to see if students find any relationship between the number of pet announcements and the onset of an earthquake. Repeat using other newspapers either from the same area, or from some other area where a different earthquake disaster took place.

Interviews could be conducted with people who spend a great deal of time with animals, to ask them if they can substantiate any of the claims. The class could also correspond with the scientists who have made the claims about animal behaviour, so that the students could find out how the research was conducted. (In order to duplicate the research, this would be very useful information.)

Relate this activity to pet behaviour before and during a thunderstorm. This helps to put the activity within some perspective familiar to students.

Students should be involved in writing to obtain back issues of these newspapers. (Alternatively, they could search for this information on-line, or find out how it could be borrowed through an interlibrary loan system.) During the activity, take advantage of the opportunity to investigate newspapers for different kinds of information. Local newspapers offer a fascinating glimpse of culture and lifestyles.

- Earthquake legends are found in different cultures. Here are a few examples:

    The world rests between the divine pillars of Faith, Hope, and Charity. When the deeds of humans weakens any of the pillars, the Earth shakes. (Romania)

    The Earth is held up by four elephants standing on the back of a turtle. The turtle stands on a cobra. If any of these animals moves, the Earth trembles and shakes. (India)

    The devil makes giant rips in the Earth. He and his friends use the cracks when they want to come up and stir up some trouble on Earth. (Mexico)

    The Earth rests on a sled driven by the god Tuli. The dogs who pull the sled have fleas. When the dogs stop to scratch, the Earth shakes. (Siberia)

    Mother Earth has a child within her womb called the god Ru. When he kicks and stretches inside the womb, he causes earthquakes. (New Zealand)

    The Earth is a living creature, much like humans. Sometimes the Earth gets sick, with fever and chills. When that happens we can feel it shaking. (Mozambique)

    Powerful winds are trapped and held in caverns in the Earth. They struggle to escape. Earthquakes are the result of their struggle. (Greece)

  Share and discuss these and other earthquake legends from around the world. Explore how analogical reasoning is used in the legends. Have students consider why the analogies are appropriate. Perhaps students can develop their own legends, and show how those legends reflect what actually occurs during earthquakes.

- Research the safety precautions that can be taken to protect people against loss of life during earthquakes. For instance, here are a variety of questions that could be researched:

  In areas with a high risk of danger from earthquakes, what design engineering considerations could be used to make a building earthquake resistant? What can a person do to reduce the risk of being injured if an earthquake is taking place? What do emergency response teams do to prepare for disasters in areas where there is a high risk of an earthquake? Compare the potential danger of earthquakes and safety precautions used along Canada's west coast and in California. What precautions can be taken to reduce potential damage from tidal waves?

  Ask students to generate other questions. Add those questions on a large classroom chart as the students progress in their research.

- Are there any active volcanoes in Canada? Have there been any in the past? If you had to predict the most likely place in Canada for a volcano to occur, where would you choose?

- Why are there so few earthquakes in Saskatchewan? Has anyone in the classroom or in the families of the class felt an earthquake in Saskatchewan? Where have earthquakes occurred in Saskatchewan? Why do they occur there? Where is the most likely place in Canada that an earthquake will be experienced? In some safety books, it recommends that if you are in a classroom when an earthquake starts. the best idea is to get down on the floor under your desk. Why would this be the best place? Why wouldn't it be better to run outside?

Ecosystems

Unit overview

Life on earth derives from a complex interdependence among biotic and abiotic components. This is the concept of the ecosystem. The whole earth can be seen as one ecosystem, or ecosphere. Alternatively, it can be viewed as a series of linked subsystems. Species and the spaces they inhabit are equally important. We can not separate and priorize the components because in fact, the components have no meaning apart from the whole. Components such as land, water, and air are not resources as much as they are the source of life.

Often, the view that something is worth saving if it has economic or aesthetic value to humans is expressed. An example is "Rainforests should be saved because we haven't explored them completely yet, and there may be many valuable drugs or interesting creatures yet to be discovered." Rainforests should be preserved because they are a part of the system in which life has developed, and we anticipate that removing part of the system will have a negative effect on the whole system. Humans are an important component of the ecosphere but do we have a legitimate claim to primacy in the system?

In addition to developing an understanding of what the ecosystem is, students must become directly involved in helping to restore and protect it. Whether it be by cleaning up litter around the school, developing a recycling project, or writing to politicians about environmental issues, action to help improve the environment is essential or nothing, in effect, has been learned. What will drive this action is a love of the land. Love of the land is best developed out on the land. If students can be given opportunities to develop such a love during this unit, the understanding and action will follow.

In this core unit as in all others, two additional emphases are important. **Science writing and reading**, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing plays or skits, recipes for restoration or preservation, or drawing cartoons are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written (and illustrated) word. Readings from newspapers (*Earthwatch*, for example), popular magazines, and science journals abound. Students can use these as models for their writing style and as comparisons for their developing view of nature and the world.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. The topic of ecosystems offers possibly the widest choice and interest to students for finding and carrying out independent or small group investigations.

Factors of scientific literacy that should be emphasized

A3 holistic

B2 interaction
B4 organism
B10 cause-effect
B12 conservation
B13 energy-matter
B18 population

C3 observing and describing

D4 science, technology, and the environment

E2 using natural environments

F1 longing to know and understand
F2 questioning
F4 valuing natural environments
F6 consideration of consequence

G1 interest
G3 continuous learner

Concept development

grade 1
- plants and animals have identifiable needs

grade 2
- plants and animals are adapted to their habitats

grade 3
- pressures on plants and animals through habitat loss

grade 4
- characteristics, interconversions, and effects of energy

grade 7
- food, water, shelter, space as requirements of life

grade 8
- how plants and animals interact with each other
- how plants and animals influence the structure and condition of their environment

grade 9
- how humans interact with and alter their environment

grade 10
- issues in large scale human environmental intervention: global warming, water quality, use of nuclear energy

Foundational and learning objectives for Science and the Common Essential Learnings

1. Investigate factors which influence an ecosystem.
   1.1 Recognize abiotic and biotic components of an ecosystem.
   1.2 Identify interrelationships among the biotic and abiotic components of an ecosystem.
   1.3 Acquire skills in estimating the population of an area.
   1.4 Appreciate the importance of food webs in conveying information about interrelationships in the local community.

2. Inquire into the effects of change in an ecosystem.
   2.1 Identify some events that cause change.
   2.2 Examine an ecosystem that has experienced change.
   2.3 Appreciate the fragile nature of ecosystems.
   2.4 Explain how living oganisms cooperatively share an environment.
   2.5 Illustrate ways that change cascades through an ecosystem.
   2.6 Identify changes that have global implications.
   2.7 Assess pressures on various populations.

3. Develop a sense of responsibility for the preservation of the ecosphere.
   3.1 Identify direct personal links to the local ecosystem.
   3.2 Investigate the impact that humans have on ecosystems.
   3.3 Recognize the role that humans play in protecting or destroying ecosystems.
   3.4 Demonstrate actions that will ensure the health of the local ecosystem.

4 Understand the personal, moral, social, and cultural aspects of how we interact in the ecosphere. (PSVS)
   4.1 Understand how human emotional, mental, spiritual, and physical needs are met within the ecosystem.
   4.2 Explore how cultural values influence behaviour.
   4.3 Consider how our definition of needs and wants influences our decisions.

5 Understand how technology both shapes society and is shaped by society. (TL)
   5.1 Examine the impact of technological change on the local ecosystem.
   5.2 Understand the reciprocal relationships between the natural and constructed worlds.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level –Key Resource Correlations* describe activities or ideas for activities.

♦ Relate this unit to the unit **Exploring Space**. In a space colony, all the interacting systems that sustain life must be provided. Brainstorm some ways in which organisms and inorganic components interact in the space colony. Emphasize that human life would cease to exist if a breakdown took place in the essential interactions.

The Earth can be viewed as a spaceship or a space colony. Life on Earth is interrelated in much the same way. Any changes invariably have an effect on a variety of living things. Complex patterns of dependence exist. Changes in one ecosystem influence other ecosystems. Ultimately, the study of changes that take place in an ecosystem should consider the larger, global implications of those changes.

Factors: A3, B2, B4, B12, D4, F1, F4, F6, G1
Objectives: 1.1, 1.2, 2.4, 2.5, 2.6, 3.1, 3.3, 5.2
Assessment Techniques: contracts, self- and peer-assessments, written assignments
Instructional Methods: simulations, brainstorming

♦ Have student groups develop aquatic or terrestrial ecosystems. (The sections dealing with aquaria and terraria in this Curriculum Guide give some practical suggestions.) The ecosystem must be as self-sustaining as possible. The terrarium could simulate a desert, woodland, or pond community.

Energy transformations and food webs in the ecosystems should be examined. How do the abiotic factors within the ecosystem enable life to be sustained? If the ecosystem changes with time, students might consider how the change has affected life within the ecosystem.

Factors: A3, B2, B4, B13, C3, E2, F4, G1
Objectives: 1.2, 1.4, 2.3, 2.5, 3.3
Assessment Techniques: anecdotal records, observation checklists, group evaluations
Instructional Methods: model building, discussion

♦ Estimate the population of grass plants on a lawn. Students can randomly select and mark off an area of the lawn. (The area bounded within an overhead transparency mount, or half that area, is suitable.) Count the number of grass plants within the selected area. Repeat the counting procedure within an area of identical size at two other places in the lawn. If there are some places on the lawn where the grass is more sparsely distributed, then ensure that counts are taken in those places. Compare the three population counts.

The students might need to establish criteria for what constitutes a grass "plant." They might consider that each stem emerging from the ground represents a single plant, even though grass sends out underground stems through vegetative reproduction.
Calculate the total area of the lawn. Estimate the total number of grass plants in the lawn. Have the students establish a method for determining this. (Divide the total area of the lawn by the area used in making each count. Multiply the result by the number of plants in the counted area. Make any necessary adjustments to the calculations to account for such things as bare spots on the lawn, competing vegetation growing on the lawn, or sparse growth in some places on the lawn.)

Discuss the idea that some estimates have more credibility than others. Estimates should always be more than just "wild guesses." They must be reasonable. Are the results reasonable? Consider any assumptions that have been made in arriving at the estimate.

Consider the variety of plant species within a given area. Does a larger variety indicate a healthier ecosystem? Consider why bare spots exist. Are they indicative of a healthy ecosystem?

This procedure can be used to estimate populations such as trees in a forest, wildflowers or weeds in a field, plants in a field crop, and so on.

Factors: B18, C3, E2, F2, G1
Objectives: 1.3, 2.2, 5.1
Assessment Techniques: rating scales, homework, short answer test items
Instructional Methods: problem solving, field observations

♦ Have students investigate various cropping procedures. Extension agrologists, regional soil conservationists, or local farmers could be invited to discuss various tillage techniques, why and when they are used, and how the techniques impact on the environment. Different equipment and approaches to tillage could be examined during farm visits. Invite someone interested in organic farming to talk to the students about farming without the use of chemicals.

Crop specialists or extension agrologists could be interviewed on methods of crop rotation.

♦ Have students work in groups to stake off 2 m by 2 m study plots in a field. Use posts and string to mark off the area. Have each group examine their area carefully. They should look for any evidence of plant and animal life, as well as any symbiotic relationships that exist.

For successful group work, all students must contribute to the group effort. Encourage students to share and rotate the responsibilities for the required tasks, such as investigating, observing, recording, and reporting.

Magnifying glasses, small garden tools for digging, scissors, tweezers, assorted jars and containers with lids, shoe boxes, and plastic bags are some things that students might use in this activity. While the investigation is taking place, students can collect samples for further investigation in the classroom.

Students should record the kind and number of each organism they find in their plot. Any indirect evidence of life, such as animal droppings or burrows, should also be noted. Students should try to determine if organic matter on the ground came from plants within the plot or was transported in from elsewhere. Dig up some of the soil in the plot and examine it for any further evidence of animal life. Emphasize the need for the careful recording of what has been observed.

Relationships and interactions among biotic and abiotic factors in their study plot should be examined carefully. Abiotic factors which help to support life should be noted.
Teachers may wish to assist students in developing organizers for their observations, to provide more structure to this learning experience. If so, here are some categories that students might consider.

- date and time of visit
- seasonal considerations
- weather and climatic conditions
- vegetation
- small animals found beneath the ground
- large animals found beneath the ground
- small animals found on the ground
- large animals found on the ground
- animals found on vegetation
- flying animals likely to visit the area
- moving animals likely to visit the area

Other ways of organizing the observations are encouraged. Before the actual study is conducted, students could plan learning activities in collaboration with their peers and with the teacher.

Using estimating techniques similar to those in the previous activity, students can measure the area of a much larger section of the field and estimate the number of a particular kind of living organism that might be found there.

Caution students about things like broken glass, insect bites, bee stings, and poison plants that they might experience in the area they survey.

♦ Conduct a pond study to examine biotic and abiotic interrelationships. *Potholes and Ponds: A Pond Study Guide for Elementary School Children* (see Elementary Science Bibliography) is an excellent resource for this activity. It is available from the Book Bureau.

Interrelationships between living and nonliving things in the environment are very complex. We are only just beginning to appreciate some of those complexities. One thing, however, is virtually certain. If people do not act quickly to protect the environment, the destruction that would otherwise occur could have a devastating impact. All life forms on Earth could be threatened, including the human race. By developing an awareness of nature's beauty, students may begin to value its preservation.

Students must develop an awareness that all forms of life need to be protected. **Humans have the responsibility for preserving the environment**. Endangered species can, in many cases, be saved if people act quickly and responsibly. All things are interrelated. A change in one ecosystem, however small that change might be perceived to be, may have serious global consequences.

- On small index cards, write the names of a variety of living things found within a particular ecosystem. Have students pick a card at random and fasten it to their clothing. Using string, have students connect a number of animals that form a food chain. Examine relationships between chains, and make connections from one chain to others to develop a food web.

  Remove one of the animals once the food chain has been constructed. Consider how other animals in the ecosystem would be affected.

  Imagine that the population of one of the animals in the ecosystem suddenly increased dramatically. Identify what changes might occur as a result.

  Simulate human encroachment in the ecosystem. Imagine that some of the habitats are destroyed, or various types of pollutants are introduced. Consider the implications that these types of changes would have on living things within the ecosystem. Research actual case studies involving these changes.

  The intricacy of the connections, graphically illustrated with the string, gives students a better understanding of the complexity of biotic interrelationships within an ecosystem. By introducing a change into the ecosystem, students can begin to recognize what types of responses would occur.

- Contact the appropriate municipal officials and arrange for permission to tour a landfill waste disposal site. Virtually every community throughout the province has a dumping site that would be available. It is strongly recommended that the site be previewed carefully by the teacher. Make note of any health and safety considerations at the site, and inform students of these things prior to the trip.

  See if you can establish the criteria that were used in selecting the site. Was it in close proximity to a populated area? Were there abiotic factors which influenced the selection of the site? Was the decision to use the site based primarily on economic or political factors? These are interesting things to research prior to the trip. Try to obtain newspaper articles describing a recent decision regarding the placement of a landfill site.

  Examine the natural ecosystem within a short walking distance from the landfill site. Record some of the living things that thrive in that location.

  At the landfill site, see what living things exist. How have the conditions changed to make it a preferable site for some life forms, but a less desirable site for others? What other changes might take place over time at this site? Perhaps the class could visit a very old landfill site which is now being used for some other purpose.

  Classify the type of waste found at the site. What resources went into the production of the materials? How much energy was consumed in making, using, and disposing of the materials? How are materials sorted on the site? Which materials could be reused, recycled, reduced, or recovered? Which of the materials are biodegradable and non-biodegradable? Which materials might potentially leach into ground water? Which materials are potentially toxic? (Keep this in mind in planning the trip. Some materials may need to be identified beforehand as being hazardous, in order to not expose students to any potential harm. Establish clear guidelines with the class.)

  What are some of the less obvious consequences of landfill? Are there any long-term global consequences that students might be able to identify? What are the alternatives? Are they any better or worse? Research "accidents" that have occurred at landfill sites, such as tire fires or explosions.

  Landfill sites are not places that one would normally plan to visit -- unless, of course, one were interested in photographing seagulls! They are intentionally located so as not to become too objectionable or the subject of political controversy. It is worthwhile to visit a site like this occasionally, if only to serve as a reminder of the impact that humans have on the environment.

- Visit a farm in the early spring. Observe how the fields are prepared and how the seeds are planted. If a farm visit can not be arranged, consider some alternative, such as visiting a garden, a farmer's market, a greenhouse, or a neighbourhood park.

Farms are special environments within ecosystems. Farming results in a change in the way in which living things interact within the ecosystem. Examine life forms on the farm from this perspective. Determine how living things have either had to adapt or had to move as a result of the cultivation of land. Consider interviewing an older farmer to reflect on the changes that have taken place in agriculture over the years.

Investigate ways in which farmers are trying to protect natural ecosystems. Determine how interdependence develops in cultivated and natural areas. In what ways is the protection of natural ecosystems an advantage?

- Old farmsteads are interesting to visit. Have students find evidence of manure or compost piles, find trash that has not decomposed over time, examine any old machinery and buildings on the site. Consider where the house is placed and try to determine if it was placed in an advantageous location. Collect soil samples, taking them back to the classroom for later analysis. (Refer to the activity in the grade 3 Core Unit on **Earth** which uses exposed film to test for microorganisms in the soil.) Have students suggest other interesting projects associated with this visit.

  Have students speculate on when the farm was abandoned and what some of the reasons were for the abandonment. This could either take the form of an archaeological dig, or students could research the history of the farm in local archives or by talking to neighbouring farmers.

  The students could re-create what the farm might have originally looked like, in a model or a drawing. A creative writing exercise could be a short story about a fictional character on the farm.

  Compare the cost per hectare of the land as it might have been fifty years ago and now.

  Be sure to ask the owner's permission to explore and investigate the property. Find out about any possible dangers on the premises.

- Take the class out on a litter collection project. (This activity is similar to one described in the grade 2 Science unit **Habitats**. Perhaps the activity can be coordinated with the same one the grade 2 class is working on.) It could be something as straightforward as a fifteen minute activity done on or near the school grounds. Once the litter is collected, bring it back into the classroom. Push all the chairs and tables out of the way, put a tarp down on the floor, and dump the trash right on the floor! Look at it and try to identify the different types of litter -- plastics, metals, paper, etc. Wear gloves during this phase! Sort the pile according to whether or not the material is biodegradable. See which things might be reused, recycled, repaired, or whether the amounts used might be reduced.

  Try to divide the litter into two piles: one for all of the litter that could have been likely produced by students, and another for the most likely litter made by other people. From the two piles, they will be able to get some idea of what their contribution to the damage in the environment has been. They might want to speculate on what effect the litter might have on living things. For further impact, leave the litter in the room for several hours, to give students a lasting impression of how unsightly and smelly it can be. This activity is one which could be a school project, getting everyone involved in caring for the environment.

  Consider ways in which litter affects living things. What are some of its long-term consequences? What are some of its other implications, such as the reduced potential for tourism?

  A project like this helps to develop a better understanding of conservation and care for the environment. Use it as a way to get students and other members in the community interested in starting things like recycling projects.

- Invite Elders to the class to explain how the community has changed over time. Try to obtain any old pictures showing how the community used to be. Identify ways in which the physical environment has changed. What impact have those changes had on life forms found within the community?

  By examining changes that have taken place over a longer period of time – one or two generations at least – students will begin to appreciate that long-term changes in an ecosystem may cause it to take on very different characteristics.

  Customary courtesies should be extended to Métis and Indian Elders. Offer transportation if they accept an invitation to visit the classroom. Arrange to provide gifts in exchange for information or service. Emphasis should be placed on sharing. During oral communication, students should ask a question and allow pause time for the question to be reflected upon before an answer is given. Permission to record an interview should be obtained beforehand. Other courtesies that are normally offered to any visitor to the school should be extended.

- Rotting logs are an interesting mini-ecosystem to investigate. Different logs may be at various stages of decomposition, which would make for some interesting comparisons. Find any producers and decomposers that are living on the log. See if there is any evidence of consumers near the log.

  Students can use this experience to further their understanding of ecosystems. It serves as a good model of how larger, more complex ecosystems function.

- Units 4 - 6 of the World Wildlife Fund guidebook *Operation Lifeline*, contain activities and information regarding the protection of endangered species. Consider becoming a member of *Operation Lifeline*. Your class can join the lifeline of 180 000 students and 6 000 teachers across Canada who care about protecting endangered animals and plants their habitats from destruction. For more information contact Operation Lifeline.

- Invite an ecologist or a naturalist to your classroom to answer student-generated questions about local ecosystems and issues.

- Introduce the term 'sustainable development'. Establish a file on this topic, and involve students in discussions about the future of ecosystems and the ecosphere. The sustainability of specific components of ecosystems could be discussed. Water, soil, air, and biota are such components.

- Research and report on how plant and animal populations have increased, decreased, or disappeared on the prairies during the last 100 years.

  Ask each student group to identify some aspect of the current prairie community and describe what it is like now and what it may be like 50 years from now. Ask them to consider both environmental and economic factors in their deliberations.

Exploring Space

Unit overview

The unit examines the impact of technology on the space program, in the past, and at present. Students also have an opportunity to speculate on the direction that space exploration could (or should) take in the future. Due to the nature of the material in this unit, fewer opportunities exist for hands-on activities. However, the unit provides many opportunities to develop Independent Learning, in conjunction with a Resource-Based Learning approach to researching and investigating space exploration.

The optional unit, **Earth's Climate**, can also be integrated with this unit. Climatic patterns on Earth can be studied by analyzing information which has been sent back to Earth from weather satellites. These satellites provide us with information that would have been difficult, if not impossible, to obtain otherwise. Once consideration is given to climate, then the related life science units on **Ecosystems** and **Plant and Animal Adaptations** can be brought in as well.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing science fiction stories based on science fact, reading articles from newspapers or magazines, and summarizing what they have read in the form of a chart are only two strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A1 public/private
A2 historic

B1 change
B15 model

C2 communicating
C4 working cooperatively
C8 hypothesizing

D1 science and technology
D3 impact of science and technology

E4 using audiovisual aids
E5 computer interaction

F6 consideration of consequence

G1 interest
G5 avocation

Concept development

grade 3

- rotation of earth on an axis to produce day and night
- revolution about the sun to produce the seasons
- structure of the solar system

grade 8

- orbital periods of the planets and their relative motion with respect to the earth
- interplanetary and interstellar travel and life

Foundational and learning objectives for Science and the Common Essential Learnings

1. Discuss the role of satellites and space probes in describing and monitoring the Earth and other planets.
   - 1.1 Explain how rockets work.
   - 1.2 Investigate how Landsat is used to monitor aspects of Canada's environment.
   - 1.3 Describe Canada's network of communications satellites.
   - 1.4 Study the problem of establishing geosynchronous orbits.
   - 1.5 Examine the successes and failures of the Hubble space telescope project.
   - 1.6 Compare the advantages and disadvantages of space missions which carry humans and ones which only carry remote sensing equipment.
   - 1.7 Discuss the impact of the space program on the development of new technologies.

2. Predict the future impact of space exploration.
   - 2.1 Research the NASA space program from the Mercury flights through the space shuttle program and beyond.
   - 2.2 List some examples of international cooperation in space.
   - 2.3 Identify some of the technical problems associated with space travel and space colonization.
   - 2.4 Discuss some of the psychological and physical problems of human ventures into space.
   - 2.5 Discuss ways that space may be used in the future.
   - 2.6 Evaluate different scenarios of future space exploration.

3. Appreciate the value and limitations of technology within society. (TL)
   - 3.1 Understand the dependence of the space program on technology.
   - 3.2 Explore innovations in technology which have led to advances in the space program.
   - 3.3 Assess technological developments in terms of economic factors, adaptation of the technology to uses other than for which it was designed, and public and worker health concerns.

4. Promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and objects in meaningful contexts. (CCT)
   - 4.1 Respond to activities, projects, and assignments in innovative ways.
   - 4.2 Develop ways to evaluate creative processes, assignments, and projects.
   - 4.3 Understand that real life problems often have more than one solution.
   - 4.4 Provide arguments related to principles and evidence for their answers, ideas, and responses.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level –Key Resource Correlations* describe activities or ideas for activities.

♦ Pioneer 10, launched on March 3, 1972, has now passed through our solar system and is heading into the deep space of the Milky Way galaxy. On this space probe a message about human knowledge and life on this planet has been etched on a gold-anodized aluminum plate. If there is intelligent life beyond our solar system, then perhaps someday in the distant future the information placed on that plaque may be important in establishing communication with such life. What information did people feel was important enough to place on this plaque? What were the designers trying to communicate to other life forms about life on Earth?

Ask students to extend this activity by designing their own space plaque to be placed inthe next deep space mission. Have them explain what they put on their plaques, and why they felt that information was important.

Another extension of this activity would be to create a time capsule which contains important information about the school, the community, and the culture. Arrange to have the time capsule placed in the cornerstone of a new building being erected in the community, with an inscription commemorating the project which will enable people at some later time to learn about their past.

If you found such a time capsule from the past, what would the artifacts and the information reveal about the people who made it? Perhaps the class could be presented with such a hypothetical time capsule, allowing them to explore their time capsule project from several different perspectives. How would time capsules from different parts of the province differ? How would they be the same? How would time capsules from different cultures compare?

Factors: A1, A2, C2, C4, D1, D3, E4, G1, G5
Objectives: 2.2, 2.5, 2.6, 4.1, 4.4
Assessment Techniques: group evaluations, written assignments, extended open response test items
Instructional Method: reflective discussion

- Research Canada's participation in the space program. How are Canada's astronauts selected? What role does Canada play in planning what goes on during shuttle missions? Is the CanadArm the only piece of Canadian designed technology on the shuttle? Has Canada been involved in aspects of the space program other than the shuttle missions on which Marc Garneau, Roberta Bondar, and Steve McLean have flown? A good source of information is the Ministry of State for Science and Technology in Ottawa.

  Factors: A1, A2, C2, C4, D1, D3, G1, G5
  Objectives: 1.6, 1.7, 2.1, 2.2, 2.3, 3.2, 3.3
  Assessment Techniques: portfolios, self- and peer-assessments, presentations
  Instructional Methods: research, reports

- Draw a diagram illustrating the paths taken by the Voyager 1 and Voyager 2 space probes. Alternatively, draw a diagram to show what these space probes looked like. What new information about our solar system did these space probes provide? Make posters showing the timelines of different space probes.

  Pioneer, Mariner, and Venera were several other space probe projects. Have students investigate these projects to determine how our knowledge of the solar system was increased. What are some of the advantages and disadvantages of using probes with remote sensing equipment rather than using space vehicles with humans on them? How have these space probes been of benefit to society? Has society been at risk from the development of this technology?

  Design a future space probe. What characteristics does it have? Why are these characteristics important?

  Factors: A1, A2, B1, B15, C2, C4, D1, D3, E4, G1
  Objectives: 1.6, 1.7, 2.1, 2.5, 2.6, 3.1, 3.3, 4.3
  Assessment Techniques: written assignments, oral assessment, presentations
  Instructional Methods: model building, discussion

- Develop a model for an Earth-orbiting space station. Show how the space station would have to be designed to allow humans to occupy it for extended periods of time.

  How successful was the Biosphere-2 project in Arizona? What aspects of its design would be useful for an orbiting space station? Which aspects would be impractical for an orbiting station but useful or essential for a station built on the surface of another planet or a moon?

- The following are some examples of open-ended assignments which can be used as group or individual projects, or as debates. They require students to use a resource-based approach to acquiring, interpreting, analyzing, synthesizing, and evaluating information. Note in particular how these activities help develop Critical and Creative Thinking. Extended periods of time should be provided because of the level of complexity involved. Suitable resource materials would also have to be available. This requires planning with the resource centre staff.

  - The Soviet Union had many accomplishments in space. A "space race" between the two major superpowers developed even before 1957, when the Soviet Union launched *Sputnik*, the world's first artificial satellite. What were some of the scientific, political, economic, military, or social consequences of the "space race" between the two superpowers?

  - The Soviet Union had many accomplishments in space. Cosmonauts on their space stations set records for staying in space for long periods of time. Their research led to the discovery of new problems facing cosmonauts (or astronauts) who remain in a confined space for a long time. Find out what some of those problems are. Find out how scientists are trying to make it easier for humans to stay in space for a long time. Use what you have learned to design a special gym for space stations, to allow people to stay healthy in space.

- Suppose you were assigned to be a research member of an orbiting space station. Prepare an outline of the types of research projects you would suggest for inclusion on the space station. Be able to explain why that research should be done in space rather than on Earth. Assume that each crew member is given an allotment of 3 m^3 (2 m by 1.5 m by 1 m) of private living space for sleeping and storage of personal equipment. Design an arrangement for your space.

- Suppose that within the next few years, an international space station will be put into orbit around the Earth. Discuss how this effort might affect international relationships. How might the space station be designed and what functions might it serve?

♦ What type of training does an astronaut need when preparing for a space mission? How does role differentiation on a flight have an effect on the type of training needed? Compare the training for such roles as a payload specialist, a researcher, an engineer, or a navigator. What are the educational backgrounds of the astronauts?

Another good research project involves investigating life in a zero gravity environment. What problems might be encountered trying to eat, sleep, or exercise in that situation?

Students could also examine the features of a space suit to see how the suit has been designed for the conditions in space.

♦ In April, 1985, astronauts on the Space Shuttle Discovery took some toys with them into space. They were interested in seeing how these "Earth toys" behaved in a microgravity environment. They used the following toys: gyroscope, wind-up car, metal top, Ratstuff™, paddle ball, Wheelo™, magnetic marbles, yo-yo, ball and jacks, Slinky™, and paper airplanes.

Have students bring some Earth toys to class. They should experiment with each one, becoming familiar with how they behave in response to gravity. Have the students predict how the toys would behave in microgravity. They can illustrate, record, or attempt to simulate any unusual characteristics that they anticipate.

If it is available, view either *Toys in Space*, showing the Space Shuttle crew investigating the toys they brought along, or *Microgravity*, which illustrates how microgravity has its own peculiar characteristics. Some of these characteristics are useful for scientific or industrial processes which can not be done easily on Earth. Consider the predictions made earlier. Compare those predictions to what actually occurs in the *Toys in Space* video.

♦ The way in which television and motion pictures have depicted space travel and exploration over the years has undergone change. These changes keep pace with advances in the technology of space exploration as well as with the new technologies available in special effects cinematography. Science fiction has also changed to keep up with new advances.

View a motion picture or a television program that was made several decades ago. Find any inaccuracies and stereotypes about space travel. The dialogue, costumes, and hair styles are interesting to consider to see if there are any trends or cultural assumptions depicted which are no longer popular. It may be interesting to look specifically for highly propagandized narratives. The *Buck Rogers* series and *The Day the Earth Stood Still* are examples of science fiction classics. There are dozens of such classics available. Ask your resource centre staff to gather science fiction books suitable for grade 6. If a teacher-librarian is available, ask that some book talks be scheduled.

Students may have more difficulty analyzing a modern science fiction production. Often it is difficult to appraise cultural assumptions and stereotypes unless they can be isolated in a different time or a different place. Nevertheless, have students examine a more recent production. (As an example, the sound effects in the space combat in *Star Wars* mimic the sound of jet fighters in the atmosphere. Sound does not travel in a vacuum.) An interesting comparison might be to consider how the *Star Trek: The Next Generation* series differs from the original *Star Trek* series.

As either a follow-up activity or an alternative activity, depending on one's preference, analyze some science fiction writing. A novel by Jules Verne might be compared to a more recent one by an author such as Isaac Asimov, Arthur Clarke, Robert Heinlein, or Orsen Welles. Look as well for differences in writing style and language usage based upon the time in which the material was written.

Integrate the activity with Arts Education and English Language Arts.

- Recently, an experiment designed at the University of Saskatchewan was selected for a Shuttle mission. Crystals would be grown in space. The crystals would then be analyzed back on Earth, using x-ray diffraction techniques. From this experiment, scientists hoped to learn more about protein structures from this experiment and thus a better understanding of viral infections.

  Have students research this or other experiments that are particularly suited for a microgravity environment.

  Students could also design their own experiments to be performed in space. How can the conditions that are found in space be an advantage in performing those experiments?

- There have been several disasters and near-disasters in space. As humans push the limits of technology, accidents occur out of neglect, complacency, or from other causes.

  Have some students research disasters that have occurred in space. Others can be assigned to research tragedies that have occurred for other types of technology. Examples to consider might be the sinking of the Titanic, the explosion of the dirigible Hindenburg, the Tenerife jumbo jet collision, the Bhopal chemical plant disaster, the Chernobyl nuclear disaster.

  Compare similarities and differences in each of these disasters. Identify those factors that can be attributed to "human error." What changes took place after the disaster? Were safety regulations improved? Were changes made to the technology to ensure that such a disaster would never occur again?

- Investigate the S.P.A.C.E. club network established in Saskatoon and other cities. How can this type of activity be used to link your students to the rest of the world?

Energy in Our Lives

Unit overview

How important is energy in our lives? How does energy have an impact on what we do, and on what information we receive? Thinking, walking, listening – all require an energy expenditure. Energy brings us information about everything around us – light energy enables vision, sound energy vibrates our eardrums, and electrical energy can be used to create sound and light.

In this unit, students will have an opportunity to examine the forms of energy that they think are most important to them in their lives, focus on three of the forms, and to discuss their dependence on energy. What is the nature of energy? How are the different forms related? How are they different? How does each behave? How is each generated? This unit is the third in a sequence of six core units from grade 4 to grade 9 that examine various aspects of energy.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in learning logs, reading from newspapers and using those articles as models for reporting on the activities of science class, as well as writing editorials which express viewpoints on topics of interest with respect to the energy and energy use are three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A3 holistic

B10 cause-effect
B12 conservation
B13 energy-matter

C6 questioning

D1 science and technology
D3 impact of science and technology
D4 science, technology, and the environment

E4 using audiovisual aids
E5 computer interaction

F4 valuing natural environments

G1 interest
G3 continuous learner
G6 response preference

Concept development

grade 3
- production and transmission of sound
- investigate echoes and pitch of sound

grade 4
- characteristics, production, and interconversions of all forms of energy
- relationships among force, motion, and friction

grade 5
- distinguish between renewable and nonrenewable energy resources

grade 7
- evaluation of alternative energy sources for producing electricity

grade 8
- extraction of nonrenewable resources for energy production
- production, distribution, and conservation of energy from nonrenewable resources

grade 9
- effect of electrical production and use on society and individuals

Foundational and learning objectives for Science and the Common Essential Learnings

1. Investigate the forms of energy.
   - 1.1 Identify various forms of energy.
   - 1.2 Compare and contrast forms of energy.
   - 1.3 Demonstrate how we recognize the presence of energy in a system.
   - 1.4 Examine conversions of energy between forms.
   - 1.5 Assess the efficiencies of conversions of forms of energy.

2. Consider how light, sound, and electrical energy have an impact on our lives.
   - 2.1 Investigate how these forms of energy are formed and transmitted.
   - 2.2 Recognize how individuals use and depend on these forms of energy.
   - 2.3 Prioritize energy use in our lives.
   - 2.4 Examine and consider low energy use lifestyles.
   - 2.5 Explore the role of society in encouraging and enabling low energy lifestyles.

3. Develop a contemporary view of technology. (TL)
   - 3.1 Examine their experience with technologies involving light, sound, and electricity.
   - 3.2 Understand the social and cultural forces which underlay technological developments.
   - 3.3 Appreciate how technological developments affect culture and society.

4. Understanding how knowledge is created, evaluated, refined and changed within science. (CCT)
   - 4.1 Make careful observations during activities and discuss observations with others.
   - 4.2 Strengthen perceptual abilities through concrete experiences.
   - 4.3 Understand how knowledge is created and evaluated in science.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level –Key Resource Correlations* describe activities or ideas for activities.

♦ Which form of energy is most important to our lives: light, sound, or electricity? Which is second most important? Pick one of them and visualize a life without that form of energy? How would you adapt to survive? What other forms of energy or what changes in behaviour would help you accommodate the loss of use of the form you have chosen?

Write a short story that describes the ideas you have about how your life, and life in general, would change without that form of energy.

Factors: A3, B13, C6, D3, G6
Objectives: 1.2, 2.2, 2.3, 3.1
Assessment Techniques: peer-assessment, portfolios, homework
Instructional Methods: reflective discussion, focused imaging

♦ Brainstorm to produce a list of all uses of all types of light. Categorize these according to essential to life and nonessential. Ask each group to choose one use that has been identified as essential. What type of adaptations would be necessary to permit life to proceed in the absence of light?

If each group has a different use, ask them to present their ideas orally to the whole class. An alternative way to present their ideas might be to create a story describing life that has adapted to no light or draw a mural depicting such adaptations.

Factors: B10, C6, E4, G1
Objectives: 2.3, 3.1
Assessment Techniques: self-evaluation, written assignments, presentations
Instructional Methods: concept formation, discussion

♦ Carefully remove the glass from an incandescent light bulb. Is the filament still completely or partially intact? If it is completely absent find out where it goes by inspecting a new clear glass bulb. Trace the path of electricity in the bulb. What are the uses of the structures that aren't part of the circuit in the bulb? How does a light bulb produce light? Draw a diagram of a light bulb.

Factors: B10, C6, D1, G1, G3
Objectives: 1.4, 1.5, 3.1, 4.2
Assessment Techniques: performance assessment, short answer test items
Instructional Method: inquiry

♦ Find out how light is produced in a fluorescent tube. Compare this method to how light is produced in an incandescent bulb. What are the advantages of each type of light production? Are there other ways in which light can be produced? How many ways of producing light can you discover?

♦ How do the *aurora borealis* produce light? Is the light reflected light or light that is created in the sky? Is there a corresponding effect in the southern sky? Some people say that the northern lights make noise when they are especially bright. If you have heard the noise, describe it. Or find someone who has heard the noise and ask that person to describe it. In what way might the noise be generated? Is there any way we could use the energy of the northern lights? In what ways might the same process that produces them be useful to us?

♦ How does a flashlight work? Obtain some flashlights and ask the students to take them apart to determine how they work. Ask them to draw a diagram of the path electricity would take through the flashlight, and then write a story pretending they are an electron in one of the dry cells, getting ready to embark on the voyage through the bulb and back to the cell.

♦ How does a toaster work? Obtain some old non-working toasters and ask the students to take them apart to determine how they work. It would be a good idea to cut the electric cord about 2 cm from where it enters the toaster so that no one is tempted to plug it in. Ask them to draw a diagram of the path electricity would take through the toaster, and then write a story pretending they are an electron in the house circuits which encounters the plug of a toaster. What adventures would the electron encounter going through the toaster?

Repeat this activity with other small appliances, but not with old television sets. The coil in a television set may be charged with up to 25 000 volts.

- Modify a flashlight to produce a narrow beam by making from poster board a mask with a small hole or narrow slot to tape over the reflector. Investigate the characteristics of the beam at various distances from the flashlight. Arrange six mirrors so that the beam bounces off each of them to hit a target. Draw a diagram of the path the beam takes as it hits the mirrors. What is the effect of taking one mirror out of the path?

- List as many devices as possible which use mirrors as essential components. Draw diagrams to show how mirrors are used in each case, and build models of the devices if that is practical.

- Convert a flashlight to produce a star-shaped beam. What design gives a star with the best definition (sharpest edges)?

- A converging mirror can be used to reflect light to create an image on a card held between the object and the mirror. Experiment with images formed in and by converging mirrors? What characteristics do the images have? In what devices are converging mirrors used?

  See if the same type of image formation is possible with a diverging mirror. (These are the mirrors that say on them: "Warning! Objects may be closer than they appear.")

- Observe a speaker cone when a recording or the radio is playing. Design and build a vibration detector to amplify or enhance the vibrations you can see.

- Use a balloon inflated to its limit as a vibration detector in front of large speakers. How sensitive are the balloon-detectors? How do distance, amount of inflation, size, colour, shape, thickness of walls, and other factors you can identify affect the performance of the balloon as a vibration detector?

  If you put a string on the balloon, will the vibrations cause the string to vibrate? What type of sound (rock, classical, jazz) or instrument (clarinet, tuba, piano) cause the most or best vibrations?

- Cut both ends from a large (1.3 litre) juice can. Cut the palm from a latex glove and stretch it over one end of the can. Fasten it in place with a heavy elastic band. Use silicone to attach a small (approximately 1 cm square) piece of a mirror to the centre of the latex across the end of the can. Shine a beam of light on the mirror so that it reflects onto a wall or screen. Sing a single note into the end of the can. Observe the reflected light on the wall. Talk into the can. Sing a phrase consisting of several notes. What effect does each have?

- Cover a record turntable with foil. Set the speed of the turntable to 78 rpm. Gently touch the surface of the foil with one tine of a vibrating tuning fork. Stop the turntable and examine the pattern on the foil. What causes the pattern that appears? How could this method be used to estimate the frequency of a tuning fork? What improvements can you make to this vibration detector?

- Build a record player with a needle and drinking cone (Sno-Kone) or other stiff paper cone. Use a magnifying glass or a stereo microscope to look at record grooves. A supply of records for this use can be obtained relatively cheaply from garage sales or record store clearance bins. Put the record on a turntable and place the pin in the groove. Turn on the player and adjust the pressure on the cone and pin so that sound is reproduced.

  How do the grooves, pin, and cone each contribute to the production of sound? Why don't you have to move the pin (or the needle of a regular pick-up) from track to track on the record to play the whole record?

- Play a record at different speeds. How does spinning the record faster affect the speed of vibration of the needle? What is the effect on the sound of changing the rate of vibration?

- How do our vocal cords produce sound? When we whistle how is the sound produced? How does holding a blade of grass flat between the two thumbs cause a sound when one blows into the gap between the thumbs? Do birds have vocal cords to produce their sounds? When an object is going very quickly through the air, why does it make a whistling sound?

- How does a dry cell produce electricity? Why do dry cells run down? If two or more cells are hooked together, the result is a battery. Most flashlights take two cells to form their battery. How many cells are there in a car battery? What produces the electricity in a car battery? How does an alternator or a generator in a vehicle produce electricity? How do rechargeable cells and batteries get recharged?

- How is electricity produced at Boundary Dam? How is it produced at Coteau Creek and at Island Falls? Compare the processes used.

- What effects on the body does an electrical shock have? Why do paramedics use electric shock to restart a stopped heartbeat? How does a pacemaker work? Does a healthy heart generate electrical impulses on its own?

- What is the sound barrier? Why was it difficult to design planes that would "break the sound barrier"? What is a sonic boom? Why are the Concorde SST and all military aircraft prohibited from flying faster than the speed of sound at low altitudes? Present these questions for a brainstorming session or fact-finding period to generate questions for students to research.

- How fast does sound travel? How fast is this compared to the speed of light? Here is an old method of determining the distance to a lightning strike. Count the seconds between the flash and the thunder, and divide this number by three. The result will give you the number of kilometres from you to the lightning. How does this method work?

- Analogy for a sonic boom: Until the 1960's, trains had special cars that were used for sorting and transporting mail. There were people whose job it was to ride in that car and sort the mail. When the train would stop at a town, a postal worker would bring to the train the mail which had been posted at the post office since the last train was through town and then pick up a bag for that town. The outgoing bag would be loaded into the mail car and the clerks who worked in the car would sort the mail into the appropriate destination bags while the train was travelling to its next stop. At the next stop the same thing would be repeated. **Individuals could also mail postcards or letters by putting them through a slot in the wall of the car.**

  Suppose that in 1947 a boy was riding the transcontinental train from Montreal home to Biggar. He decided to send postcards from various places across Canada to his mother who worked at the post office in Biggar. At Ottawa he got off the train, walked along the train to the mail car and put a postcard of the Parliament Buildings into the slot in the mail car. Then he got back on the train and rode to North Bay. There he got off and mailed a postcard of Lake Nipissing at the mail car. He repeated this at Capreol, Hornepayne, Longlac, Armstrong, Minaki, Winnipeg, Carberry, Melville, and Saskatoon. When he got to Biggar, his mother was at the train to meet him and pick up the mail. Among other things, what was in the mail bag his mother picked up at the train?

  Application: Close your eyes and imagine how much sound a jet makes. The sound it makes travels at about 300 metres per second. If a jet is 1 500 metres away from you, how long will it take the sound to get to you?

  Now suppose that the jet that is 1 500 metres away from you is coming toward you at 300 metres per second. How long will it take the jet to get to you? How does this compare to the time it will take the sound to get to you? The jet is travelling at the speed of sound, called Mach 1. The jet is like the person on the train. The sound is like the postcards. How is the air like the train?

  Imagine that sound travels through the air in bundles. Are any of the bundles of sound from the last five seconds going to get to you before the jet does? When is the sound going to get to you? How much sound does a jet make in five seconds? What would this sound like if the whole five seconds worth of sound got there all at once?

Word Find Puzzle

F	U	E	L	C	O	N	C	V	W	E	M
H	E	A	T	A	L	R	I	A	S	R	I
Y	O	L	N	L	I	O	T	W	O	R	K
M	G	F	E	A	G	T	E	F	E	N	E
A	R	R	G	C	H	A	N	G	E	Y	F
G	R	J	E	I	T	O	I	E	M	O	N
N	S	O	U	N	D	R	K	E	T	F	O
E	S	U	N	A	E	R	I	M	E	O	T
T	E	L	C	H	E	M	I	C	A	L	P
I	V	E	O	C	A	N	R	O	A	T	H
C	A	A	R	E	W	O	P	E	R	L	F
O	W	F	R	M	F	M	O	T	O	R	M

Find the words on the following list in the puzzle. Mark off the letters in each word you find. Some letters are used in more than one word. The letters remaining unmarked after the words are all found form a nine-word phrase.

Word List

change	fuel	magnetic	sun
chemical	heat	mechanical	watt
electrical	joule	motor	waves
energy	kinetic	potential	work
force	leaf	power	
form	light	sound	

Phrase

_ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _

Growth and Development

Unit overview

During this unit, students consider how different animals, both invertebrate and vertebrate, reproduce, and how traits are passed from parents to offspring. Topics for discussion include the human life cycle and the spectrum of changes that occur during life.

Adolescence is a time of rapid change and development. The changes which puberty brings makes many young people wonder, "What is happening? Am I the only one feeling like this? Do I fit in?" Opportunities for students to discuss change in their lives and see it as a normal occurrence experienced by all maturing organisms are important.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing reports, letters and stories are only three ways through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word. Examples of activities which contain writing or reading components are found in the **Suggested activities** section of this unit.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. The **extension** phase of each lesson is an ideal place for students to create their own challenge opportunities or to choose from opportunities suggested to them.

Factors of scientific literacy that should be emphasized

A1 public/private

B1 change
B4 organism
B10 cause-effect
B14 cycle

C2 communicating
C3 observing and describing
C9 inferring

D1 science and technology

E4 using audiovisual aids

F1 longing to know and understand

G1 interest
G3 continuous learner

Concept development

grade 1
- relationship between animal babies and parents

grade 2
- plant growth and reproduction

grade 7
- sustenance of life in its environment

grade 10
- functions and interrelationships of human body systems

grade 12
- human reproduction

Foundational and learning objectives for Science and the Common Essential Learnings

1. Explain how different organisms reproduce.
   1.1 Trace the development of organisms from fertilization to birth or hatching.
   1.2 Describe the stages of development of the human embryo from fertilization to birth.
   1.3 Compare how different organisms reproduce.

2. Understand the basic principles of heredity.
   2.1 Explain how traits are passed from parents to offspring through genes.
   2.2 Describe how dominant and recessive genes result in variations in offspring.
   2.3 Discuss the nature of hereditary conditions and disorders.

3. Describe the stages in the human life cycle.
   3.1 Identify infancy, childhood, adolescence, adulthood, and old age as stages in human development.
   3.2 Describe physical changes that occur during each stage of human development.
   3.3 Consider cognitive changes that occur during human development.
   3.4 Compare the human life cycle to that of other organisms.

4. Use language (listening, speaking, reading, and writing) to communicate to others what is observed and thought. (COM)
   4.1 Use writing to record thoughts.
   4.2 Use the vocabulary associated with the science of heredity and development to present information and develop arguments.
   4.3 Use dictionaries, encyclopedias, and reference books to gather information.
   4.4 Use fiction, nonfiction, periodicals, newspapers, and audiovisual materials as resources.

5. Understand heredity through applying mathematical skills and abilities. (NUM)
   5.1 Collect and organize quantitative information into charts, graphs, and tables.
   5.2 Read and interpret graphs, charts, and tables.
   5.3 Begin to investigate the use of odds, probabilities, and likelihoods in describing hereditary traits.

Suggested activities

♦ Why can't cats have puppies? What is it about organisms that makes them have offspring of the same species instead of producing a different species? What would the world be like if the species of offspring of parents weren't necessarily of the same species as the parent, but just a matter of random chance?

  Factors: B4, B10, C3, C9, F1
  Objectives: 1.1, 2.1, 4.1, 4.2
  Assessment Techniques: written assignments, presentations, oral assessment
  Instructional Method: discussion

♦ Establish a mealworm culture in your classroom. ***Cockroaches and Things*** has a section on caring for a mealworm culture. Mealworms show metamorphosis. Ask each group of students to draw a series of pictures depicting the life cycle of the mealworm. When the drawings are complete, ask them to meet with another group and compare their products.

  Factors: A1, B1, B14, C2, C3, E4, G3
  Objectives: 1.3, 4.1, 4.3
  Assessment Techniques: group evaluation, observation checklist, oral assessment
  Instructional Methods: conducting experiments, circle of knowledge

♦ Categorize organisms on the basis of whether they reproduce by producing fertilized eggs or not. Is a seed (e.g. a grain of wheat or a lentil) a fertilized egg? Are there organisms which reproduce in more than one way? What generalization can you make from the list produced? Based on what characteristics of reproduction could you further subdivide each of the lists? What advantages and disadvantages are there to each type of reproduction?

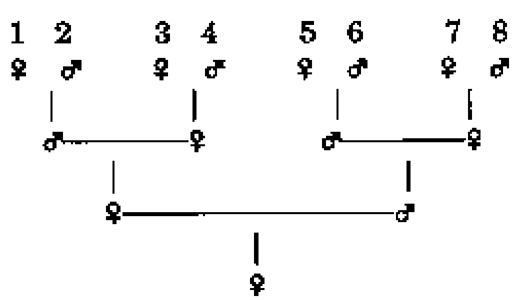
  Factors: B4, B14, C2, C9, F1, G3
  Objectives: 1.3, 2.1, 4.3, 4.4, 5.1
  Assessment Techniques: rating scales, observation checklists, written assignments
  Instructional Method: compare and contrast

- Survey the variability in five traits among members of your class. Contact a grade one teacher and ask whether you can survey the members of her class with respect to the same traits. Repeat this for a grade 11 class. Possible traits are shoe size, little finger length, wrist circumference, pulse rate, and eye colour. Record the sex of each participant in the survey. Analyze the data to determine for which characteristic there is the most variability in your class and for which characteristic there is the least variability. Bar graphs are one way to compare variability of traits. You will have to make a decision on how you are going to gauge the variability in each characteristic. Repeat this process for the other grades you have surveyed. Is the same characteristic most variable in each class? Does the amount of variation in each characteristic stay the same over the eleven years or does it change? Is there more variation between the male group and female group within one class or between members of the same sex in different classes? Identify other questions to guide analysis of your data.

  On a chart, list characteristics which are variable in one column and those which are invariable in the other. For instance, eye colour would go in the variable column and two arms in the invariable column. Where would `personality' go? How about `requires water' or `needs sleep'? Are there more variable or invariable characteristics among humans?

- If it is grasshopper season, bring a number of grasshoppers into the classroom. A good place to collect samples is from behind the front grill of a car. Measure body length, upper backleg length, lower backleg length, and so on. Chart the variability of the dimensions.

- Draw a pedigree chart that goes back four generations. (If possible, fill in with the names of your ancestors and the places where they were born. Use sensitivity when assigning this part of the activity.)



The example given is for a female student. Her greatgrandparents are numbered 1 through 8.

Humans have 46 chromosomes. When egg cells and sperm cells are produced, this number is divided in half through a process called meiosis, or reduction division. This is so that when the sperm fertilizes the egg, the number of chromosomes in the zygote is the normal number (46).

Cut 23 squares 1 cm on a side from poster board, and label each square #1, to represent the chromosomes from the ancestor labelled 1 on the chart. Repeat this for each ancestor numbered 2 through 8. Keep the squares in separate piles.

Mix the squares labelled #1 with those labelled #2 and then randomly withdraw 23 squares. The mixture represents the chromosomes of the son of persons 1 and 2, half coming from his father and half from his mother. The 23 chromosomes drawn represent the chromosomes he produced in reduction division to form a sperm cell.

Mix the piles labelled #3 and #4 and randomly withdraw 23 chromosomes to represent the chromosomes in an egg cell of the daughter of #3 and #4 ancestors. Mix these to get the representation of the chromosomes of your mother. From this group of 46 chromosomes, withdraw 23 at random, to represent your chromosomes from your mother's side of the family.

Repeat this whole process with the squares that represent the chromosomes of persons 5 through 8, your greatgrandparents on your father's side of the family. From the #5 and #6 mixture, withdraw 23 and mix with 23 drawn from the #7 and #8 mixture. From those 46, withdraw 23 at random to represent the chromosomes from your father's side of the family. The combination of this group with the final group of 23 from your mother's side of the family represent your chromosomes. Draw a bar graph showing the source of your chromosomes by greatgrandparent. How does your distribution compare to the distribution obtained by other members of the class?

Suppose that everyone in the class had the same set of four grandparents. Is everybody in the class going to have identical genetic inheritance? What is the chance that all your chromosomes will come from greatgrandmother #1 and greatgrandfather #8? Is there any chance all your chromosomes will come from greatgrandfather #2 and greatgrandmother #3? Is it possible that none of your chromosomes came from either greatgrandfather #2 or greatgrandmother #3?

Suppose that we were to continue labelling the people on this chart with numbers so that your grandparents became persons numbered 9 through 12, your parents are numbers 13 and 14, and you are #15. Why don't you have any chromosomes labelled #14 and #13 on your bar graph of the pile of squares representing your chromosomes? Didn't you get your chromosomes from your parents? Did the set of chromosomes which you have today originate with your greatgrandparents, or did they get them from somebody else?

♦ Ask each student to prepare a card showing the fingerprints of both hands. Fingerprints can be captured on cellophane tape if the finger has been wiped on a patch of 2B or 4B pencil shading. (See pages 406-409 of *Science: A Curriculum Guide for the Elementary Level* for more detailed instructions, and for identification of pattern type.)

Once the card has been prepared, ask the students to classify the prints as whorl, loop, arch, or composite. Collect and report class data on the variability of the fingerprints in the class. Is there more variability in the class set than in any one student's set? Can any student find two fingerprints that appear to be exactly the same?

An extension would be to do an analysis of the fingerprints within a family group to see if there is as much variability in such a group as in the class. Other classes in the school could also be surveyed.

♦ Over the course of several months collect newspaper and magazine articles that deal with hereditary conditions and disorders. Post the articles on a bulletin board. Encourage students to remove the articles for reading about conditions of interest. When a sufficient number of articles has accumulated, ask the class to select one or two conditions as a class research project.

Create a class concept map with the condition as the central concept. Identify areas where the concept map needs enhancement or verification. Divide the research tasks among small groups. Each group should present its findings in a written brief and as a revised section of the concept map. Illustrations, posters, audiotapes or videotapes, and demonstrations may be used to enhance the class presentation of their written brief.

Human Body Control Systems

Unit overview

The structure and function of the central nervous system and the endocrine system are examined in this unit. These topics do not lend themselves to a lot of investigations involving student experimentation. The focus of the unit will involve predominantly research of print and audiovisual information about the human nervous and endocrine systems.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, are essential in this unit. Readings from reference books, journals, magazines, and newspapers will be the primary information gathering method employed. In order for students to assimilate this material and convey the results of their research to their classmates, writing is essential. Writing in personal, reflective journals and creating innovative reports in various formats are strategies through which students may refine their understanding of the concepts in this unit.

Examples of activities which contain writing or reading components are found in the **Suggested activities** section of this unit.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. The **extension** phase of each lesson is an ideal place for students to create their own challenge opportunities or to choose from opportunities suggested to them.

Factors of scientific literacy that should be emphasized

A3 holistic
A4 replicable

B2 interaction
B5 perception
B10 cause-effect
B16 system

C2 communicating
C4 working cooperatively
C11 controlling variables

D1 science and technology

E4 using audiovisual aids
E5 computer interaction

F3 search for data and their meaning
F5 respect for logic

G1 interest
G2 confidence

Concept development

grade 1
- identification of the senses

grade 4
- function of the brain in interpreting sensory information

grade 10
- human body systems

grade 12
- animal systems

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize the importance of the central nervous system.
   - 1.1 Describe the function of the central nervous system.
   - 1.2 Describe the function of the peripheral nervous system.
   - 1.3 Compare voluntary and involuntary actions.
   - 1.4 Evaluate the importance of reflex actions.
   - 1.5 Describe the structure and function of different types of nerve cells.
   - 1.6 Locate major regions of the brain.
   - 1.7 Describe the known functions of different regions of the brain.
   - 1.8 Identify several disorders of the nervous system.

2. Recognize the importance of the endocrine system.
   - 2.1 Explain the function of the endocrine system.
   - 2.2 Identify some of the endocrine glands.
   - 2.3 Describe the function of some endocrine glands.
   - 2.4 Associate the major hormones with the glands that produce them.
   - 2.5 Describe the functions of each of the major hormones.
   - 2.6 Identify several disorders of the endocrine system.

3. Understand how knowledge is created, evaluated, refined and changed within science. (CCT)
   - 3.1 Focus attention on knowledge possessed and knowledge desired with respect to the brain.
   - 3.2 Gather and interpret evidence about CNS and endocrine system functions.
   - 3.3 Consider how nonintrusive investigations can reveal information about the brain and nervous system.

Suggested activities

♦ Listed below are a number of effects. Classify each according to whether the effect is a result of activity in the nervous system, the endocrine system, a combination of the two, or neither system.
- You feel a bee sting you.
- Your bee sting swells up.
- Starch in foods starts to be digested in the mouth.
- When you eat a slush drink, your head aches.
- When you're really frightened, you sometimes have a lot more strength than normal.
- Insulin controls the level of sugar in your blood.
- When you've been up 24 hours in a row, you feel tired.
- A lot of men become bald as they grow older.
- When an object is moving towards your eye, the eye automatically closes.
- Most humans grow to between 150 cm and 185 cm tall.
- You can remember when your birthday is.
- Once you learn how to ride a bike, you never have to learn again.
- Light coloured skin tends to become burned or darker when exposed to sunlight.

During your research to find the causes of these effects, each group of students should make some more statements for other members of the class to evaluate. Each statement should be submitted to the teacher for checking.

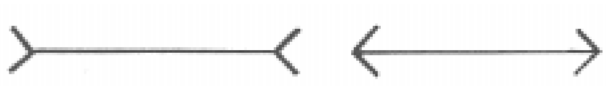
Factors: A3, B2, B16, F3
Objectives: 1.1, 1.2, 2.1, 2.3, 3.1, 3.2
Assessment Techniques: anecdotal records, homework, short answer test items
Instructional Method: research projects

♦ Brainstorm with the class to find out what they know about the brain. Record their ideas and information in one column of a chart on the board. In a second parallel column, record questions which arise from the statements in the first column or other questions which they might generate about the brain and its functioning.

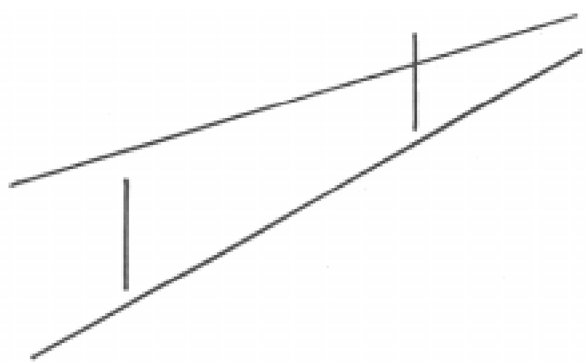
Once questions have been recorded in the second column decide how they will be distributed among the groups in the classroom. Groups might volunteer to answer one or two of particular interest to them, or the questions written on slips of paper and drawn from a hat. Ask the groups to prepare a short oral presentation to the class to discuss the results of their research. The presentation should be supplemented with posters, diagrams or other visual aids to help their classmates understand what they have found out.

Factors: B16, C2, C4, E4, F3, G2
Objectives: 1.6, 1.7, 3.1
Assessment Techniques: group evaluation, observation checklist, presentations
Instructional Methods: reports, reading for meaning

♦ Which central line segment in the two diagrams below appears to be longer?



Which vertical line appears to be longer?



Find other line illusions and produce posters that illustrate them. Why do these effects fool our eyes?

Factors: B5, F5, G1
Objectives: 1.1, 3.2
Assessment Techniques: performance assessment, written assignments
Instructional Methods: inquiry, problem solving

♦ A Russian scientist named Pavlov trained dogs to salivate when he rang a bell. How might this have been done? Outline a training scheme which would produce this effect. Then find out what Pavlov did.

A science fair project from several years ago involved fish which had been trained to come to the side of the aquarium when the student tapped the wall of the aquarium. How might this have been accomplished?

This process is called conditioning. How does it relate to the process of house-training dogs or teaching dogs to roll over and play dead? Do you suppose that a grasshopper could be conditioned to do something? How about an earthworm?

♦ Hold a metre stick vertically so that its lower end is about one metre from the floor. Ask your partner to put a thumb and forefinger on either side of the metre stick, at the end closest the floor. Drop the metre stick and ask your partner to catch the metre stick between the two fingers.

Read the distance the metre stick has dropped before being caught. You will have to decide how to determine the end-point for the measurement. Will it be from the end of the stick to the top of the fingers, the bottom of the fingers or somewhere in between? Record the result. Repeat the process, recording the distance the stick has fallen each trial. Is there a learning effect involved in this procedure? If your partner doesn't catch the stick during one trial, how would this be recorded in the data? Does your partner's catching distance keep getting shorter and shorter?

Bend a 2 cm by 4 cm piece of paper into the shape of an L. Tape the strip of paper to the 50 cm mark of the meter stick so that the longer arm of the L sticks out perpendicular to the surface of the metre stick. Tell your partner to again hold the index finger and thumb at the bottom of the stick, close her eyes and catch the stick as soon as the paper hits one finger or the other. Collect data for a number of trials with this method, measuring the distance from the piece of paper to where the stick is caught. How would you report a trial when your partner caught the stick before the paper hit the finger? Occasionally move the paper strip to other places along the metre stick to alter the time between when the stick is dropped and the paper tab hits the fingers.

Analyze the data collected from your partner's catches. What trends are evident? How can this data be reported as a line graph? as a bar graph? Repeat the procedure with your partner and yourself switching roles. Compare your results with those from one other group. Are the results comparable or different? Pool all data from the class and analyze the trends in the class.

- ♦ Draw an outline of your body on the central part of a piece of poster paper. On this outline, sketch the location and shape of the endocrine glands. Around the outside of the paper, briefly describe what hormone(s) each gland secretes, and the effect of each hormone.

- ♦ The word endocrine is a compound word made from two Greek words. Find out what the Greek words are, what they mean in English, and how this compound word describes the endocrine glands or system.

- ♦ Your brain is encased in thick bones which make up the skull. These bones are very strong and protect the brain. However, if you fall and hit your head on the floor, ground, ice, or other hard surface your brain may be injured without your skull being broken. How does the brain become injured if the skull doesn't break? How does wearing a helmet when you skate or ride a bicycle protect your brain in case of a fall? What are characteristics of a good helmet?

- ♦ Taste buds to sense sweetness, sourness, bitterness, and saltiness are found in different locations on the tongue. Use a sugar solution, lemon juice, 0.1% quinine sulfate solution, and salt solution to locate areas of the tongue sensitive to each of these stimuli. (A solution of instant decaffeinated coffee could be substituted for the quinine sulfate.) Adjust the initial strength of the solution so that the effect is noticeable but not overpowering when a few mL are rinsed in the mouth.

  Draw a full size outline of each tongue to be tested and determine a testing grid. Mark that grid by number on the outline of the tongue so that for each numbered location the result of the sweet, salty, bitter, and sour tests may be recorded and eventually mapped back to an outline of a tongue to show the tasting zones.

  Administer the solutions to the tongue with a dropper, placing a small drop at each sampling location as determined by the chart. 15 to 30 sampling locations should be identified. Record the effect as each drop is added. As sensitive areas are located, their extent may be mapped by more intensive measuring of those locations. An alternative to administering the solutions with a dropper is to use a Q-tip™ type cotton swab.

  Compare the results of the testing. Does everyone have approximately similar areas of sensitivity to each stimulus, or is an area that is sensitive to saltiness in one person sensitive to sweetness in another?

- ♦ Devise and conduct a test to determine a person's ability to hear. Identify as many variables as possible that may be important in conducting the test.

- ♦ Some people have difficulty distinguishing between red and green. Find out what kind of tests are used to help identify this condition. Do you know someone with this condition? What effect would this have on everyday activities?

- ♦ Devise a test to gauge a person's sense of touch. Do all people have equally sensitive senses of touch? Is the palm of the hand more sensitive than the back of the hand? Is the upper arm more sensitive than the fingertips?

- ♦ Design an investigation to study the relationship between the sense of smell and taste. Does an orange taste sweet if you are smelling a lemon while you eat the orange? How does water taste if you are smelling an onion when you drink the water? If you plug your nose and then eat a piece of lemon, does its taste change?

- ♦ Experiment with your sense of balance to see how much depends on visual cues. Can you stand balanced on one leg as easily when your eyes are shut or you are blindfolded as when you can see? Devise some other balance tests.

  Be careful when experimenting with balance so that you don't fall and hurt yourself. It might be a good idea to have one or two friends ready to support you if you lose your balance.

Earth's Climate

Unit overview

During this unit, students study the factors that influence the climate of a region. They identify and compare characteristics of tropical, mid-latitude, and polar climates, and discuss theories of long-term climatic change. This is an opportunity to consider evidence of climatic change and global warming due to the greenhouse effect.

There are strong links from this unit to several other grade 6 units. The climate is the chief determining factor in development of an ecosystem. How organisms are able to modify their immediate environment to accommodate themselves to the overall environment (of which climate is a major part) determines whether they can successfully inhabit an ecosystem. The climate influences how much energy humans use and the extent to which solar energy and wind energy may be useful alternative sources. Climatic factors help determine the range of human habitation on the planet.

Satellites are being used to record information about the Earth including data about weather and climate change. As we explore space, we also develop techniques of looking back on the earth and seeing it from a different perspective.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, writing reviews of videos seen during class, and reporting on the activities of science class by creating jokes, riddles, or poems are only a few strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A2 historic
A3 holistic

B1 change
B2 interaction
B10 cause-effect
B11 predictability
B13 energy-matter
B14 cycle
B16 system

C6 questioning
C9 inferring

F3 search for data and their meaning

G3 continuous learner

Concept development

grade 2
- comparing different environments
- observing and recording weather phenomena
- discussing patterns of weather

grade 3
- comparing climates of Venus, Mars, and Earth

grade 4
- predicting weather

grade 9
- mapping patterns of activity in the atmosphere
- identifying the effect of human activity on the atmosphere

Foundational and learning objectives for Science and the Common Essential Learnings

1. Describe the Saskatchewan climate.
   - 1.1 Identify the factors that produce our climate.
   - 1.2 Explain how the factors which influence our climate have the effect they do.
   - 1.3 Explain how landforms influence climate.
   - 1.4 Examine how prevailing winds are influenced by the rotation of the Earth.

2. Identify and compare different world climates.
   - 2.1 Identify characteristics of tropical, mid-latitude, and polar climates.
   - 2.2 Compare characteristics of tropical, mid-latitude, and polar climates.

3. Recognize long-term climatic patterns.
   - 3.1 Recognize that climatic change can take place over prolonged periods of time.
   - 3.2 Synthesize geologic, glacial, and fossil information for evidence of long-term climatic change.
   - 3.3 Evaluate theories of climatic change.

4. Develop a positive disposition towards lifelong learning. (IL)
   - 4.1 Participate in a wide range of individual and collaborative learning activities with both peers and adults.
   - 4.2 Make choices for study which reflect personal needs and interests.
   - 4.3 Choose topics for indepth study.
   - 4.4 Develop support strategies and the language of encouragement in order to help peers persevere at learning tasks.

5. Become compassionate, empathetic, and fair-minded people who can make positive contributions to society, as individuals and as members of groups. (PSVS)
   - 5.1 Reflect upon the benefits of cooperative, respectful, or empathetic behaviours in specific situations which arise in the classroom.
   - 5.2 Develop an understanding of the virtues needed for a classroom environment which supports learning and development by all members of the class.
   - 5.3 Recognize the importance of respecting evidence, truth, and the views of others, and distinguishing among these, when engaged in rational discussions.

Suggested activities

♦ Brainstorm, either in groups of three or as a whole class, terms that are associated with the concept of climate. Then brainstorm words that are associated with the term weather. Organize each of these groups into a concept web or map. Compare the two webs or maps. How are they interrelated? Draw one concept map showing both concepts.

  From the map identify areas of interest where groups can investigate to enhance their understanding about climate. Ask the group to research the area they have selected, prepare a report for the class, and create an extension or enhancement of the concept map which outlines what they have discovered. Encouraged groups to use a wide range of reporting strategies, from illustrated lectures with notes provided, to live or recorded interviews with a renowned `expert' from within the group, to a poem or drama that conveys the information. In all cases, the concept map enhancement will put the information into a new context or allow connections to a context which the class understands.

  Factors: A3, B1, B2, B16, C6, F3
  Objectives: 1.1, 1.2, 4.1, 5.1, 5.3
  Assessment Techniques: group evaluation, self-assessment, anecdotal records
  Instructional Methods: concept maps, reports

♦ Build a device to indicate wind direction and speed. Determine if there are objects or structures in your schoolyard that will influence or disrupt the flow of the wind. Move the device from place to place on a day when there is a steady wind blowing to record test data. Select a site to mount the device permanently and record wind direction and speed from one to three times a day for as much of the year as possible. Try to record the data as close to the same time each day as is possible.

Contact from five to fifteen grade six classes in other schools in the province and arrange to exchange data on wind speed and direction. Keep the data from your school and other schools in a binder so that students in subsequent years will have access to it and can contribute their own data to the collection.

Does the direction of the prevailing wind help determine the climate or is it a result of the climate? What other weather data are related to determining climate? How about rainfall? What weather data are a result of climate rather than determining the climate?

Factors: A2, B1, B2, B11, B14, C6, C9, F3, G3
Objectives: 1.1, 1.2, 1.3, 1.4, 4.1, 4.4, 5.1
Assessment Techniques: contracts, oral assessment, presentations, rating scales
Instructional Method: circle of knowledge

♦ Is the climate of Saskatchewan the same as the climate of Alberta? Does Saskatchewan have the same climate as North Dakota? As the Northwest Territories? Is there one climate for the whole of Saskatchewan? How do we tell where one climate stops and another one starts? Does the whole Earth have one climate, as compared to Venus or to the Moon?

Factors: A2, B10, B16, C6, F3
Objectives: 2.1, 2.2, 5.2
Assessment Techniques: written assignments, short answer test items
Instructional Methods: comapre and contrast, reflective discussion

♦ What is a microclimate? How are microclimates produced? Where can you find a microclimate in your area? Experiment with creating terrariums to illustrate different climates and microclimates.

♦ How do ocean currents influence the Earth's climate? What is the meaning of El Niño? What is El Niño? What is El Niña?

♦ How does the tilt of the Earth's axis with respect to its orbital plane affect the climate of Saskatchewan? Why is winter colder than summer in Saskatchewan when the Earth is closer to the sun during our winter season? Why doesn't the tilt of the Earth's axis affect the climate of Hawaii or of Ecuador?

♦ List areas of the Earth that have distinctive climates. Ask each group to choose one of the regions and report to the rest of the class about the climate and the effect the climate has on the activities in that area. Ask each group to prepare a poster summarizing the highlights of their findings for a bulletin board display.

♦ Dr. Elaine Wheaton is a climatologist who works at the Saskatchewan Research Council in Saskatoon. She believes that the increase in the carbon dioxide level of the atmosphere is causing global warming, which will lead to a major climate change. Dr. Tim Ball is a climatologist at the University of Winnipeg. He believes that it is impossible to predict whether the increase in level of carbon dioxide in the atmosphere is causing global warming now, or will cause it in the future. He says there are too many other factors which influence climate to select increase in carbon dioxide levels as one which will cause an overall change.

Which scientist is correct? They both have the same data. How can they disagree?

♦ Collect information on the debate about whether we are in the first stages of a period of global warming caused by increased carbon dioxide levels. Also collect information about the influence of other factors on the global climate – volcanic eruptions, amount of water vapour in the air, continental drift, ocean currents, and so on. Prepare a bulletin board display that gives people who stop and look a chance to learn something about this area of research.

♦ How do volcanoes affect the Earth's climate? Read the article reproduced on page 645. Was the prediction made by Mr. Hopkinson in the last sentence accurate? Find 1993 Canadian climate data to support your claim.

The graphs near the top of the page communicate some of the data from the charts at the top. Which data is represented on the graphs? Redraw the graphs, showing the scale on the vertical axis and the data from the tables that is not included on the original graphs.

Examine the **Totals & Averages** line of the data table. Is the 5.7° under the column headed *Warmest* the average of the numbers in column above? Write a sentence or two that explains what this average represents. Do this for other column totals and averages as well.

Volcano left us dry in the dark

By Tracy Elsaesser of the Leader-Post **Reprinted with permission**

Regina residents suntanned less and had fewer puddles to wade through in 1992 than in years past.

Statistics released by Environment Canada show 1992 saw almost 270 fewer hours of sunlight and nearly 93 millimetres less precipitation than normal.

Both numbers are the result of a volcano in the Philippines that erupted more than a year and a half ago. "There's some lingering influence from the eruption of Mount Pinatubo in 1991," Ron Hopkinson, a meteorologist for Environment Canada, said Thursday. "The effects linger a year or two after."

Mount Pinatubo shot huge amounts of debris 35 kilometres into the atmosphere.

In addition, the storm track changed in 1992. Normally, it crosses over northern Saskatchewan. But last year, especially in June, July and August, it crossed lower, Hopkinson said.

As a result, Regina didn't get the usual summer thunder showers, but did see a lot more cloud cover. "The summer of 1992 came as quite a shock to us," Hopkinson says.

The most significant changes came in June, which had 51.8 millimetres less precipitation than normal, and in July, when there were 89.8 hours less sunshine.

Despite having less sun and rain, the mean temperature in 1992 rose to 3.5 from a normal 2.2.

The temperature was most likely affected by the lingering impact of El Nino, which causes warm ocean temperatures to occur off the coast of Peru every four to five years.

In January, February and March the mean temperatures were as much as 8.5 degrees warmer than normal. However, combined with the lower sunshine and precipitation, the effect was a cooler year. For instance, in September there was less sunshine, lower temperatures and higher rainfall.

This produced bad harvest conditions for farmers. Although it's hard to tell right now, Hopkinson expects 1993 to be a different year.

"The influence of Mount Pinatubo is waning quite rapidly and we don't expect that influence to be a factor in 1993."

– from the **Regina Leader-Post**
January 15, 1993

Science 7

The Basics of Life

Unit overview

Life has an astounding variety of forms and occupies a diverse range of habitats. Yet all life shares common characteristics. The structure of DNA, the ability to respond to environmental stimuli, and the existence of a finite lifespan are common to all living organisms. In this unit, students consider the characteristics shared by all living things and how organisms acquire their basic needs from their environment.

When students see or use the word 'environment', we want them to regard all aspects of their surroundings, supportive to life and not, rather than associate a negative connotation – pollution, habitat loss and so on – with the word. Their environment is inside the classroom, just outside the classroom door, and in the schoolyard. It's the yards at home and the open fields and ditches where they can explore. Students should have the opportunity to investigate the life and the life-support system which surrounds them.

This unit establishes a foundation for the consideration of adaptation and succession in a grade 8 unit. The discussion of the consequences of environmental change caused by urbanization and by the agriculture and forestry industries in grade 9 is also based on an understanding of the characteristics and needs of living organisms.

Integrating the study of this unit with the optional unit **Microorganisms** is strongly recommended. The study of microorganisms can serve as an engaging introduction to the question "What is life?".

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. A good way to generate ideas for such activities is to have students brainstorm every thing they know about a particular topic and then generate questions which arise from what they know, or from gaps in their knowledge.

The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A3 holistic
A5 empirical

B1 change
B2 interaction
B10 cause-effect
B14 cycle
B16 system

C3 observing and describing
C6 questioning
C10 predicting
C12 interpreting data
C13 formulating models
C15 analyzing

D3 impact of science and technology
D4 science, technology, and the environment
D8 limitations of science and technology

E2 using natural environments
E13 using quantitative relationships

F4 valuing natural environments
F6 consideration of consequence
F7 demand for verification

G5 avocation

Concept development

grade 1
- plants and animals have needs

grade 2
- reasons for those needs
- some of the ways in which needs are met

grade 4
- concept of cells, cell organization in multicellular organisms

grade 5
- structures of plants

grade 6
- interactions among living things and the environment which surrounds them.

grade 7
- recognize characteristics, roles, and effects of microorganisms

grade 8
- interdependencies between organisms and habitats

grade 9
- existence and reasons for ecoregions

Foundational and learning objectives for Science and the Common Essential Learnings

1. Identify the essential characteristics and processes of living organisms.
   - 1.1 Distinguish between living and nonliving organisms.
   - 1.2 List those attributes of life shared by all organisms.
   - 1.3 Observe and describe how various microorganisms exhibit the attributes identified.
   - 1.4 Observe and describe attributes of life in macroorganisms, both those kept in captivity and those in their natural habitats.
   - 1.5 Give evidence which allows inferences to be made about traits which are not directly observable.

2. Appreciate how organisms meet their basic needs.
   - 2.1 Observe and describe the response of organisms kept in the classroom to changes imposed on their environment.
   - 2.2 Assess and discuss the welfare of animals in the classroom and in the laboratory.
   - 2.3 Observe and describe the reactions of organisms in their natural environment.
   - 2.4 Examine how natural and human-related alterations to the local environments during the past two hundred years have changed the ability of organisms to survive.
   - 2.5 Respect the intricate support network which sustains life.

3. Acquire appreciation of the personal, moral, social and cultural aspects of understanding life. (PSVS)
   - 3.1 Value the environment.
   - 3.2 Accept the potential narrowness in adopting a single perspective on experiences or events.
   - 3.3 Refine understanding of the needs of all living things.
   - 3.4 Consider the needs of other organisms in the context of human activity.

4. Develop the ability to describe and to evaluate ideas and processes which involve the environment. (CCT)
   - 4.1 Use metaphoric and analogical thinking to create insights and build understanding about organisms and their behaviour.
   - 4.2 Compare observed information with information from other (print or nonprint) sources.
   - 4.3 Bring prior experience to the discussion of observations and ideas.
   - 4.4 Criticize ideas and explanations encountered.
   - 4.5 Evaluate arguments in texts and other information sources by recognizing contradictions and distinguishing fact from opinion, relevant from irrelevant information, supported from unsupported inferences.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Display, at various places in the classroom, living organisms of various types. Lichens, fungi, mosses, flowering plants, insects, small mammals, and reptiles are organisms which are relatively easy to acquire for a short term stay in the classroom, or as permanent inhabitants. Assign two of the organisms to each student. Ask them to describe, in as much detail as possible in 10 minutes, the organisms they have been assigned.

Then, in groups of four, brainstorm a list of characteristics of living things. Once the list is complete, examine it and consider each characteristic. Try to identify organisms which are exceptions to the characteristic under consideration. Try to identify nonliving things (pebbles or water, for example) which fit the characteristic. For each anomaly identified, decide whether the characteristic should be struck from the list or revised to restate the principle.

Compile a class list of characteristics which have made it through the screening process. Repeat the screening procedure as a class group to produce a final list. Compare this class-produced list to a list from a text or other source. Discuss the similarities and the differences.

Factors: C3, C6, C12, C15
Objectives: 1.1, 1.2, 1.3, 1.5, 3.2, 4.3, 4.4
Assessment Techniques: individual anecdotal records, self- and peer-assessment checklists, self-assessment journal entries
Instructional Methods: brainstorming, problem solving, reflective discussion

♦ Describe the natural habitats of animals kept in the classroom or animals kept in the home as pets. Compare these habitats with their habitats in the classroom or at home. Can there be a suitable substitute for a natural habitat? Are there advantages in a constructed habitat? Are there disadvantages? Are all needs of the animals being met? These questions could form the basis for a classroom debate.

Extension: "I am a rabbit. I have lived in a cage in the classroom since September. I hear the students talking about setting me free so that I can live in a natural environment." What would this mean to the rabbit if the rabbit was domesticated? wild?

Factors: B1, B2, C3, C6, C15, D3, F4, F6
Objectives: 1.4, 2.2, 2.5, 2.8, 3.3, 3.4, 4.1, 4.4
Assessment Techniques: written presentation, oral presentation with self- or peer assessment
Intructional Methods: focussed imaging, concept formation

♦ Design interview questions to discover what environmental changes have been seen by longtime residents. If negatives or copies of pictures from the early part of the century are available, prepare an illustrated report. If the interviewee agrees, videotape the interview or invite the interviewee into the class to share knowledge with the rest of the class.

Factors: B1, C6, C12, F4
Objectives: 2.6, 3.1, 3.4
Assessment Techniques: rating scale, portfolio entry, presentation
Instuctional Method: interviewing

♦ Earthworm, mealworm, or ant colonies offer good opportunities for students to observe animal behaviour in the classroom. Testing the reaction to light of earthworms gives students an opportunity to design a simple experiment with animals. This can lead to a discussion of the ethics and principles of animal experimentation, and the use of animals in the classroom. Discuss as well how these types of observations can be made in the animals' natural habitats, and with the least possible disruption to the animals' lives.

Instructions for creating and caring for animal communities and individuals in the classroom can be found in **Cockroaches and Things** (Murawsky, Bandurka, 1982 BB# 6086).

♦ Composting with worms is a good classroom activity. Commercial kits are available to get your class started. Sources of compostable materials are the lunch refuse from students in your class and other classes, the school lunchroom, home, or homes in the school's neighbourhood. The compost generated can be used in school gardening projects or bagged and sold as a fund raising activity.

- If the optional unit **Microorganisms** will not be used this year or integrated with this unit, use some of the suggested activities from that unit to study how microorganisms exhibit the attributes of life.

- Create a butterfly garden in an appropriate area of your schoolyard, or in the yard of a cooperating neighbour of the school. A butterfly garden consists of species which will serve as food and habitat for butterflies in both larval and adult stages.

- Take a field trip through the schoolyard, an adjacent park or field, a ditch or pasture to look for evidence of life. How many plant species can be found? What ways do they have of acquiring their basic needs? How do they reproduce? How many animal species can be sighted? What evidence that animals were present but have moved on can be discovered? Can you find fungi, lichens, and algae? How are these organisms classified?

- Go for a field trip in the neighbourhood. Collect as many different leaves as possible. Make sure that students understand that leaves from endangered species should not be collected. Leaves from private property should be only collected with the permission of the property owner, and with great care to avoid damaging the plant. A rule is not to collect more than one leaf from each plant.

  Back in the classroom, divide the leaves into as many groups as there are working groups. Ask each working group to list all the similarities and all the differences of the set of leaves which they have. Ask them to select one leaf and produce a magazine add which 'sells' the leaf on the basis of its appearance and function. Ask each group to present its advertisement to the rest of the class. Discuss the various functions of leaves which are promoted in the advertisements.

- Ask each working group to prepare responses to the questions below. Ask them to support their answers as much as they can.
  - How is a tree like a grass plant? How is it different?
  - How is a tree like a human? How is it different?
  - How is a tree like a rock? How is it different?

  Discuss responses with the class. Clarify their concept of what life is and the diversity of life through the discussions of the responses. Extend this activity using ideas from **Planning Adventures: Synectics** from the Saskatchewan Professional Development Unit and Saskatchewan Instructional Development and Research Unit.

- Construct pooters for capturing insects. Observe the insects in a microbox and then return them to the environment. Write a report explaining to the class the physical characteristics, any behaviours noted and method(s) of locomotion of the insect. Alternatively, this report could be written from the insect's point of view – how did it feel to be captured, etc.

  Pooters were described by Dan Stoker in an outdoor activity book *Monsters and Minibeasts*. Materials needed are two drinking straws, one of slightly smaller diameter than the other, and a 2 cm square of panty hose material. Take the square of material, put it over one end of the straw with the smaller diameter and slide the combination into one end of the larger straw. Insert it far enough so that the corners of the square of material just protrude. Wrap the joint between the two straws with a piece of masking tape. Hold the pooter to the light to see if the square of material is in place to act as a filter. Insects can be drawn into the larger bottom straw by sucking on the small straw.

- Make up jokes or riddles dealing with attributes of life. Discuss humour that does not ridicule or make fun of individuals or groups of people. Ensure that the creations of the students are appropriate.

- Create a class list of attributes of life shared by all organisms. In a class discussion prioritize these attributes.

- Owl pellets make good objects for dissection. Owls and some other birds swallow their prey whole. Later, they regurgitate a pellet containing the bones and fur of the prey. Contents of the pellet provides indirect evidence that helps identify the owl's prey and construct a partial food chain or web.

  Project WILD activity "Owl Pellets" discusses the classroom use of pellets. Boreal Laboratories carries an owl pellet kit, catalogue #69831-01.

- The human nervous system exists, but can not be directly observed by students in grade 7. How can we infer that it exists? What role does ir play in meeting and facilitating meeting of our basic needs?

- Collect pictures of examples and nonexamples for concept: living or nonliving organisms. Use the strategy of concept attainment as described in *This is a YES: Concept Attainment* from the Saskatchewan Professional Development Unit and Saskatchewan Instructional Development and Research Unit.

- A field trip to observe animals in their natural habitats (school yard, ditch, field) is a good opportunity to give students a chance to make and record observations and then do some creative writing based on what they have recorded. The trip does not have to be to a remote site or take a long time. There is a great deal to be gained by having students become keen observers and develop an appreciation for the life in their immediate environment.

- Form working groups of three to four students. Give each group the name of one organism with the assignment - is it more difficult for this organism to survive near __________________ (name of city or town) now than it was two hundred years ago. Choose from this list of organisms, or ask students to find an organism appropriate to the area: dandelion, mallard duck, rabbit, coyote, white tail (or mule) deer, canola, grasshopper, blue grama (or other grass native to your area), wolf, pasture sage, meadowlark, avocet, etc.

  When they have discussed and recorded their ideas (five minutes), merge two groups and ask each to present their ideas to the students in the other group. Assign this project for research for enhancement of arguments over the next two weeks. After two weeks, each group should present its ideas to the whole class.

- Test leaves for the presence of starch. Leaves from a vigorous coleus or geranium plant which has been in bright sunlight for two or three days work well for this activity. Ask the students to find a method of removing the chlorophyll and other pigments from the leaves so that it doesn't interfere with the test for starch.

  Use the pigments extracted for paper chromatography.

  Discuss why starch is present in leaves. What is the function of the leaf for the plant? What process serves the same function for humans?

Saskatchewan – The Land

Unit overview

The last period of glaciation left a profound effect on the topography of Saskatchewan. Evidence of this effect, and of the impact of the glacier's grinding, sorting, and redeposition of parent material on today's soils form the major focus of this unit. The force of human actions as an agent of change is also considered.

Since their earliest outdoor experiences, students have been altering, and observing alterations of, the soil and landforms . This unit of study asks them to focus their thoughts on some of the causes of the effects which surround them. To infer causes for these effects, students consider the 'why' of the surface features and soil characteristics of the province.

Understanding the search for cause and effect relationships in the historical sciences is an important component in student's education. Students must see that science is not all laboratory-based controlled experimentation and prediction. The creation of theory from observing evidence of nonrepeatable historical events is the core of some areas of science.

Since soils are certainly a renewable resource, and the topography of Saskatchewan could be considered as renewable, this unit would integrate very well with the core unit **Renewable Resources in Saskatchewan**.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Reading maps and charts, writing directions for procedures and travels, writing advertisements for various regions of the province at different times in history by modelling them after travel advertisements in magazines are ways through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

This unit may be coordinated with the grade 7 social studies units on location and resources. How does the shape, and shaping, of the land shape society? How are locations in Saskatchewan described? Why does each quarter section of land have an address? How do we know that Saskatchewan has changed latitude?

Factors of scientific literacy that should be emphasized

A6 probabilistic
A7 unique
A8 tentative
A9 human/culture related

B3 orderliness
B10 cause-effect
B15 model
B24 scale
B25 time-space
B26 evolution

C6 questioning
C8 hypothesizing
C9 inferring
C12 interpreting data
C15 analyzing
C18 using time-space relationships
C19 consensus making

D4 science, technology, and the environment
D9 social influence on science and technology

E4 using audiovisual aids

F5 respect for logic

G6 response preference
G7 vocation

Concept development

grade 1
- features of the earth's surface and the rocks and soil

grade 2
- ways that environments differ
- how differing environments are suited for different organisms and for different human uses

grade 3
- topographical features of the environment
- formation and preservation of the soil and rocks

grade 5
- soil as a natural resource which can be polluted, degraded, and eroded

grade 6
- role of soil in the ecosystem

grade 9
- effect of urbanization and agriculture on soil quality

grade 11
- soil as a growth medium, nutrient supplier, and habitat

Foundational and learning objectives for Science and the Common Essential Learnings

1. Consider the effects of glaciation on Saskatchewan.
   - 1.1 Assess the effect of the major geological events of the Quaternary period in Saskatchewan.
   - 1.2 Illustrate the positions of the icefronts, glacial lakes, and drainage channels at various stages of the last period of glaciation.
   - 1.3 Identify, using appropriate maps, landforms shaped by the glaciers and their meltwaters.
   - 1.4 Contrast the appearance of glacial landforms as seen from the air or from the ground.
   - 1.5 Use maps as a way of gathering information about an area.

2. Recognize the weathering processes which have occurred since the last period of glaciation.
   - 2.1 Observe and describe samples of sandy, silty and clayey soils.
   - 2.2 Identify the regions where chernozemic, podzolic, and organic soils are found.
   - 2.3 Describe the conditions under which the chernozemic, podzolic, and organic soils develop.
   - 2.4 List the nutrients which are stored and released by the soil.
   - 2.5 Illustrate the nutrient cycles in the soil.

3. Appreciate how natural and human forces have shaped the land.
   - 3.1 Describe the vegetation of the province when Europeans arrived.
   - 3.2 Discuss how wind, water, and fire have altered the face of the prairies.
   - 3.3 Describe the impact of agriculture and forestry on the province's lands.
   - 3.4 Consider the effect of urbanization on Saskatchewan.

4. Understand how knowledge about the glacial period is created, evaluated, refined and changed. (CCT)
   - 4.1 Make careful observations during active involvement in constructing knowledge, and discuss the observations with others.
   - 4.2 Focus attention on student knowledge and the gaps in their knowledge of glaciation, soils, and effect of human activity on the land.
   - 4.3 Reflect upon how knowledge is developed and tested in the historical sciences.

5. Understand and use the vocabulary and forms of expression which ecologists and geographers use to describe the environment. (COM)
   - 5.1 Incorporate both technical vocabulary and common terms with specialized usage into talk and writing.
   - 5.2 Develop skills in reading and interpreting maps, diagrams, and other visual aids which are used to communicate information in the study of glaciers and soils.
   - 5.3 Understand how soils are categorized.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Ice covered Saskatchewan during the last glacial period. The last ice sheet (the Wisconsin) began to retreat about 15 000 years ago. For each 500 year period, starting 14 000 years ago and continuing until 9 000 years ago, assign one group of students to produce sketch maps of Saskatchewan showing the extent of the glacier, the meltwater channels and lakes formed, and the location of significant moraines. The eleven maps produced will provide a basis for developing a concept of the extent of the influence of ice then and now. Discuss the sequence illustrated by the maps with the class.

Divide the class into eleven groups. Each group has the task to make a papier-mâché representation of the province at one of the selected times in this period. Use Ivory Snow mixture as paint for the papier-mâché. Mix glue and Ivory Snow soap to make a thick paste. Use it to coat the "glaciers" on the maps of Saskatchewan. Indicate the location of your school on the maps, as well as the location of major Saskatchewan cities and towns.

Looking at these maps, estimate when the habitat would have been able to support plant and animal (including human) life.

Sources of information on the glacial history of Saskatchewan are the *Atlas of Saskatchewan* (Richards, 1969), *Geology of Saskatchewan* (Gordon, 1979), and *Geological History of Saskatchewan* (Storer, 1989).

Factors: A8, B10, B15, B24, B25, B26, C8, C18, C19, E4, F5
Objectives: 1.1, 1.2, 4.2, 5.2
Assessment Techniques: individual and group anecdotal records, self-assessment checklists
Instructional Methods: cooperative learning groups, research project, reading for meaning

Extension: Imagine you are a plant that is one of the first colonizers of post-ice age Saskatchewan. What kind of plant would you be? How would you have arrived in Saskatchewan? What would the soil be like? Would there be other types of plants, or just plants of your species? Write your story.

This same idea, with different cue questions, could be used for animals or humans.

♦ How do the changes introduced when agriculture became dominant in Saskatchewan affect the populations of plants and animals in the province? How do the changes introduced when agriculture became established in Saskatchewan affect ways in which Indian peoples use the land? Which traditional uses are compatible with agricultural development? Which are not compatible?

Imagine that you are a newspaper reporter with a time machine. Write an article describing what you would see and experience when you had the machine take you back to the area south of the Qu'Appelle valley. Compare that region to the region south of the southernmost part of Eagle Creek, and to those areas today.

Factors: A9, B10, B26, C9, C12, F5
Objectives: 3.1, 3.2, 4.2, 4.3
Assessment Techniques: written assignment for portfolio, oral assessment items
Instructional Methods: research project, report, discussion

♦ Examine maps to identify glacial features such as moraines, eskers, outwash plains, drainage channels, lacustrine plains, large erratics, etc. Determine which of those features are present in the vicinity of your school. Visit them if possible.

If you can't visit a site, predict what the topography, native vegetation, soil type would be like at a site featuring one or more of these glacial features. Identify a school in a region where these features exist and send your prediction to a grade 7 at that school. Ask them to comment on your prediction and return their comments to you. Take pictures (polaroid or video) which illustrate glacial features in your area. Exchange these records with schools in other areas.

Factors: B10, C8, C9, C15, E4, G6
Objectives: 1.2, 1.3, 1.4, 2.3, 4.1, 5.2
Assessment Techniques: group rating scale, source of extended open response test items
Instructional Methods: explicit teaching, didactic questions, field trips

- Assign each group within your class a different area of the province. Ask each group to find out about the glacial characteristics of their assigned region and report to the class. This research may involve communication and exchange of video and descriptive information with students in a grade 7 class in the region assigned.

- Obtain aerial maps of the region around your school and use them to identify features. Identify watersheds and drainage patterns. Where are the heavy clay soils of Saskatchewan found? With what glacial features are they associated? What glacial effects produced the light, sandy soils of the area south and west of Saskatoon? Survey the soil types of your region. How can the distribution of soils in your region be attributed to glacial action?

- Find a place where you can see a deep cross-section of the soil strata (new dugout, cliff along a river, badland areas). Observe the layering of strata. How could such layering have occurred? How do the size of particles in each layer compare? How do the size of particles between layers compare? What does that tell you about how the layers were deposited?

- Look for places where runoff has produced soil erosion. How are the characteristics of the rills and channels produced by the running water similar to the features produced by glacial meltwaters. Measure the ratio of width of eroded channel to depth. How does this ratio compare to the ratio in glacial meltwater channels in your region. Examine the area where the soil removed by erosion is deposited. What patterns are evident in the deposition? Remove a cross-section of the deposition. Is layering evident?

- Draw a map on transparency material which shows the soil zones of Saskatchewan. Draw another which shows the vegetation zones. Draw a third which shows the average rainfall. Overlay these and look for patterns.

- To half a baby food jar of soil, add enough water to make a mixture about the consistency of fresh (moist) playdough. Remove the soil/water mixture from the jar and kneed to form a ball. Adjust the consistency by either adding more water or some dry soil. The ball should not be so wet that it drips or makes the hand wet. Form a ball with the soil sample. If the ball crumbles or will not maintain its form, the soil is predominantly sand.

  If the soil remains in a ball, squeeze the soil upwards between the thumb and the forefinger so that it forms a ribbon. If a ribbon will not form but the soil crumbles as it is forced between the thumb and forefinger, the soil is classified as loamy sand.

  If a ribbon forms, the length of ribbon before it breaks is used in further determination of soil type. Take a sample of the ribbon and form a watery paste in the palm. There must be enough water so that you can feel the texture of the soil particles. A good idea is to have samples of pure sand, silt, and clay to try this with them before doing these tests. That will make it easier to put the soil sample in one category or the other. The chart on page 712 summarizes this test.

  Ribbon < 2 cm If the sample is mainly gritty, like fine sandpaper, the soil is called sandy loam. If there is some grit and some smoothness, the soil is classifies as loam. If the predominant feeling is smooth, the soil is placed in the silty loam soil group.

  Ribbon between 2 and 5 cm long If the sample is mainly gritty, like fine sandpaper, the soil is called sandy clay loam. If there is some grit and some smoothness, the soil is classified as clay loam. If the predominant feeling is smooth, the soil is placed in the silty clay loam soil group.

  Ribbon longer than 5 cm If the sample is mainly gritty, like fine sandpaper, the soil is called sandy clay. If there is some grit and some smoothness, the soil is classified as clay. If the predominant feeling is smooth, the soil is placed in the silty clay soil group.

  Collect soil horizon samples from a variety of sites in your area. Make sure you get permission from the land owner before removing samples. Try to take the samples so that the area is disturbed as little as possible.

  Remove the sample so that the soil horizons are clearly visible. One way to do that is to make an excavation with straight sides to an appropriate depth. Then remove thin samples showing the profile from the exposed edge. Replace the material from the original excavation.

Ribbon Length → Texture of paste↓	< 2 cm	between 2 cm and 5 cm	> 5 cm
gritty	sandy loam	sandy clay loam	sandy clay
smooth	silty loam	silty clay loam	silty clay
mixed gritty and smooth	loam	clay loam	clay

Sketch and write descriptions of the profiles collected.

- ♦ Make a circle graph showing the proportions of the components of healthy soil. The graph should show 45% mineral (clay, silt, sand) content, 5% organic material, 25% water, and 25% air. Collect samples of the soil and devise a procedure to analyze these samples to determine their relative composition. Where is soil that is closest to the 'ideal' composition found? What does that soil look and feel like?

- ♦ Which soil nutrients are most important for wheat? How are these nutrients supplied and recycled in agricultural practice in Saskatchewan?

- ♦ Make cardboard squares 15 cm on a side. These will be used as markers for soil sampling. Discuss with students the principles behind and reasons for sampling schemes. Select a site where a number of holes 15 cm square and 8 cm deep can be created.

  To sample soil, throw the cardboard a short distance away onto soil which can be removed. Remove the soil from the sampled area to a depth of 6-8 cm. Look for large animals (earthworms, ants, beetles, grasshoppers, etc.) as the area is excavated. Include them in your count. Sift the soil through a course screen, then a fine screen, and finally through cheesecloth. At each stage, examine the screenings for organisms and gently crush any lumps of soil.

  Put the portion which comes through the cheesecloth in an aluminum pan. Place the pan on a stand and heat from underneath with a heat lamp or 150 W light bulb. The heat from below may drive small organisms to the surface. Alternatively, the soil which comes through the cheesecloth could be placed bit by bit on white paper and separated into a thin layer to search for organisms. A magnifying glass, binocular microscope or other magnifier will be useful at this stage.

  From the count of the organisms in the sample calculate the number of organisms in 1 hectare (100 m by 100 m). What is the niche of the organisms in the soil? Diagram a food web involving the organisms which you are able to identify.

- ♦ Create word find puzzles using the terminology of soils and soil conservation.

- ♦ Go into your schoolyard or a nearby field and make a list of organisms (both plant and animal) which you can identify. What role do these organisms play in the ecosystem? How do they use the soil? How do they contribute to the nutrient cycle? Make nutrient cycle diagrams, plays, stories, or advertisements which convey the message of nutrient cycles.

- ♦ Working with a partner, draw a map of the classroom where you are now. Decide how much detail to include. Decide what scale is appropriate. When you have finished, find another pair with whom you can compare maps. Discuss how you can improve each map and draw a new one for your group of four. Post these maps on a bulletin board.

  Without leaving the room, sketch a map of your school or of one floor of your school. Take the map out into the school and note the accuracies of the map and the innaccuracies of the map. If the map were given to visitors when they came to the school, would it be good enough for them to be able to find their way? As a whole class project, create a map of the school. Divide the tasks among the groups so that everyone has a significant part.

Force and Motion

Unit overview

All people make use of the principles of force and motion in most things we do. To get out of bed, to walk, to throw a ball, to remove a bottle cap from a bottle of pop – all require an application of force to produce a desired motion. The wrong amount of force or force improperly or carelessly applied results in a different effect than desired. In this unit, students will have opportunities to examine, measure, reflect upon, and discuss how forces of various origins are used to produce and control motion.

The heart of this unit should be in encouraging students to look for regularities or patterns in motion and in the forces which influence motion. To analyze what we often take for granted is a difficult but useful task. It requires that we look at things from a different perspective and consider what we may previously have overlooked.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from both fiction and nonfiction, and reporting on the activities of science class by charts, cartoons, or plays are some strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

A challenge activity relevant to this unit might be designing a paper airplane which will stay aloft a maximum amount of time, or building some sort of Rube Goldberg device using a variety of simple machines to transfer force in order to accomplish a task.

Factors of scientific literacy that should be emphasized

A5 empirical

B2 interaction
B5 perception
B7 force
B8 quantification

B9 reproducibility of results
B10 cause-effect
B14 cycle
B20 theory
B24 scale
B25 time-space

C4 working cooperatively
C8 hypothesizing
C9 inferring
C10 predicting
C11 controlling variables
C12 interpreting data
C15 analyzing
C16 designing experiments
C17 using mathematics
C18 using time-space relationships

D3 impact of science and technology
D6 resources for science and technology
D8 limitations of science and technology

E6 measuring distance
E8 measuring time
E13 using quantitative relationships

F2 questioning
F7 demand for verification

G3 continuous learner
G6 response preference

Concept development

grade 1
- description of the variety of motion in everyday activities

grade 2
- magnetic force acting at a distance

grades 3 and 5
- transfer of force by direct contact and by force fields to produce motion

grade 9
- forces produced by electrical and magnetic fields

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize the relationship between force and motion.
   - 1.1 Identify and demonstrate types of motion which are encountered daily.
   - 1.2 Describe and analyze motion.
   - 1.3 Identify which factors that influence motion are forces or related to forces.
   - 1.4 Devise some ways to measure force.
   - 1.5 Create some ways to measure motion.

2. Know the forces which influence various types of motion.
   - 2.1 Design experiments to demonstrate the relationship between force and motion.
   - 2.2 Discover how engineers test car and truck designs to determine wind resistance (drag).
   - 2.3 Explore the alteration of the friction between two solid surfaces.

3. Understand ways in which forces are used to control motion.
   - 3.1 Design paper airplanes which illustrate how forces are important in flight.
   - 3.2 Compare the principles of take-off, flight, and landing in birds and planes.
   - 3.3 Identify situations in sport where forces are used to create or change motion.

4. Develop students' abilities to meet their own learning needs. (IL)
   - 4.1 Connect what is already known with what is being learned.
   - 4.2 Plan brief, self-directed projects describing what, how, and when.
   - 4.3 Look for associations among items of knowledge and extend these relationships through additional inquiries.
   - 4.4 Collaborate with teachers and others to analyze and monitor the learning process.

5. Strengthen students' knowledge and understanding of how to compute, measure, estimate and interpret mathematical data, when to apply these skills and techniques, and why these processes apply to a study of force and motion. (NUM)
   - 5.1 Recognize when a computed answer is sensible.
   - 5.2 Understand the nature of the quantitative problem and work toward a suitable solution.
   - 5.3 Understand that divergent thinking and reasoning often precede convergent thinking and solutions to real life problems.
   - 5.4 Understand the meaning of precision and determine the most appropriate degree of precision for a needed measurement.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ An excellent starting place for examining the relationship between force and motion is in the analysis of the operation of common hand tools such as the hammer, screwdriver, and can-opener.

Where is the force applied? Where does the critical (intended) motion take place?

Factors: B7, B10, C8, C9, C15, D3, F2, F7
Objectives: 1.1, 1.3, 2.1, 4.1, 4.2, 5.3
Assessment Techniques: observation checklists, presentations, self-assessment
Instructional Methods: inquiry, conducting experiments, discussion with peers

♦ Why does force cause some objects to change shape? How is this property useful? How is it a disadvantage? Crumple a paper bag. Blow into it. What happens? How do hot air ballons become inflated? Why do bicycle tires become flat? Why is it more dificult to ride a bicycle with flat tires than with inflated tires?

Factors: B2, C6, C10, F2, G3
Objectives: 1.3, 4.2, 4.3, 5.3
Assessment Techniques: self-assessments, anecdotal records, written assignments
Instructional Methods: reflective discussion, conducting experiments

♦ Cut strips of paper approximately 20 cm by 4 cm, four or five for each student. Distribute the strips and ask them to hold the top side of the narrow end of the strip just under their lower lip so that the strip hangs down toward their chest. Ask them to predict what will happen to the strip when they gently blow across the top of it, deflecting the stream of air downward with the upper lip. Ask them to try it and see what happens. It is sometimes easier to see the effect if the students form pairs to observe each other.

What happens to the motion when they blow harder? What happens if a cut is made lengthwise from the free end about halfway up to the end near the lip? What happens when the strip is folded across the short dimension so that there is a flap about 3 cm long sticking up at the free end? What happens when the end is held on the top lip and the stream of air is directed under the strip?

Further investigations of the forces related to lift and flying can be found in the book *Super Flyers* (Francis, 1988). This book is an excellent collection of activities and is protected by copyright. Sufficient copies should be purchased so that each student or group has easy access to a copy while it is being used. Depending on how the class is organized, one copy for every three to ten students should be adequate.

Factors: B5, B9, B20, C11, C16, D3, G3
Objectives: 1.3, 3.2, 4.2
Assessment Techniques: contracts, rating scales, short answer test items
Instructional Methods: reflective discussion, model building, learning centres

♦ Experiment with a pendulum to identify significant variables such as mass of bob, shape of bob, density of bob, length of string, thickness of string, wood or other substitutes instead of string, and so on. Which of these variables make a difference to the operation of the pendulum?

What starts a pendulum moving? What keeps a pendulum moving? What determines the direction it moves? Does the string stay in a straight line as it moves or does it curve? How about if paper clips are used instead of string to support the bob? How many uses of pendulums can you list?

♦ Activities 5 to 27 from *Methods of Motion –An Introduction to Mechanics (Book One)*, (Gartrell, 1989), and Activities 1 to 4, 25 to 30 from *Evidence of Energy –An Introduction to Mechanics (Book Two)*, (Gartrell, 1990) are useful to deal with the interrelatedness of force, mass, speed, acceleration, gravity, and friction. These books include extensive reading sections containing background information on each of the activities and concepts, written for a teacher who is not a science specialist. Lists of all materials needed to do the activities and a glossary are included. The books are produced and published by the National Science Teachers' Association in the U.S.A. Permission is granted by that organization for reproduction of any of the materials in the books for classroom use. One copy of each book, at a 1991 price of US$16.50, is sufficient for each classroom.

- Build balloon rockets. Stretch a piece of fish line with a drinking straw threaded on it across the room at about 1 m to 1½ m above the floor. Inflate a balloon and, holding the nozzle end to prevent escape of air, tape the balloon to the drinking straw. Release the nozzle and observe the flight of the balloon rocket.

  What is the purpose of the string? of the straw? What happens when a balloon is inflated and released without being attached to the fish line by the straw? Why does the balloon take the path it does? Why doesn't the rocket carrying the space shuttle travel in a path similar to a balloon? Does it have a fish line to outer space to travel on? Can you devise a ballon rocket that will fly straight without a line to guide it?

- Take apart a water pistol. Analyze how the force is transferred from the trigger to the water. Design a water pistol which can be made from commonly available materials.

- How can a rubber band be used to measure forces? What other ways can you devise to measure forces?

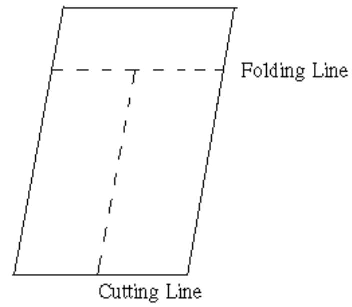
- Why do you wear rubber-soled shoes in the gym? What would happen if you used leather-soled shoes or slippers knitted from wool or acrylic for playing basketball. Devise a way to measure the diference in grip you get from different kinds of shoes. Does the type of floor matter? What type of floor would be best for using leather-soled shoes to play basketball?

- Build a windmill. Devise a way to store the energy which the windmill converts from the wind to rotation. How do the shape, surface area, and angle of the vanes influence the speed of rotation? How can you measure the speed the windmill turns. Create a device to measure the number of rotations per minute.

  Extension: How does the speed of the wind influence the energy output of the windmill? Create a device to measure this relationship. Is the relationship linear?

- Take an ordinary 7.5 cm by 12.5 cm file card. Measure 3.75 cm along one of the short edges and make a cut 10 cm long, parallel to the long edges of the card to produce two 3.75 cm by 10 cm arms attached to a 7.5 cm by 2.5 cm base.

  While the card is flat on the table, label one of the arms #1 and the other #2, as in the diagram below. Along the line where the arms join the base fold the arms in opposite directions so that they are perpendicular to the plane of the base. The number on one arm will now be facing up and the other number will be facing down. Note which number is up.

  Holding the card with the base down at arm's reach above the head, drop the card and observe its fall. Add a paper clip to the centre of the base and repeat. Keep adding paper clips, dropping, and recording observations until five clips are attached to the base. What generalization can you make about the effect of paper clips on the fall of the card?

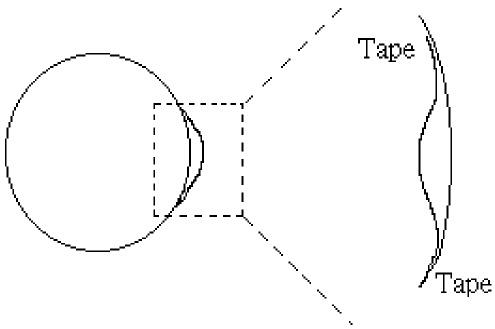
  Drop the card again. In which direction does it rotate? Does it always rotate the same direction every time you drop it? Compare your direction of rotation with the direction of rotation other groups have found.

  Change the direction the arms are folded so that the number which was previously up is now down, and vice versa. Drop the card and note the direction of rotation. Discuss your observations with other groups and create a general statement which can be used to predict how any unlabelled card of this type will rotate.

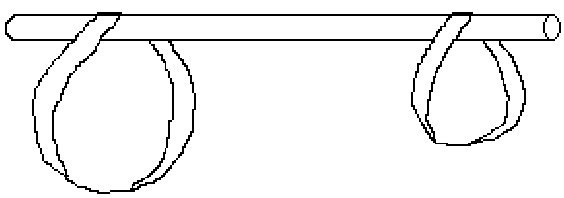
  As a class brainstorm a list of variables which can be tested to determine their effect on the fall of the card. Divide these variables for investigation among the groups in the class.

- The book *Super Flyers* (Francis, 1988) has lots of ideas for activities involving the investigation of forces which influence flight. These activities are useful for science challenge activities.

♦ Build a flyer with two loops of paper and a straw. Make one loop by marking one end of a 3 cm by 30 cm strip 2 cm from its end and taping the other end of the strip art that point. Tape the inner loose end as well. When this overlap is opened, a small channel is created through which the straw can be threaded. See diagram below. Make the other loop with a 3 cm by 20 cm strip.



Assemble the aircraft so that each loop is taped to the straw so that 5 cm of the straw protrudes from each end.



Identify and investigate the variables that influence the flight of this type of aircraft – diameter of the loops, width of the loops, thickness of paper, length of the straw, weight of apparatus, distribution of weight, composition of the loops (substitute styrofoam cup cross-sections for paper loops), and so on.

♦ Analyze the forces and motions involved in walking. How do the legs bend to exert the force required to get you moving? In what direction is the force exerted by your leg against the ground? How does the walking motion differ when you are walking in deep snow, on ice, or in fine dry sand. When the motion of walking differs is the way the force is transmitted to changed? Compare four modes of walking: strolling; brisk walking; aerobic walking; and, race walking. How do they differ?

Analyze the motion of a person running. Is the motion more similar to the motion of a person walking or to the motion of a person jumping?

Structures and Designs

Unit overview

Birds build nests. The nests of barn swallows are quite different from those of the oriole, although both use mud as a major component. Owls and woodpeckers don't use mud at all. There are numerous ways to make a nest.

One of the questions which gives focus to the grade 7 curriculum is: How do we use specialized knowledge to meet our needs and suit our wishes? Humans construct all sorts of structures for a variety of purposes. Students here have an chance to examine the principles of construction and put their discoveries to use. Many structures or artifacts are designed to transmit or enhance the application of force. Structures must resist forces applied to them by wind, gravity, mechanical sources and other effects. Therefore, this unit could be integrated with the grade 7 unit **Forces and Motion**.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Through writing, students clarify their thoughts and understandings about the concepts they are considering. Through reading students can compare their ideas to the ideas of others and reconcile their view of the world with the scientist's view. Writing in personal, reflective journals, reading from newspapers and magazines, and reporting on the activities of science class in a variety of ways are only some ways through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

One possibility of a science challenge activity is to hold a competition to build a structure of paper and white glue which will support a minimum mass of 500 g some arbitrary height (15 cm for example) above the surface of a table. Prizes or points could be awarded for greatest mass supported, mass supported to mass of structure ratio, innovative design elements, imaginative use of coloured paper for visual effect, tallest structure, completing project on time and within budget, minimum mass of paper and glue used to meet design criteria, and so on.

Factors of scientific literacy that should be emphasized

A2 historic
A9 human/culture related

B6 symmetry
B7 force
B11 predictability
B15 model
B16 system
B24 scale

C4 working cooperatively
C8 hypothesizing
C11 controlling variables
C13 formulating models
C14 problem solving
C16 designing experiments

D2 scientists and technologists are human
D3 impact of science and technology
D6 resources for science and technology

E2 using natural environments
E6 measuring distance
E7 manipulative ability

F1 longing to know and understand
F2 questioning
F5 respect for logic
F6 consideration of consequence

G2 confidence
G5 avocation
G7 vocation

Concept development

There is no single topic at the elementary level that is a direct precursor to this unit. Many life experiences have prepared students to consider the topics raised in this unit. Veins are the structural support for the photosynthetic tissue of the leaf. Stems are the structures which support the leaves so that they are exposed to the sun. Skeletons of both vertebrates and invertebrates give their bodies form and act as attachment sites for muscles. The physical properties of different types and states of matter are crucial when considering building materials.

This unit provides an excellent opportunity to consider some of the technological achievements which shape our society.

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize elements of design in a diverse group of objects.
   - 1.1 Discuss why structures are constructed.
   - 1.2 Observe and compare the shapes found in some natural and some human-constructed objects.
   - 1.3 Identify the purposes of various parts of constructed objects.
   - 1.4 Recognize design components which occur regularly.

2. Understand principles of good design.
   - 2.1 Analyze how structural components react to stresses.
   - 2.2 Compare the strengths of different components of a structure.
   - 2.3 Create procedures for constructing and testing components of a structure.
   - 2.4 Use some of the elements and principles of design to build objects.

3. Develop a contemporary view of technology. (TL)
   - 3.1 Examine experiences with various structures in the home and in the school.
   - 3.2 Explore the benefits and limitations of structures.
   - 3.3 Investigate the technical, social, and cultural implications of design and construction of objects.

4. Promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and objects in meaningful contexts. (CCT)
   - 4.1 Develop ways to evaluate creative processes and projects.
   - 4.2 Use metaphoric and analogical thinking to create insights and build understanding about structures.
   - 4.3 Design and construct objects.
   - 4.4 Determine that real-life problems often have more than one solution.
   - 4.5 Discover relationships and patterns.
   - 4.6 Imagine and manipulate objects and ideas.
   - 4.7 Provide arguments related to principles and to evidence for ideas and choices expressed.

Suggested Activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Brainstorm to produce a list of uses for structures. Stems to start idea generation might be "We make things that...(give shelter from weather, open canned food, hit golf balls, pump water...)" or "Some natural objects which we use are (rocks as doorstops, trees for shade, lakes for swimming...". Then classify or group the items on each list. Make sure you record the criteria which you use to establish the groups.

Factors: A2, A9, B16, C4, D3, F2, F5, G2
Objectives: 1.4, 3.2, 3.3, 4.5
Assessment Techniques: presentations, oral assessment, performance assessment
Instructional Methods: cooperative learning groups, concept formation

♦ If there is a bridge or railway trestle nearby, visit it. (Alternatively, pictures of a bridge taken with this activity in mind could be used.) How is the span of the bridge supported? How is the span designed to carry its load? Are there any signs of stress in the bridge? Are there joints to allow for thermal expansion and contraction? Sketch the bridge and build a model of it in the classroom.

Factors: A2, B6, B7, B15, B24, C13, C14, D6, E6, F6, G7
Objectives: 1.2, 1.3, 2.1, 2.4, 4.3, 4.5
Assessment Techniques: self and peer assessments, observation checklists, rating scales
Instructional Methods: compare and contrast, model building, problem solving

♦ Build models of tipis and hogans. What design elements give these structures their strength? What advantages do they have for the environments in which they were created and used?

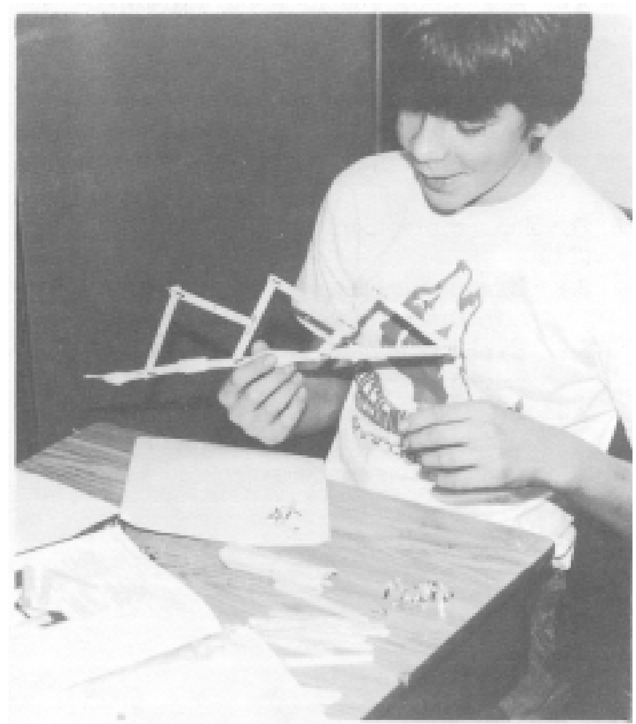
Factors: A2, A9, B6, B15, B24, C13, D2, D6, F1, G2
Objectives: 1.2, 1.3, 2.1, 2.1, 3.2, 4.4, 4.7
Assessment Techniques: group evaluations, anecdotal records, presentations
Instructional Methods: reflective discussion, model building

♦ The books *City*, *Cathedral*, and *Castle* (Macaulay, 1975, 1973, 1977) are excellent sources for a discussion of the principles and mechanics of design. A large group project might be to build a model of a gothic cathedral by following the commentary in *Cathedral*.

♦ Activity 21 from *Methods of Motion* (Gartrell, 1989) could be used during this unit. It involves using fettucini and masking tape to build a structure which will support a heavy book (possibly 1 kg) at least 5 cm above the surface of a table.

♦ Gather pictures or samples of structures which humans have constructed. Analyze the structures and make simplified diagrams or three-dimensional models which indicate how square, rectangular, circular, or conical components are linked in structures. Bridges, buildings under construction, and egg cartons are examples of structures which could be examined in this way.

♦ Purchase one of the Canadian-designed 3-D puzzles. Have students assemble them during class or as an extra-curricular project. Study the design of the puzzles.



- What structures can you find that are examples of identical components linked together? (Hint: Look at a building under construction, at the underside of a bridge, or at a cultivator.) How are the components linked? Is there an advantage gained by linking them? Is there only one way to link the units?

- Read about the structure of plastics. How are plastics similar to chains? How are they different? How many objects can you identify that are made of plastic or have plastic components?

  Activity 2 from the CEPUP unit on plastics, **Plastics in Our Lives**, is a good one to use during this activity.

- Build a water and air trombone. Cut three-quarters way through a drinking straw about 4 cm from one end. Bend the short end at right angles to the long end. Place the long end vertically into a clear water glass three-quarters filled with water. Blow through the short end so that the air stream goes across the top of the section of the straw that is in the water. Adjust the angle between the mouthpiece and the long tube until a tone is produced. Move the long tube vertically in the water to vary the length of the air column inside it. What happens to the pitch of the tone produced? How is the structure of this instrument similar to the structure of a slide trombone?

- Put three pushpins into a piece of plywood so that they form a triangle with all sides of a different length. Stretch a short rubber band so that it circles the pins. Pluck each segment in turn and notice the sound produced. How do the sounds compare? What would happen if you used a longer elastic band? Predict what would happen if the band stretched when left on the pins overnight? What would happen if you tightened the band by tying a knot in a section of it? What would happen if you used a band the same length but thicker or wider? What would happen if you tied fishline or snare wire tightly around the pins? How about if you tried a skipping rope? What musical instruments are based on this principle? How is the sound these instruments produced varied or modified? What other instruments can be simulated or modelled with simple devices? Discuss these experiments with your Arts Education teacher.

- Estimate the height of the seat of a chair above the floor. Estimate the height of a desk top above the floor. What body measurements determine the heights that should be used?

- Sand bags are used to build dykes for temporary flood control. What advantages do sandbags have for this use? What disadvantages are there for their use? Brainstorm a list of substitutes for use instead of sandbags.

  In Japan, water bags have been designed for this same use. What advantages and disadvantages can you see in this innovation? Try to design a water bag. Produce some water bags and sand bags and devise a test to compare their effectiveness.

- Kaleidoscopes contain equilateral triangular mirrors. Using three pieces of mirror supplied, tape them into a triangular prism. Try to reproduce the effect of a kaleidoscope.

- Get an unopened small (holds 50-75 grams of product) bag of chips. How are the seams of the bag sealed shut? By heat? With glue? Some other process? In what order are the seams sealed? Record your thoughts and the evidence you have in your journal.

  Carefully open the bag. Can you find more evidence about the way the bag was sealed, and the way it was assembled originally? Is the bag made from one piece or several pieces of material? Of what material is it made? Can you make a model of the bag from paper or plastic? What other questions about the bag are there to investigate?

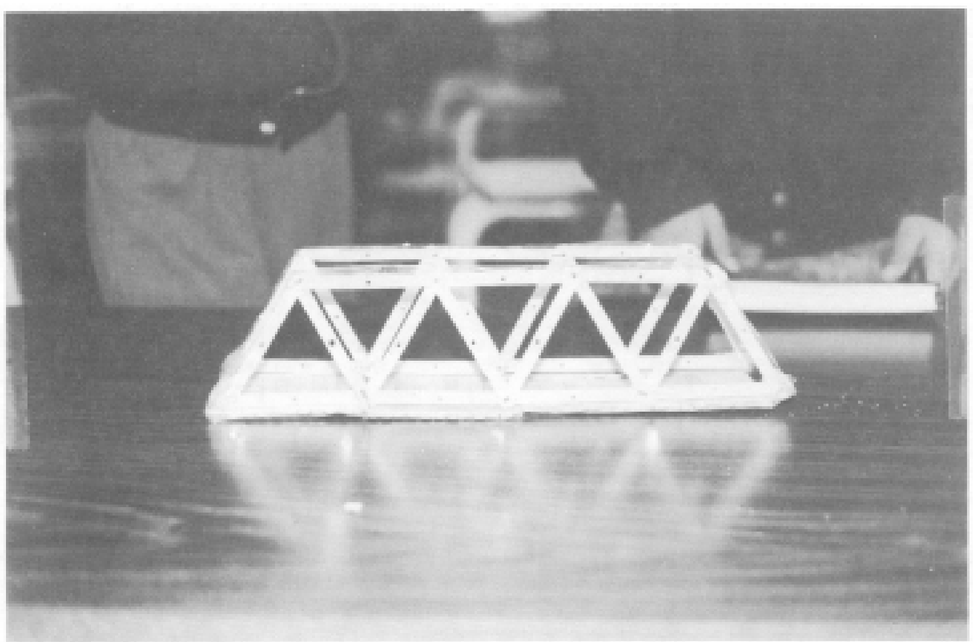
  Some one invented a machine which takes a piece of plastic, seals the back and bottom seam, blows air into the empty bag, fills it with chips, and then blows more air into it as the top is being sealed. Why would the machine blow air into the bag at two different stages? Sketch the design for a machine that could do this, keeping in mind your conclusions about how the seams of the bag are sealed.

- Sketch a diagram of a plastic disposable cellophane tape dispenser (the kind Scotch™ tape comes in). What are the key structural and functional parts? (Structural parts are what make up the body of the device and hold everything together. Functional parts are those which are essential for the device accomplishing its task. Some parts may be both structural and functional. Some are only one of the two.) Show the spatial relationships of the various parts. The diagram need not show the scale as much as the relationships.

Obtain an empty cellophane tape dispenser. How closely does it match your concept of what the dispenser was like? Carefully separate the dispenser into 2 parts. How do the parts hold together when it is being used?

What type of process might be used to manufacture each part? Are they carved from a block of solid plastic? Can you discover what kind of plastic is used? What materials could be substituted for plastic in making a dispenser? Give the advantages and disadvantages of each material.

- ♦ Draw a diagram of a bicycle. Try and include all essential structural and functional parts and their spatial relationships. When you have completed your diagram, compare it to a real bike or the photo of one. What modifications can you devise to make the bike work better? What modifications can you devise to make the bike stronger, function better, or be more attractive looking?
- ♦ Build I-beams and measure strength per gram of weight. Who can build the I-beam with the greatest strength to weight ratio?



Renewable Resources in Saskatchewan

Unit overview

Statistics indicate that Canadians have the highest per capita use of energy in the world. Saskatchewan generates the second highest amounts of greenhouse gases per capita in Canada. Statistics Canada reports that between 1971 and 1986 cropland area in Saskatchewan increased 20% and woodland area decreased by 62%. But still, the environment – everything that surrounds us – supports us, gives us a high quality of life, is aesthetically pleasing to most, and seems capable of accepting mistreatment without too much protest. But, for how long?

When we look closely at our environment, can we see signs of complaint? How closely should we be looking? What aspects of the environment are most vulnerable to attack from extravagant energy use? Is energy from one source less damaging to the environment than from another, or is the difference only in type of damage? These questions are the ones to be considered in this unit.

Students should start to make a distinction between needs and wants. Such reflection establishes a base for examining current land and energy use (patterns and sources), and for debating alternate energy sources and changing patterns of land and energy use.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing may take the form of stories, letters, advertisements or records of interviews. Reading may be from texts, magazines, or nonfiction books. The important thing is to give students a broad range of both writing and reading experiences so that they have an opportunity to refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

As a challenge activity, from the renewable resources of Saskatchewan – solar energy, wind energy, lakes and rivers, soil, forests, other biomass, and geothermal energy – students could select a topic and research to report to the class.

Factors of scientific literacy that should be developed

A3 holistic
A9 human/culture related

B1 change
B2 interaction
B12 conservation
B13 energy-matter
B16 system

C6 questioning
C8 hypothesizing
C12 interpreting data
C13 formulating models
C14 problem solving
C15 analyzing
C19 consensus making

D1 science and technology
D4 science, technology, and the environment
D8 limitations of science and technology
D9 social influence on science and technology

E2 using natural environments

F1 longing to know and understand
F3 search for data and their meaning
F4 valuing natural environments
F6 consideration of consequence

G6 response preference
G8 explanation preference

Concept development

grade 2
- needs of plants and animals are met from the organism's environment

grade 5
- differences between constructed and natural environments

grade 6
- how human actions alter the environment
- energy use in our daily lives
- conversion from one form of energy to another

grade 8
- production, distribution, demand for, and conservation of energy resources in Saskatchewan

grade 9
- effect of energy use on the environment

grade 10
- role of individuals and governments in influencing and developing energy management policy

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize the renewable resources of Saskatchewan.
   - 1.1 Distinguish between renewable and nonrenewable resources.
   - 1.2 Identify those resources in Saskatchewan which are renewable.
   - 1.3 Appreciate the impact that human activity has on renewable land and water resources.
   - 1.4 Introduce the concept of sustainable use of renewable land and water resources.

2. Compare renewable and nonrenewable sources of energy.
   - 2.1 Describe how energy is used in Saskatchewan.
   - 2.2 Recognise how energy sources are transported to where they will be consumed.
   - 2.3 Consider some of the effects of production, transportation, and use of energy on the environment.
   - 2.4 List sources of renewable energy.
   - 2.5 Discuss why each source identified is classified as renewable.
   - 2.6 Investigate the extent of current use of each source.

3. Investigate critical attributes of renewable sources of energy.
   - 3.1 Describe how renewable energy sources could be substituted for nonrenewable energy sources.
   - 3.2 Create a list of benefits, disadvantages, and interesting points about each of the resources.
   - 3.3 Reach a class consensus on the desirability, possibility, and implications of increasing the use of renewable forms of energy.

4. Develop "strong sense" critical and creative thinkers. (CCT)
   - 4.1 Understand human needs in relation to the needs of other living organisms.
   - 4.2 Explore the implications or consequences of human actions.
   - 4.3 Distinguish between needs and wants.
   - 4.4 Clarify their motives and develop insight into the motives of others with respect to energy use.

5. Develop an understanding that technology both shapes society and is shaped by society. (TL)
   - 5.1 Explore the reciprocal relationships between the natural and constructed worlds.
   - 5.2 Investigate how human wants and needs shape the direction and development of technological innovations regarding energy use and environmental concerns.
   - 5.3 Examine how the development of technology effects change in the physical world and in society.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Design and build a solar water heater that works by focusing the sun's light on a container of water and another that heats water circulating through closed tubes. Compare the rates at which each heats water. What are the advantages and disadvantages of each method?

  Are there any solar water heaters in your community or nearby communities? Try to obtain permission to study the design and operation of any facilities you are able to locate.
  Factors: A9, B12, B13, C19, D9
  Objectives: 2.1, 3.1, 3.2, 5.2
  Assessment Techniques: group evaluation, observation checklist, oral assessment
  Instructional Methods: model building, reflective discussion

♦ Design and build a solar oven. Research existing designs or design your oven independently of any consultation. Have a hotdog cook-off to test the ovens. How practical are solar ovens for home use? What would be some other uses in addition to home use?

  Factors: A9, B12, B16, C12, C15, D4, D9, G6
  Objectives: 3.1, 3.2, 3.3, 4.4, 5.3
  Assessment Techniques: anecdotal records, presentations, oral assessment
  Instructional Methods: model building, cooperative learning groups

♦ Research the state of development of wind generated power. Try to find some people who had wind-driven electric generators or water pumps on their farms before the electric grid reached all areas of the province. Find out from these people how the systems worked, the limitations and the benefits of the systems.

  Factors: A9, B2, C6, C12, C15, D8, E2, F6
  Objectives: 1.2, 2.6, 3.2, 5.2, 5.3
  Assessment Techniques: extended open response test items, written assignments, self assessment
  Instructional Methods: guides for reading and listening, conducting interviews, writing reports

♦ Prepare a magazine advertisement selling one of the following:
  - a house heated by geothermal energy
  - a property which has potential for geothermal heat extraction
  - a machine that captures and stores geothermal heat.

  Brainstorm to produce a list of other renewable resource-related attributes that could be advertised. (How about the windiest property in Saskatchewan?)

♦ What types of energy are used in Saskatchewan? (e.g. heat, chemical...) List sources of each of these types. Classify each source of energy as renewable or nonrenewable. For each use in the nonrenewable group, give alternative sources of renewable energy which could be substituted.

  On a map of North America indicate where each type of energy is produced? Where is each type used? If these places are different, how is the energy transferred from the point of production to the point of use? Does this transfer require energy? What type of energy is used? Where does this energy come from?

♦ Ghetto blasters produce sound energy from their speakers. What form of energy causes the speakers to vibrate? Trace the forms of energy used in a ghetto blaster back to their original sources.

♦ One day the sun will run out of fuel and stop providing enough heat for life to exist on the earth. Does this mean that the sun is a nonrenewable resource?

♦ There is a finite amount of matter on the earth. This means that matter cycles are essential for maintaining a constant supply of matter for new life. Is there a finite amount of energy on the earth? Is energy recycled in a way similar to matter?

  It takes energy to get out of a chair and walk across the room. Trace that energy you used the last time you got up back to its ultimate source. Can the energy used do any useful work after you have used it?

- Suppose you have constructed a solar-heated house. Identify substances which could be used to store heat to be released at night or on cloudy days. Devise an experiment to determine which of the substances is the best for storing heat.

- Which source of energy is more easily renewed: burning wood for heat or using hydroelectricity to run an electric heater? Define what you mean by "more easily" and give your reasons why the source you picked meets your criteria.

- Suppose that electricity to your area was cut off for two weeks during December. What would you have to do to survive in your house for that time period? How would you cook? How would you keep warm? How would you prevent your water system from freezing?

- Use the kit *Forestry* (Saskatchewan Education, 1993) from the Saskatchewan Resource Series to deal with the impact of human activity on land resources and the concept of sustainable use of such resources.

- The SEEDS module *Renewable Sources of Energy* is an excellent resource for this unit. If it is available in your school, it should be used.

- Saskatchewan has extensive deposits of peat. Where are these deposits located? Is it practical or possible to harvest them for use? How long do peat bogs take to regenerate? Investigate the prospects for peat as a fuel.

Microorganisms

Unit overview

Microorganisms play an important part in our lives. As decomposers of organic material, they help keep the soil fertile, and recycle once-living matter into valuable nutrients for plants. Microorganisms in food production, and microorganisms as primary causes of food spoilage are some of the things students could consider while they observe, describe, and identify microorganisms which they culture in their classroom.

The use of microscopes, previously suggested in units of grades 4 and 6, is a necessity. Students should have an opportunity to acquire some skill with the microscope, and appreciate the diversity of lifeforms in the microscopic world.

It is difficult for students learning to use a microscope to know whether what is in the field of view is significant or not. High quality microscopes help alleviate this challenge. One $750 microscope, used in rotation by five groups, may be a better value than five $150 microscopes. A television camera adapter for a microscope, so that a group of students can watch the screen, may be a good solution. Viewing videotapes or films which show active microorganisms may give students an idea of what to look for and how to recognize what they see. It is important to make this contact with the study of microorganisms and the use of microscopes as frustration-free as possible.

When doing any activities with microorganisms, it is best to treat them all as if they were human pathogens. While it is fairly safe to use student-prepared microscope slides to examine protozoans and algae from pond water or from hay infusions, the examination of bacteria should be restricted to unaided viewing, or using a hand lens or stereomicroscope to view cultures grown in sealed petri dishes. Commercially-prepared slides may also be used.

This unit offers the opportunity for integration with the core unit **Life: Keys to Survival**. Together, they offer a good background for the environment units in grades 8 and 9.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Reading from newspapers, texts, and journals broadens students' input from what can be experienced in the classroom or in their day-to-day lives. Reporting on the activities of science class through learning logs, writing newspaper editorials expressing informed opinions, and writing scripts for video newscasts are three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. A class booklet describing various bacterial and viral infectious diseases, with each group contributing a chapter, is an example of a cooperative science challenge activity that results in a product usable in the students' own classroom.

Factors of scientific literacy that should be developed

A3 holistic
A9 human/culture related

B2 interaction
B14 cycle
B18 population
B26 evolution

C1 classifying
C15 analyzing

D2 scientists and technologists are human
D3 impact of science and technology

E1 using magnifying instruments
E2 using natural environments
E7 manipulative ability

F1 longing to know and understand
F4 valuing natural environments

Concept development

grade 2

- complexity of the interdependencies which surround us

grade 5

- components of ecosystems
- essential function of microorganisms

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize some microorganisms.
   - 1.1 Appreciate and use safe procedures for the collection and handling of cultures containing microorganisms.
   - 1.2 Collect and maintain cultures of microorganisms from pond or dugout water, bread and fruit mould or other sources.
   - 1.3 Observe and describe macroscopic changes in the culture containers.
   - 1.4 Use a microscope and an identification key to name organisms from the cultures.
   - 1.5 Use a microscope to observe the structure and activity of microorganisms.

2. Appreciate the beneficial roles of some microorganisms.
   - 2.1 Describe how microorganisms and fungi are essential in the nutrient cycles.
   - 2.2 Investigate foods which require microbial action during production.
   - 2.3 Categorize microbes according to how they produce their desired effect in the foods.
   - 2.4 Identify which microorganisms participate in symbiotic relationships with plants and animals, including humans.
   - 2.5 Eat some fungi (mushrooms).

3. Realize how microorganisms can cause food spoilage.
   - 3.1 Identify microorganisms which produce toxins.
   - 3.2 Categorize toxins by effect.
   - 3.3 Identify those microorganisms which spoil the aesthetic quality of the food.
   - 3.4 Identify other effects of microorganisms.
   - 3.5 Group foods by their susceptibility to microorganism-induced decomposition or nutrient loss.
   - 3.6 Investigate the production of allergens by microorganisms.

4. Consider some attempts to avoid problems created by microorganism-induced food spoilage.
   - 4.1 Investigate methods used to reduce food spoilage.
   - 4.2 Evaluate legislated food standards, inspection, and monitoring procedures.

5. Promote both intuitive, imaginative thought and the ability to evaluate ideas, processes, experiences and objects in meaningful contexts. (CCT)
   - 5.1 Compare similarities and differences in microorganisms.
   - 5.2 Understand that real-life problems have more than one solution.
   - 5.3 Generate and evaluate alternative solutions to food preservation problems.
   - 5.4 Generate, classify, and explore reasons or rules used to categorize microorganisms.
   - 5.5 Render a judgement and support that judgement by referring to clearly defined criteria.

6. Develop students' abilities to access knowledge. (IL)
   - 6.1 Seek out information from people who are knowledgeable about microorganisms.
   - 6.2 Locate resources in a resource centre.
   - 6.3 Recognize that limited equipment and resources, such as microscopes, must be shared equally in order for all to benefit.

Suggested activities

Note: If any students in the class are taking immunosuppressive drugs, microorganisms should not be cultured in the classroom. **It is a prudent practice to treat all cultures as if they contained human pathogens**.

♦ To culture paramecia in the classroom, prepare a growth medium by boiling the outer leaf of a head of lettuce in about 500 mL of well water, pond or dugout water, or distilled water for about 10 minutes. Cool the mixture and divide the water and the lettuce up among a number of small culture jars. (Baby food jars work very well.) Add a dropper full of a commercial paramecium culture to each jar. Pond water or dugout water in which you have identified paramecia can also be used as a starter for your cultures. Allow three to four days for the paramecia to reproduce to give a high-density population.

To collect pond or dugout water, obtain a 2 or 3 metre length of 10 mm to 20 mm inside diameter plastic tubing. Holding your finger tightly over one end of the tube, introduce the other end into the pond. When you have manipulated the tube to where you want to take the sample, remove your finger from the end of the tube and the water should flow in. Replace your finger over the end, withdraw the tube from the pond and release the captured water into an ice cream pail or other container by removing your finger.

A hay infusion can be used to produce a protozoan culture. Add a small handful of hay or dried grasses to about 500 mL of water. Boil for about 10 minutes and then distribute the water and materials to culture jars. Wheat (20-30 kernels) may be added to provide additional nutrients for the microorganisms. The water should be distilled water, well water, pond or river water, or from some other source that has not been treated.

Paramecia and other protozoans move fairly quickly across a 100x field of view. A drop of methyl cellulose solution or polyvinyl alcohol solution added to the drop of culture when preparing the wet-mount slide slows the movement of these organisms, making them easier to observe. Consult a high school biology lab manual for tips on producing wet-mount slides of protozoans.

If you have access to a video camera and can adapt it to take pictures through a microscope, a video clip of paramecia on a TV monitor can be very useful in helping first time microscope users to identify protozoans, algae and air bubbles. This can save students a lot of frustration and requests for assistance.

Factors: B4, B18, C1, E1, E7, F1, G1
Objectives: 1.1, 1.2, 1.4, 1.5, 5.1, 6.3
Assessment Techniques: performance assessments, self assessments, observation checklists
Instructional Methods: guides for viewing, inquiry, assigned questions, discussion

♦ Investigate the use of food irradiation, chemical treatment, and refrigeration to reduce spoilage of food during processing, distribution, and storage. What classes of microorganisms are of concern to the food industry? How do these processes affect the microorganisms that cause food to spoil?

Factors: A9, B2, C15, D3, G3, G5
Objectives: 3.5, 4.1, 4.2, 5.3, 5.5
Assessment Techniques: presentations, short answer test items, written assignments
Instructional Methods: case studies, research project, cooperative learning groups

♦ Ask students to bring a variety of moulds from home. Fresh fruit, preserves, cheese, bread, and other baked goods are prospective sources. Clear polyethylene bags are good for culturing moulds. The bags can be sealed with twist ties or ziplocks and the moulds observed without having to open the bags. Do some samples have more than one type of mould? Will mould that grows on fruit also grow on bread? If you wish to experiment with this question, devise a procedure to be checked with your teacher before you start.

Factors: B4, B18, C1, E1, G3
Objectives: 1.1, 1.3, 4.1, 6.1
Assessment Techniques: anecdotal records, presentations, self and peer assessment
Instructional Methods: inquiry, conducting experiments, laboratory groups

♦ Design and conduct an investigation to observe the growth of bread mould on a variety of brands and types of bread. For each bread used, whether commercially baked or home made, list the ingredients of each for use in the analysis of your results.

- Obtain a yogurt culture and produce some yogurt as a class project. Compare the yogurt you produced to a commercially prepared product. What reasons can you identify for the differences observed?

- What is the name of the bacterium that grows in the nodules on the roots of legume plants? What benefit do these bacterium give to the plants? What benefits do they derive from the plants? Identify and describe other situations where microorganisms live together with multicellular organisms for mutual benefit.

- Buy fresh mushrooms at a store. If possible, get samples of at least two varieties. If the season and weather is right, specimens can also be collected from the wild. If wild specimens are used, make sure that hands are washed very well after handling the mushrooms.

  Sketch the mushrooms and describe their colour, odour, surface characteristics, and structure. Cut the stem as close as possible to the cap. Lay the cap gill side down on two pieces of paper (one white, one black) arranged so that half the cap is over the white sheet and half over the black sheet. In two to three hours, enough spores should be released from the gills to produce a spore print on the paper. Invert a beaker or a jar over the cap while the spores are being deposited. This prevents air currents from disturbing the pattern. When the print is complete, it can be preserved by spraying with hair spray.

  Spore prints are used in identifying the species of mushroom since the colour of the spores is an important characteristic property.

- Make a wall chart identifying uses people make of fungi or the useful effects of fungal action. Keep adding to the chart as new uses are identified.

  Keep another chart of ways that fungi or their effects are harmful to people. Again keep this chart open for additions.

  Items from either of these charts may be selected by individuals or groups to prepare complete explanatory reports.

- Grow a yeast culture in a baby food jar or some other small container. What conditions are necessary for yeast growth? The class may want to identify these variables and then assign different conditions to each group. This will give data for the class to share with each other. Will the culture grow as well in a cold sugar solution on a window sill in the bright sunlight as in a sample of distilled water on the same sill?

  If the cultures are started at the beginning of the day, they can be observed at 30 minute intervals and changes recorded.

- **Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.**

Temperature and Heat

Unit overview

Although all students have experienced the effects of heat, they may have many misconceptions about what heat is, how heat is produced, and how it is measured. This unit provides them with the opportunity to test some of their ideas and to examine how heat affects the physical properties of substances. The ways that we use heat in our homes and industries provides the context for these investigations. This unit could be integrated with the sections of **Renewable Resources in Saskatchewan** that deal with solar and geothermal heat and alternative fuels.

For students one of the key steps in understanding the kinetic molecular theory is to first understand that one form of energy can be converted to another. An electric motor converts electric energy to motion energy; a generator converts motion energy to electricity.

Kinetic molecular theory can be understood in terms of molecules as energy converters. Molecules convert heat energy to kinetic (motion) energy as heat energy is added to a group of molecules, and convert kinetic energy to heat energy as heat energy is removed from the system. The definition of temperature as the average kinetic energy per molecule can be understood in this context of molecules as energy converters. Thus if the temperature of a substance is high, this means the molecules have lots of kinetic energy that can be converted to heat energy.

If temperature is the average energy (kinetic or heat) per molecule, multiplying the temperature by the number of molecules gives the total amount of heat (or kinetic) energy in the system. Or dividing the total amount of heat by the number of molecules gives you the temperature. What students should understand is that high temperature doesn't always mean lots of heat, as in the case where only one molecule is present.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Reporting on the activities of science class by writing recipes for making heat, writing stories for their peers, and reading their peers' stories, and writing reports of interviews with each other to determine ideas and understanding about a topic are strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word. Students should be given an opportunity to do research using a number of written formats: pamphlets and brochures; company reports; newspaper articles and editorials; and texts.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A5 empirical
A6 probabilistic

B11 predictability
B12 conservation
B15 model
B20 theory
B24 scale

C5 measuring
C9 inferring
C12 interpreting data
C16 designing experiments

D1 science and technology

E3 using equipment safely
E4 using audio visual aids
E10 measuring temperature
E13 using quantitative relationships

F2 questioning
F3 search for data and their meaning
F5 respect for logic

G6 response preference
G8 explanation preference

Concept development

grade 3
- change of state
- sources of heat
- heat transfer

grade 4
- relationship of all forms of energy, including heat

grade 5
- use of temperature as a measure of heat energy
- how heat affects the particles of matter in a substance
- insulation to inhibit heat loss

grade 6
- examples of energy conversion

grade 7
- how energy is used - needs and wants
- relation of heat to energy use

grade 8
- conservation of energy used in space heating
- heat flow

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize energy conversions which involve heat.
   1.1 Identify uses, and corresponding sources, of heat.
   1.2 Discuss ways of detecting the presence of heat.
   1.3 Identify situations where heat is produced as a by-product.
   1.4 Propose ways in which heat produced as a by-product could be used.

2. Understand the relationship between heat and the motion of particles in a substance (kinetic molecular theory).
   2.1 Observe and describe diffusion.
   2.2 Compare rates of diffusion in similar systems at different temperatures.
   2.3 Define heat as a form of energy that is converted by molecules to motion.

3. Recognize differences between heat and temperature.
   3.1 Design and use devices to measure temperature.
   3.2 Discuss how liquid bulb thermometers detect the presence of heat through the motion of molecules.
   3.3 Understand that temperature is one criterion in estimating the amount of heat present.
   3.4 Explain why temperature difference rather than difference in the quantity of heat determines the direction of heat flow.

4. Develop compassionate, empathetic and fair-minded students who can make positive contributions to society as individuals and as members of groups. (PSVS)
   4.1 Recognize that the behaviour of an individual can affect the quality of an experience for others.
   4.2 Develop an understanding of the virtues needed for a classroom environment which will support the learning and development of all those involved.
   4.3 Recognize the importance of respecting evidence, truth, and the views of others when engaging in rational discussion.

5. Strengthen students' understanding of heat by applying knowledge of numbers and their interrelationships. (NUM)
   5.1 Collect and organize quantitative information into a list, table, graph, or chart.
   5.2 Analyze information to produce a conclusion.
   5.3 Use the language of estimation.
   5.4 Explain to others how to make accurate estimates.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Design and conduct an investigation to measure the rate of diffusion in some system. The system may be gas diffusion through a gaseous medium, liquid diffusion through a liquid or aqueous medium, the diffusion of a solid dissolving in an aqueous medium, or any other one which can be identified. Encourage the students to identify all pertinent variables and create a good experimental design.

  Factors: A5, B15, C16, E3, E13, F5, G6
  Objectives: 2.1, 2.2, 5.2
  Assessment Techniques: peer assessment, observation checklists, rating scales
  Instructional Methods: inquiry, conducting experiments, problem solving

- Create analogies that help explain the concepts of temperature and heat. Present your analogy to the rest of the class in the form of a poster or a skit.

  Factors: B15, C12, E4, F5, G8
  Objectives: 2.3, 4.2.
  Assessment Techniques: peer assessment, presentations, rating scale
  Instructional Methods: synectics, concept attainment, peer practice

- Identify several external sources of heat which we use to keep ourselves warm. Make sure to distinguish between an external source of heat and something that prevents internal heat from escaping. For each source of heat identified, explain how the heat is produced.

  Factors: B15, C12, F2, G6
  Objectives: 1.1, 2.3, 4.2
  Assessment Techniques: short answer test items, presentations
  Instructional Method: discussion

- Record the temperature of the air. Hold the thermometer bulb gently against the palm of one hand. Record the temperature after thirty seconds and one minute. Clasp hands so the palms are together. Ask another student to insert the thermometer between the palms so that the bulb is in the centre of the cavity formed. Record the temperature after thirty seconds and one, two, three, and four minutes. Discuss where the heat to raise the temperature of the thermometer comes from? Predict what temperature would be reached if the thermometer was left between the hands for ten minutes and for twenty minutes.

  Predict the temperature which could be attained by rubbing the palms briskly together for twenty seconds. Do so, clasp the hands as in the previous procedure and then record the temperature in the centre of the hands after thirty seconds and one minute.

  Discuss how our body generates heat inside to keep us warm.

- Design and construct a thermometer. Calibrate the thermometer using a laboratory thermometer. Which laboratory group can create the thermometer with the greatest temperature range?

- Write a story of life in a world without heat. What form would life take? If that idea is too far-flung, write the story of life in a world where the atmospheric temperature never rises above 0°C.

- A lot of waste heat in the operation of a car is discharged into the air through the radiator. Describe how the radiator of a car removes the excess heat and transfers it to the air. How does this compare to the ways that a forced air furnace and a hot water heating are used to heat a building?

  Brainstorm uses for the waste heat from a car's engine.

- Fill a petri dish with 0°C to 5°C water and let it stand for a minute so that there are no currents left. Place a crystal of potassium permanganate in the centre of the dish. Devise some way to measure how fast the chemical diffuses through the water. Measure the rate of diffusion.

  Predict how fast a crystal will diffuse if the water is at 20°C. Using the method for measuring rate of diffusion developed in the first part of the activity, test diffusion at 20°C.

  Predict and measure the rate at 40°C. Graph the results of your measurements.

Resource Use

Unit overview

One of the important considerations in the study of economics is the allocation of scarce resources among seemingly limitless demands. North Americans especially have treated resources as if they were limitless and demand as something which must be fulfilled. This has led to two related problems. It is becoming very evident that resource stocks are finite. The waste materials generated by trying to fulfill consumer wants are difficult to handle. Attempts to recycle waste materials as resources have run into the problem of a large supply of materials and a low demand for the products.

In this unit, two concerns are considered. What is the best use for four major Saskatchewan resources: forests, soil, water, and natural gas? How can the solid waste we generate be best handled? This unit can be integrated with the grade 7 science core unit **Renewable Resources in Saskatchewan** and to some extent with the grade 7 social studies unit **Resources**.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers and journals as well as from texts, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A2 historic
A6 probabilistic
A9 human/culture related

B2 interaction
B5 perception
B10 cause-effect
B12 conservation
B13 energy-matter
B16 system
B18 population

C4 working cooperatively
C6 questioning
C12 interpreting data
C19 consensus making
C20 defining operationally

D3 impact of science and technology
D4 science, technology, and the environment
D5 public understanding gap

E2 using natural environments

F2 questioning
F4 valuing natural environments
F6 consideration of consequence

G3 continuous learner
G6 response preference

Concept development

grade 1
- basic needs for survival

grade 2
- ecosystem requires both nonliving and living components
- ecosystem supplies the needs of all living organisms

grade 3
- ecosystems are subject to disruption, with severe consequences for organisms

grade 6
- human role in destruction and protection of habitat

grade 7
- place of renewable resources in resource-use mix

grade 8
- fossil fuel use is high in Canada and resources are finite
- politics of mineral extraction

grade 9
- soil as a sustainable resource

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand how resource use decisions are made.
   - 1.1 Identify basic needs of life.
   - 1.2 Compare our basic needs to what we consume.
   - 1.3 Recognize that the origin of all goods that we consume is from the ecosystem.
   - 1.4 Consider how the resources of water, soil, and forests in Saskatchewan should be managed for sustained use.
   - 1.5 Analyze the interrelationships of soil and water.
   - 1.6 Discuss how natural gas produced in Saskatchewan should be used.
   - 1.7 Consider the social, cultural, political, and economic values and factors which influence resource use.

2. Investigate problems and concerns involving solid waste.
   - 2.1 Identify types and sources of solid waste.
   - 2.2 Discover how solid waste is handled in your municipality.
   - 2.3 Investigate whether there are solid waste disposal problems in your municipality.
   - 2.4 Consider how the three R's of waste reduction can be implemented in your community.
   - 2.5 Discuss why reduce is a more preferable 'R' than recycle.
   - 2.6 Experiment with strategies to reduce solid waste sent to the landfill.

3. Use language (listening, speaking, writing, reading) for differing audiences and purposes relevant to the students and to understanding about how we use resources. (COM)
   - 3.1 Share in their own words, ideas which are heard, read, viewed, or discussed.
   - 3.2 Discuss the meaning of a message and the significance and appropriateness of the medium and techniques used.
   - 3.3 Use letters, essays or debates to express ideas about resource use.
   - 3.4 Identify and understand persuasion and propaganda techniques in all media.
   - 3.5 Respect, understand and empathize with the language, thoughts, expressions, and viewpoints of others.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Make three columns on a page of paper. In the first column list all those items of solid waste which are recycled in your community. In the second column, list those items that you know are recycled elsewhere, but are not recycled in your community. In the third column, list those things for which you can discover no recycling program anywhere.

  For each item listed in the three columns, propose methods of how the amount of that type of waste could be reduced. Next, for each item on the three lists, propose ways in which the item could be reused. Finally, propose ways that you could move items from column 2 into column 1 and from column 3 into column 1 or 2 by identifying uses or markets for the waste.

  Factors: A9, B2, B12, C6, D4, F4, G6
  Objectives: 2.1, 2.2, 2.4, 3.1
  Assessment Techniques: presentations, extended open response test items, self and peer assessment
  Instructional Methods: reflective discussion, problem solving

- Tetra Pak drink boxes have been criticized as being environmentally unfriendly. List the advantages and disadvantages of the boxes. From examining the list, can you make a judgement of whether the boxes are an appropriate form of packaging.

  Tetra Pak Inc., Suite 5 3260 Viking Way, Richmond, BC V6V 1N6 (604) 276 2424 will supply information and their argument for the use of the boxes in the form of a poster titled "The Juice Box Story". Analyze the arguments presented. Compare Tetra Pak's list of advantages to the advantages you identified. Once this analysis is done, decide whether your opinion has changed.

  Imagine that you are an advertising consultant who has been hired by the glass industry to promote the use of glass bottles for packaging juice. Create a poster that would meet that requirement.

  Is it possible that for some uses Tetra Pak boxes are the appropriate choice and for other uses glass bottles are the suitable choice? Must a decision be made that one packaging method is best for all situations? Can a decision be made that one packaging method is best for all situations? What are some alternatives to either method for bringing juice to school for lunch? for buying juice or milk for family use at home? for selling juice in a cafeteria at a mall?

  Factors: A9, B2, B5, B13, C12, C19, D5, F6
  Objectives: 1.3, 2.4, 2.6, 3.4
  Assessment Techniques: written assignments, observation checklists, self assessment
  Instructional Methods: reflective discussion, surveys, problem solving, role playing

- Saskatchewan Environment and Public Safety as well as Environment Canada publish fact sheets, pamphlets, and books which are useful for students doing research into recycling programs which are in existence and on ways to reduce consumption. How many of the tips are you or others in your community using or pursuing? Develop a plan to publicize some of the tips found in the materials.

  Factors: A9, B10, B18, C4, C6, D4, D5, G6
  Objectives: 1.2, 1.3, 2.1, 2.4, 2.5, 3.2
  Assessment Techniques: rating scale, presentations
  Instructional Methods: reading for meaning, role playing, reports

- Use a brainstorming session to identify second uses for disposable items such as paper milk containers, shoeboxes, plastic wrap and styrofoam trays from fresh meat packages, empty cereal boxes, burned out light bulbs, and so on. Make some of the products and test them. Write consumer product test reviews to explain the results of those tests. Articles in the **Canadian Consumer** or in **Protect Yourself** magazines might be used as models for these reports.

- Study the production of recycled paper. Divide the class into five groups, each which will be responsible for creating a model (verbal, physical, or graphic) of their part of the process. If students have not already produced their own recycled paper, that activity could be used in this unit to illustrate the process.

Following are five possible divisions for the study.

- What land, resources, buildings, and equipment are needed for a recycling mill?
- What sources and amounts of paper for recycling can be identified in your school, community, or area? How will this amount, if recycled, affect the total volume of solid waste produced by your school or community?
- What is the market for recyclable paper in your area? What are the volume requirements of the recycler?
- What are the economics of the situation? How much money and time will be required to begin? Will the process make a profit or will it need to be subsidized?
- What guidelines for persons contributing paper must be established? What kinds of paper will be accepted? How will the paper be transported to the central collection site, and then to the recycling plant?

♦ Develop ideas for gift wrapping and packing involving reducing amounts used or reusing materials such as newspapers or paper bags.

Create a sheet publicizing your ideas and distribute the sheet during the pre-Christmas season in your community.

♦ To produce your own recycled paper, you will need a bowl (rectangular cake pans work well), two pieces of screen cut so that they will fit inside the bowl, newsprint, a juice pitcher with a lid, warm water, a piece of thick cotton towel three times of the screen and a stirring spoon.

Put the warm water into the pitcher so that it is about one half full. Shred the paper so that it is in as small pieces as possible. Add to the warm water, stirring slowly. Keep adding paper and stirring until the mixture is the consistency of thick soup. (A hand mixer might be useful if the paper is not liquefying easily.) Put the lid on the pitcher and shake to further liquefy the paper. Then pour the mixture into the pan.

Slip one of the pieces of screen down the side of the pan and under the mixture. Move it gently around until it is covered with an even layer of paper. Then lift it out of the pan, taking care to keep it level. Place the screen on one end of the towel and place the other piece of screen on top of the mixture. Then fold the towel over top of the second screen and press down hard to squeeze the water out of the mixture.

Take the towel off the top screen and then carefully remove the top screen. Place the bottom screen with its layer of paper in a warm place to dry. When it is dry, carefully separate the paper from the screen.

Experiment by adding some liquid laundry starch, some Epsom salts, some 3 cm lengths of thread or some other substances to the paper. Can coloured paper be produced. Will a little alcohol added remove any of the ink from the paper?

♦ Start a class composting project. Find out what types of materials can be decomposed in a compost pile and which materials should be avoided. Find out the requirements of the compost process. Design a container to be used in the classroom or in the schoolyard. Make sure that the design ensures that all essentials are present or easy to maintain. Are there any implications for community health problems, e.g. rats or mice?

Organize a system of collecting materials for use in the compost pile. Assign tasks for maintaining and monitoring the composting process. Decide how the finished compost will be distributed or used.

♦ Create a model of a well-designed landfill. Develop posters which describe the structure and function of each component.

♦ Without indicating the purpose of this activity, ask students to bring a noon bag lunch to class on a specific day. During the class before lunch, ask the students to measure the mass of their lunch (bag and all), and then to estimate how much of that mass is packaging. Ask the students to save all the packaging materials from their lunch for use in the first period of the afternoon.

During the first afternoon period, ask the students to measure the mass of the packaging? What is the mass of the materials which can be reused? What is the mass of the materials which can be recycled? What is the mass of the excessive packaging that could be eliminated or replaced with reusable materials?

Set goals for reduce the packaging used when lunches are packaged for school. Ask those people who bring lunch regularly to save and measure the mass of the packaging each day for the next two weeks. Present the information on the various masses of packaging materials for the two week period on a graph.

- Activities 1 and 8 from the CEPUP module **Plastics in Our Lives** deal with the use and reuse of plastics, alternative substances, and the economics of production and distribution of plastics and alternatives.

- Write short songs with a resource-use message. Several examples are:

  Reduce, reuse and recycle
  Reduce, reuse and recycle
  Help conserve our resources
  Reduce, reuse and recycle
  (to the tune of Happy Birthday)

  Forests, water, soils and gas
  Let us make resources last
  Fifty years and they'll be gone
  If we don't change what goes on
  Forests, water, soils and gas
  Let us make resources last
  (to the tune of Twinkle Twinkle Little Star)

  Make musical instruments from disposable objects and use them to accompany the songs.

- Discuss the following statement. "Everything in this room eventually will be recycled, landfilled, or flushed down a toilet."

Science 8

Adaptation and Succession

Unit overview

A cultivated field does not remain free of plant life for long. After a forest fire, new plants spring up to replace the burned trees. When a new road is built, the ditches do not remain smooth, graded bare dirt. These are all examples of the beginning of the process of succession. Living organisms require air, soil, water, and heat for growth. And when they grow they alter their environment. Sometimes they no longer fit in this changed environment.

What characteristics of organisms enable them to survive in a particular environment? How do organisms alter the abiotic components of their environment? How does this alteration affect the abilities of the plants to live there? Can individual organisms change if the conditions change? These are questions about adaptation and succession.

Adaptation is not about the changing of organisms to suit the environment. It's about organisms changing the environment enough to be able to survive, or finding an environment that doesn't need changing.

This unit continues the investigation begun in the **Ecosystems** unit in grade 6. The concepts introduced in grade 6 can be considered in more depth, and new concepts introduced during this unit. The grade 9 unit **Saskatchewan – Environment** extends this look at the environment to focus on how humans are the prime agents of succession in today's world. Succession is an organic process in which organisms alter their environment. Students are asked to evaluate how human organisms have participated in the process.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing demands that we clarify our thoughts and ideas. Reading exposes us to the thoughts and ideas of others. Including writing in science activities is an important component of the science program. The writing may be expository, narrative, or personal and reflective. Different modes suit different opportunities and purposes. Students should be encouraged to read newspaper and magazine articles, narrative nonfiction, and texts. Through reading and writing they refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A2 historic
A7 unique

B1 change
B2 interaction
B4 organism
B14 cycle
B16 system
B18 population
B22 fundamental entities

C6 questioning
C9 inferring
C11 controlling variables
C13 formulating models
C18 using time-space relationships

D2 scientists and technologists are human
D4 science, technology, and the environment

E1 using magnifying instruments
E2 using natural environments
E7 manipulative ability

F1 longing to know and understand
F4 valuing natural environments
F6 consideration of consequence

G3 continuous learner
G5 avocation

Concept development

grade 2
- factors influencing plant growth, and the habitats of plants and animals

grade 3
- soil characteristics
- the pressures on animal populations

grade 5
- human impact on the environment
- concern for quality of air, soil, and water

grade 6
- interrelatedness of biotic and abiotic components of the ecosystem

grade 7
- requirements for life

grade 8
- factors influencing plant growth

grade 9
- human impact on the ecosystem

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize how abiotic components of an ecosystem support and influence life.
   - 1.1 Identify the nonliving conditions and components of the ecosphere that influence life.
   - 1.2 Discuss the interrelationships among the nonliving components.
   - 1.3 Analyze the role of matter cycles in an ecosystem, considering both abiotic and biotic components.
   - 1.4 Recognize energy sources and energy flows in the ecosystem.
   - 1.5 Appreciate how abiotic factors influence how populations which develop.
   - 1.6 Examine the behaviours and mechanisms by which organisms make use of, and coexist with, the abiotic components of the ecosystem.
   - 1.7 Explore the behaviours and mechanisms by which organisms make use of and coexist with other biotic components of the ecosystem.

2. Examine how living things alter their environment.
   - 2.1 Find examples of succession in the ecosystems of your area.
   - 2.2 Observe and describe the rate of environmental change.
   - 2.3 Assess how living organisms contribute to environmental change.
   - 2.4 Evaluate the effect of succession on ecosystems.

3. Develop a positive disposition to lifelong learning. (IL)
   - 3.1 Participate in learning activities, individually and as members of a cooperative group.
   - 3.2 Contribute to the development of objectives for learning activities.
   - 3.3 Identify, plan, and conduct activities.
   - 3.4 Develop a willingness to take risks as an independent learner.

Suggested activities:

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Create a model or a mural which illustrates the water cycle. Highlight all the places where the water cycle has an impact or an effect on human life.

  Factors: A2, B1, B14, B22, C13, C18, F1, F6
  Objectives: 1.1, 1.3, 1.5, 3.3
  Assessment Techniques: group evaluations, rating scales, presentations
  Instructional Methods: cooperative learning groups, reports

- Identify the source(s) of water supply for the community in which your school is located. Investigate whether there have been or are any threats to the quantity or quality of that supply. Identify the biotic and the abiotic factors which interact with the community's source(s) of supply.

  Factors: B2, B16, C6, C9, D4, E2, F1, G3
  Objectives: 1.1, 1.2, 3.1
  Assessment Techniques: written report, extended open response test items
  Instructional Methods: research project, interviewing, reading for meaning

- Create a model or a mural illustrating the carbon cycle. How do the carbon cycle and the water cycle interact with each other or influence each other?

  Factors: A2, B2, B14, C13, C18, F4, G3
  Objectives: 1.3, 3.1
  Assessment Techniques: homework, written assignments, observation checklists
  Instructional Methods: model building, research project, discussion

- Follow the previous activity with a class discussion comparing and contrasting how humans cope with their environment. Are physical characteristics or behaviours more important in human adaptation?

- List on the board all plants and animals which can be found in the vicinity of the schoolyard. Ask each group to pick one organism listed. For the organism they have selected, they should describe the behaviours and the physical characteristics which help the organism cope with its environment. Each group can share its findings and ideas with the whole class in the form of an oral presentation illustrated with one or more posters. Species identification is not critical – labelling them as A, B, C, etc. would suffice.

- Brainstorm a list of all migratory animals. The *Resource Reader* (being redeveloped) from Saskatchewan Natural Resources is a good source of information on migratory animals if the brainstormed list comes up short. Assign one animal to each pair of students in the class. Select animals so that a range of animals is allotted. (This is to avoid reports on the mallard, the canvasback, the green-winged teal, the blue-winged teal, the pintail, the wood duck, the shoveller, and the ruddy duck as the only reports prepared.)

  Each group of two should prepare a report outlining the characteristics, habits, and migratory path or habit of their animal. Each pair should present their report orally, using a globe to show the migratory path or habit. Each student in the class should have a copy of a world map on which to mark the migratory paths as they are described.

- During the course of the year, assign groups the responsibility for assembling and mounting a bulletin board display. An appropriate concept for this unit could be either a grassland community, an aspen parkland community, or a boreal forest community. Included with pictures and articles about the selected community should be student-created posters explaining the function of each important element of the community. These elements would include such things as the sun, air, moisture, soil, producers, various consumers, and decomposers.

- Create a model or a mural illustrating the nitrogen cycle. Be able to explain the importance of the nitrogen cycle to organisms and the concept of 'fixing' nitrogen.

- Identify five to ten living organisms which form significant populations in the area in which you live. Identify the major links to other living organisms and to the abiotic components of the area.

- In late April or early May, cultivate a small plot of soil (perhaps 1 metre square) in your schoolyard. Use a spade and hoe to make sure that the soil is well-tilled to a depth of about 15 cm, and is completely free of plant growth.

  Observe the plot over a one or two month period. Keep a record of the plant growth (number of species, population of each species, whether members of the species are also found in the immediate neighbourhood of the plot). If possible compare the schoolyard plot to plant growth in other disturbed soils in the community, such as building construction sites, abandoned lots or gardens, clearcut forest sites, road construction areas, and so on.

  If possible, leave the plot undisturbed over the summer and ask the grade eight class of the next school year to observe the plot and then create their own new plot in the spring. Over the years, this could create a longitudinal study of schoolyard succession.

- Investigate how lichens are involved in succession. Find some rocks with lichen on them. Examine the lichen's characteristics and growth pattern, and the rock surface under the lichen. Is there evidence that the lichens have had an effect on the rock?

- Go on a hike to a nearby park, open field, aspen grove, or forest. Identify the plants and animals that inhabit the area. How are they adapted (suited) to live in that space, and occupy the niche they do?

- Create a mural which shows how succession would proceed on a bare sand hill in the Great Sand Hills area of southern Saskatchewan. Other murals could be created to show succession on an abandoned field in the Milestone area, an abandoned field in the Hepburn area, and on a clearcut forest area near Hudson Bay.

- If a four wheel drive vehicle or a trail bike is driven across a sand dune community, the whole community, not just that part of it in the tracks of the vehicle, may be destroyed. If the same vehicles are driven across a patch of fescue prairie or through a spruce forest, there may be only minimal damage to the plants squashed by the tires. Why is there such a difference?

- Analyze two distinct environments in terms of the abiotic factors which give them their character. A hill with a north facing slope and a south facing slope is example of a place where distinct environments may be found close to each other. Others might be the margin of a slough compared to a grassy ditch, or the play area of the school compared to a lawn.

The Moving Crust

Unit overview

The theory of plate tectonics, as an explanation of both physical features of the continents and of the strata which make up the continents, is an excellent example of historical science. The theory is constructed from existing evidence and data and is not amenable to empirical testing. Computer modelling is as close as one can come to reconstruction of the Earth's past.

The theory is a powerful tool to enlighten us about the geological history of Saskatchewan. How did uranium come to be deposited in the Athabasca Basin? How could there have been mountain ranges through Saskatchewan? Where did the vast beds of potash come from? Was Estevan in the past in a tropical climate that would have supported vegetation to produce coal to be mined today?

This unit has strong ties to the grade 8 core unit **Renewable Resources in Saskatchewan** and to the grade 8 optional unit **Resource Use**. Since the deposits of coal, natural gas, and petroleum are the results of geologic processes, and resource use policy deals with these fossil fuels and other mineral resources, these three units could be integrated.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers and magazines, and reporting on the activities of science class in the form of stories, letters to peers, and newspaper articles are ways by which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Writing and illustrating a booklet on one of Saskatchewan's mining industries or on some phase of one of those industries is an example of a challenge activity. For example, a booklet might focus on describing how potash is produced from the ore that is mined.

Factors of scientific literacy that should be emphasized

A2 historic
A3 holistic
A6 probabilistic

B2 interaction
B3 orderliness
B7 force
B10 cause-effect
B14 cycle
B15 model
B16 system
B20 theory
B24 scale

C1 classifying
C6 questioning
C9 inferring
C10 predicting
C13 formulating models
C15 analyzing

D1 science and technology

E4 using audiovisual aids
E5 computer interaction

F1 longing to know and understand
F2 questioning
F3 search for data and their meaning
F5 respect for logic

G1 interest
G3 continuous learner

Concept development

grade 1

- recognize the existence of various landforms on a spherical Earth

grade 3

- reinforce the recognition of the Earth as a sphere
- describe features of the mantle and crust

grade 4

- evidence and inferences about the Earth's history

grade 6

- plate tectonics
- relation of earthquakes and volcanoes to plate movement

grade 8

- formation and extraction of coal, natural gas and petroleum deposits of Saskatchewan

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the concept and theory of drifting continents.
   - 1.1 Describe the concept of Pangaea.
   - 1.2 Discuss the evidence for the existence of Pangaea.
   - 1.3 Consider what forces might cause the continental plates to move.

2. Investigate the effects produced by moving crustal plates.
   - 2.1 Identify regions where plates are colliding, separating, or sliding along each other.
   - 2.2 Describe the relationship between the collision or sliding of plates and the occurrence of earthquakes, volcanoes, or mountain building.
   - 2.3 Classify rocks according to their source.

3. Relate the geological history of Saskatchewan to the movement of the North American plate.
   - 3.1 Trace the latitude of Saskatchewan through the various geological eras.
   - 3.2 Describe how the evidence of fossils and types of rocks are used to infer ancient conditions.
   - 3.3 Locate where various types of bedrock are exposed to the surface in Saskatchewan.
   - 3.4 Describe how the geological history of Saskatchewan has helped shape the physical, biotic, and human-cultural panorama of Saskatchewan.
   - 3.5 Examine the deposition and extraction of potash from sediments of the Devonian period.

4. Understand and use the vocabulary, structures and forms of expression which characterize the study of earth science. (COM)
   - 4.1 Use expressive language to enhance understanding of earth history.
   - 4.2 Interpret diagrams, charts, and graphs which supply evidence of plate activity.
   - 4.3 Recognize how evidence is interpreted to show the existence of tectonic plates.

5. Understand how knowledge is created, evaluated, refined and changed within science. (CCT)
   - 5.1 Explain how geological evidence is used to interpret the history of the land.
   - 5.2 Analyze the development of the personal knowledge of geological history.
   - 5.3 Design models and analogies which illustrate understanding of the concepts.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Use cash register tape to prepare a timeline indicating highlights of Saskatchewan geological history from -3.5 billion years to the present. Discuss the use of scale in such diagrams. If the tape is 3.5 metres long, then 1 mm is 1 million years. This suggests that a piece longer than 3.5 m will be necessary. How about 35 metres? Then 1 cm is a million years. How much time has there been since the last ice age started? Since it ended? What lengths of tape do these time periods represent?

  As an extension to this activity, divide the timeline into from 15-20 "days". If 17 "days" are used for 3.5 billion years, then 1 "day" represents about 205 million years. Then assign a group of these days to each working group in your class. If you have eight groups each group would get two days and one group three days. Group A could have day 1 (-3.5 b y to -3.3 b y), day 9, and day 17 – and so on. Ask each group to write news releases to describe their "days" in geological history. The news release for each day could then be read or posted at the beginning of each day.

  Factors: A2, A6, B3, B15, B24, C1, C13, F3
  Objectives: 3.2, 3.4, 5.1, 5.3
  Assessment Techniques: self assessment, anecdotal records, oral assessment
  Instructional Methods: model building, cooperative learning groups

- Write "geological news items" describing major events of geological history. These items can be posted along the timeline. Use stories clipped from newspapers as models for these accounts.

  Factors: A3, B16, B20, C9, C15, F1, G3
  Objectives: 3.2, 4.1, 5.1
  Assessment Techniques: written assignments, rating scales, peer assessment
  Instructional Methods: focused imaging, research project

- If you could live at any time in Saskatchewan's past, when would that be? Pretend you are a passenger in a time machine that could take you to any time during the last 3 billion years.

  Write an account of the climate, terrain, vegetation, animal life, and what you would have to do to survive.

  Factors: A2, B2, C1, C6, C10, G1
  Objectives: 3.1, 3.2 4.1, 5.1
  Assessment Techniques: written assignment
  Instructional Methods: essays

- Write the story of a time traveller who was mistakenly dropped at some point in the past. What climate, terrain, vegetation, or animal life would be encountered?

- A field trip to the Saskatchewan Museum of Natural History would be a good way to either introduce this study of the geological history of Saskatchewan or to summarize it. It is constructed in the form of a timeline from -3.5 billion y to the present. Another site that you could contact for a tour is the Subsurface Geological Laboratory in Regina at 787-2622.

- In grade 4, the unit Fossils and Rocks has an activity where students look for fossils in the building stone used in the community. Tyndall stone, which is a type of limestone from Tyndall, Manitoba is especially rich in fossils. A class project might be to identify and record locations of fossils in the stone of buildings in the community, sketch the fossils as they appear in the stone and as they appeared as living organisms. Include with each set of sketches a description of the niche(s) and habitat of the organism. Bind all this information into a booklet to present to the school for the fourth grade teachers to use with their classes.

- Construct papier-mâché models which show the lands, rivers, and bodies of water in Saskatchewan during the various geological periods. If each group does a different period, a series which show Saskatchewan through time can be produced. A companion to this might be a sketch of the continents showing the longitude and latitude of Saskatchewan during each geological period. Books for research are *Geology of Saskatchewan – A Historical Approach* (Gordon, 1979), *Atlas of Saskatchewan* (Richards, 1969), and *Geological History of Saskatchewan* (Storer, 1989).

- Construct an overlay model of the geological strata as described in *Geology of Saskatchewan – A Historical Approach* (Gordon, 1979), pages 51-52. If strata representations are attached to the border which has the longest underlying stretch of rock from that period, the model will be stronger. For example, Cambrian rocks underlie most of the western border of Saskatchewan up to about 56° N. latitude but reach the eastern border only in the extreme southeast corner of the province. Attach the Cambrian layer overlay along the western border of the province. The Silurian overlay should be attached along the eastern border.

- What evidence is there today to show that the continents were once linked together in a different arrangement? What are the root words of the name Pangaea?

- The North Atlantic Ocean is widening at the rate of about 15 mm per year. The ocean is now about 2400 km wide. Evidence suggests that at one point Europe and North America were joined. If the spreading of the Mid-Atlantic ridge is responsible for the separation and is proceeding at the same rate today as in the past, how many years ago would the North American continent and the European continent have been touching? During what geological period would they have started separating? Mark this event on your timeline of geological history, if you have one.

- Roll 3 different colours of Playdough™ or plasticine into flat sheets about 2 cm thick. Cut the sheets to form strips about 25 cm by 8 cm. Stack three strips of different colour separated with wax paper. Pressure from the ends toward the middle will cause the model to deform, showing the effects of pressure on rock strata.

- Build cross-sectional models to show the processes of subduction, mountain building, ocean ridge spreading, volcanic action, block faulting, and other geological phenomena.

- Write a tourist brochure for people who will be visiting Mt. St. Helens. Include descriptions of what they should look for and diagrams which explain the structure, eruption and effects of the volcano. Explain what geological processes produced Mt. St. Helens.

- Draw a series of maps which show the latitude and north-south orientation of Saskatchewan at various times during geological history. Once the maps have been drawn, make a poster which shows a line graph of the latitude of your school versus time.

- What is the bedrock under your school? Can you find samples of this material? Are there fossils found in this bedrock? If so, what type of fossils are there? From how many geological eras would you find rock if you drilled straight down through the crust under your school? How thick is the crust under your school?

- Why were the glaciers of the ice ages able to grind the bedrock of Southern Saskatchewan to produce thick soils, but not able to grind the bedrock of Northern Saskatchewan to produce soils?

- What are the LaRonge and Flin Flon volcanic island arcs? When were the volcanos active? What effect does the arc have on the minerals in that area today?

- Imagine that you could cut the province vertically in an east-west direction through your school. and then vertically in a north-south direction through your school. This would leave your school sitting at the corner of a giant cross-section of the province. Construct a model showing the strata of rock from the surface to the lowest stratum of bedrock. Be prepared to describe one important feature of each stratum to the rest of the class. For each geological period, prepare two trivia questions for use in a game.

- Use the Saskatchewan Resource Series kit *Potash* during this unit. Relate the mining of potash to the geological state of Saskatchewan during the Devonian period.

- The January 1993 *National Geographic* is a special issue dealing with dinosaurs. The map included in the magazine shows the North American continent 75 million years ago. Articles discuss the problem of the extinction of the dinosaurs. Included in the issue is a discussion of continental drift theory as it relates to the matter of climate change as a possible cause for extinction.

Solutions

Unit overview

Many of the substances which we use every day are solutions. This unit provides students with a chance to see how the properties which we value in the substances we use are produced by mixing two or more pure substances. Students will compare solutions to other types of mixtures and observe some of the chemical and physical properties of solutions in this unit.

It also provides an opportunity to examine the benefits and problems of water as a solvent. For example, dissolved oxygen is vital to many aquatic organisms. But the same water may also carry contaminants which may harm these same organisms, or which may prevent the water from carrying a sufficient supply of dissolved oxygen.

The expectation is that symbols for elements and formulas for compounds will be used to build on the experiences the students had with these tools in grade six. Word equations will be sufficient to describe the components of chemical reactions.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers and journals, and reporting on the activities of science class using varied formats such as recipes, directions, stories, and charts are ways through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Individual or small group projects give students a chance to pick a topic of personal interest, and through research, bring back to the class information and perspectives which it would be impossible for everyone in the class to discover individually. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A1 public/private
A4 replicable
A5 empirical

B3 orderliness
B7 force
B13 energy-matter
B16 system

C1 classifying
C2 communicating
C7 using numbers
C8 hypothesizing
C12 interpreting data
C15 analyzing

D3 impact of science and technology
D4 science, technology, and the environment

E7 manipulative ability
E9 measuring volume
E11 measuring mass

F2 questioning
F5 respect for logic
F7 demand for verification

G2 confidence
G6 response preference

Concept development

grade 3
- introduction to the states of matter

grade 5
- characteristics of some solutions

grade 6
- solutions as chemical reactants and as a holding phase for reaction products

grade 9
- impact of pollutants in water on water use

grade 10
- analysis of water for pollutants and contaminants

Foundational and learning objectives for Science and the Common Essential Learnings

1. Develop abilities to distinguish solutions from other mixtures.
   - 1.1 Compare samples of solutions and colloids.
   - 1.2 Recognize whether any combination of two substances is a solution, colloid, or mixture.
   - 1.3 Classify solutions as solid, liquid, or gas phase solutions.
   - 1.4 Recognize the difference between a mixture and a solution.

2. Investigate some properties of solutions.
   - 2.1 Describe the change in physical properties of a solution as its proportions change from very dilute to supersaturated.
   - 2.2 Examine what happens when liquid solutions undergo changes of state.
   - 2.3 Compare rate and intensity of chemical reactions between solutions when temperature and concentration are varied.
   - 2.4 Identify solutions which are essential to or which enhance our lives.
   - 2.5 Recognize the meaning in various ways of expressing strengths of solutions.
   - 2.6 Understand how solutions act as carriers of pollution.

3. Develop abilities to meet personal learning needs. (IL)
   - 3.1 Work and communicate with others as a means of meeting learning goals.
   - 3.2 Synthesize understandings and experiences discovered during activities.
   - 3.3 Take responsibility for learning by setting goals, designing plans, managing activities, evaluating success and reviewing the processes used.

Suggested activities

♦ Mix 10 mL of canola oil with 20 mL of water. Shake. Is this a mixture or a solution? Give reasons for your answer. Identify three pairs of substances which produce a solution when mixed and three pairs of substances which produce a mixture when mixed. How is a colloid similar to a solution? How is a colloid similar to a mixture?

  Factors: A5, B16, C8, C12, E9, F2, G2
  Objectives: 1.2, 1.4, 3.2
  Assessment Techniques: anecdotal records, written assignment, short answer test items
  Instructional Methods: inquiry, synectics, compare and contrast

♦ Write instructions for your classmates to follow in order to prepare 250 mL sample of salt solution which is 10% salt by weight.

  Factors: A4, A5, B3, C2, C15, F5, G6
  Objectives: 2.5, 3.1
  Assessment Techniques: peer assessment, rating scale
  Instructional Method: problem solving

- Divide 30 mL of cornstarch into five approximately equal piles. To 15 mL water in a small container (baby food jars work well), add one of the piles bit by bit, stirring as the starch is added. Describe the mixture. How well does it flow? Does it behave like water? Does it stick to the stirring rod or to the edges of the jar? Ask each group to record its observations and share them with the other groups.

  Continue to add each pile of starch to the mixture, stirring as it is added. How do the properties of the mixture change? When enough starch has been added so that the mixture can't be stirred any more, remove the mixture from the jar and knead it to mix the starch and water. One or two more drops of water may be added if the mixture becomes crumbly. Try to discover all the properties of this mixture, which is a colloid.

  Repeat the above procedure, using Epsom salts (or table salt if Epsom salts aren't available). How do the starch/water and the salt/water mixtures compare?

  Factors: A1, A4, B16, C1, C12, E9, F2, G2
  Objectives: 1.1, 3.1
  Assessment Techniques: observation checklists, presentation
  Instructional Methods: inquiry, problem solving

- Bring to class a variety of cosmetics such as lipstick, aftershave, foundation cream, eyeliner, and mascara. Separate into groups of solutions, suspensions, emulsions, gels, powders, and any other groups that can be identified.

  Why is a knowledge of properties of solutions and mixtures necessary for a career in cosmetology?

- Another interesting mixture can be made by mixing 20 mL liquid laundry starch with 10 mL white glue and a small pinch of salt. Stir until it becomes doughy and then remove from the mixing container and knead. If the mixture is too runny to remove from the container, add 5 - 10 drops of white glue and a few grains of salt. How does this mixture compare with the starch/water mixture?

  The mixtures containing starch are examples of colloids. A colloid which you might want to try is made by mixing 10 parts ethanol (ethyl alcohol) with 1 part saturated calcium acetate solution. Saturated calcium acetate is made by slowly adding 100 mL of water to 40 grams of solid calcium acetate, stirring as the water is added. The colloid produced is a gel of the type that is used to produce solid fuels such as *Sterno*. The acetate/alcohol colloidal gel will burn with a hot, blue (almost colourless) flame. A good way to burn it is to place a piece on a wire screen supported well above the surface of a table. Caution students to stay back from the flame. Hair, eyebrows, and eyelashes singe easily.

- Put about 1.5 grams of lead or copper shot in a 10 x 70 or a 13 x 100 test tube. Pour about 400 mL water into a 600 mL beaker. At what level does the test tube float in the water? Change the water level in the beaker. What happens to the level the test tube floats at?

  Predict what will happen when you float the test tube in a 250 mL beaker containing 200 mL water. Try it and see.

  Mark the water level on the wall of the test tube with wax marker or piece of masking tape. Place the tube in a beaker of alcohol. Change the volume of alcohol used. Compare the way the test tube floats in the alcohol to the way it floats in the water.

  Put the test tube in a beaker of saturated Epsom salt solution. How does it float there? Take half the Epsom salt solution and mix it with the same volume of water. Predict the height that the test tube will float in this mixture. What use could such a test tube have?

- Design an experiment to measure the change in solubility of a substance as the temperature changes. Conduct the experiment and report your data in a data chart and accompanying line graph.

  What uses are made in industries of the relationship between solubility and temperature change?

- Compare the following substances to determine which floats on which: alcohol, canola oil, molasses, water. Once you have determined the order create a layered arrangement in a clear glass jar or beaker. What is the best way to keep each layer distinct? Leave the system set up for a week. Periodically inspect it. Do the layers remain distinct?

- Make a mixture of equal volumes of pickling (uniodized NaCl) salt, bluing, household ammonia, and warm water. Stir so that as much of the salt as possible is dissolved. Provide each working group with several pipe cleaners, small blocks of wood and styrofoam, small stones, pine or spruce cones, or pieces of cork. From the pipe cleaners form a model (e.g. spruce tree) which will stand erect when placed on a smooth surface. Soak each of the objects in the solution until saturated.

  Into a reused styrofoam meat tray, pour a 0.5 cm to 1 cm layer of the solution. Stand the objects in the solution. Let the tray sit undisturbed for several days. Observe the formation of crystals. Keep a journal to record the observations and development over time. A polaroid camera, video camera or 35 mm camera with slide film could be used to record the progress of the crystal formation. On which objects do the crystals form best? How do the crystals vary?

  Extension: Using a large tray and the objects which promote the best crystal formation, create a garden, scene or abstract display which will be crystallized with the above solution.

  Experiment with different types of solutes. Epsom salts, iodized (table) salt, calcium chloride, copper sulfate (bluestone), or potash are possibilities. Also vary the proportions of the components, substitute food colouring in water for bluing, the temperature at which the trays are stored and other variables which the students may identify.

- Design and conduct an investigation to measure how much Epsom salt will dissolve in 100 mL of warm water. Coordinate your design with the designs of other groups to measure the solubility over a range of temperatures. Graph the data from the groups' experiments.

  Using the saturated solution produced in the investigation above, or a saturated solution prepared for this part of the activity if none was produced in the first part, investigate the properties of the solution. What happens if an ice cube and 25 mL of the solution are mixed in a baby food jar (or in a 100 mL beaker)? Compare the rate of diffusion of a drop of food colouring, a crystal of potassium permanganate or a drop of coloured liquid dishwashing detergent through the saturated salt solution and through a sample of water at the same temperature. Petri dish halves or jar lids are good containers for this activity. Will a crystal of pickling salt or another crystal of Epsom salts dissolve more quickly if left undisturbed?

- Float a cube of wood in a container of water. Carefully remove the block from the water so that the water line on the block remains undisturbed. Use a permanent marker to mark the water line on the block. Predict where the water line of the saturated salt solution will be. Repeat this with a styrofoam block. Dilute a sample of the saturated solution by half (e.g. 25 mL water plus 25 mL solution). Predict where the water lines of floating wood and styrofoam blocks will be. Discuss the results and publish your data on a poster.

- Give each student a sample of an unknown solution. (The unknown is hot gelatin solution – 15 grams gelatin per litre of water.) Tell the students that they will be measuring fall rates of BB pellets through a solution as it cools. A pellet should be dropped every 15 seconds and the time recorded.

  Dialysis tubing could be used to hold the gelatin. Prepare a 50 cm tube by soaking one end of 1 metre length of tubing and then tying a knot in the softened end. Experiment with various ways of suspending the dialysis tubing so that the top is open to drop the BB pellets in. Trim the tube so that it is about 55 cm long when suspended. Fill the tube by pouring the hot gelatin into it through a funnel. Support the tube so that the suspension device does not break when the gelatin is added.

  The gelatin will change from allowing a fall rate similar to that through water to bouncing the BB off the surface. Ask the students to reflect on their data. Repeat the experiment with saturated Epsom salts and with water. How do the results compare to the results with gelatin?

- The use of the CEPUP module **Solutions and Pollution** (part of the **Chemical Survey & Solutions and Pollution** book) is highly recommended for use with this unit. Since solution chemistry is an important part of understanding water pollution, this is an excellent context in which to learn about solutions.The CEPUP book **Investigating Groundwater: The Fruitvale Story** extends and applies this knowledge about solutions.

Energy Resources in Saskatchewan

Unit overview

The definition of resources can be narrow or broad. It may include only what is extracted from the earth for the economic benefit of humans or what supports and enhances all forms and aspects of life. The broader definition is the guiding principle for the conservation emphasis in Middle Level science. In this unit however, students consider three primary energy resources which are extracted and used in Saskatchewan. This unit has strong connections to the grade 7 optional unit **Resource Use**.

Coal is mined across a large area of southern Saskatchewan. The lignite coal which is produced is used primarily as a heat source in the production of electricity. Along with the formation, extraction, and distribution of coal, the production, distribution, use, and conservation of electricity is considered.

Saskatchewan is a major natural gas producer. Since the predominant use of natural gas is for space heating, students will examine the construction of, and design of, energy efficient buildings. This topic offers teachers and students who are interested a chance to explore the topic of heat flows.

Much of the petroleum produced in Saskatchewan is classified as heavy crude oil. What is heavy crude? How does it differ from light and medium grades of crude oil? How does the production of ethanol in Saskatchewan supplement gasoline as a fuel for internal combustion engines? What conservation measures can be effective for conserving petroleum?

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. The energy industry produces a large volume of informational material written at a reading level appropriate for grade 8 students. Writing reviews, summaries, and reports of these materials are strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

A class debate with students taking roles of various interest groups in Saskatchewan society on the topic "Conservation strategies can eliminate the need for new electrical production capacity in Saskatchewan." is an example of a whole-class challenge activity.

Factors of scientific literacy that should be emphasized

A2 historic
A3 holistic

B1 change
B5 perception
B12 conservation
B15 model
B25 time-space

C2 communicating
C4 working cooperatively
C9 inferring
C10 predicting
C12 interpreting data
C16 designing experiments

D1 science and technology
D3 impact of science and technology

E2 using natural environments
E8 measuring time

F2 questioning
F3 search for data and their meaning
F4 valuing natural environments
F6 consideration of consequence

G2 confidence
G6 response preference

Concept development

grade 4
- effect of energy on matter
- how forms of energy compare

grade 5
- resources which are used to produce goods and energy

grade 6
- energy as a scarce resource
- one-way flow of energy through systems

grade 7
- distinction between renewable and nonrenewable sources of energy

grade 9
- effect of energy production and use by humans on the ecosystem

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the formation and extraction of the mineral resources coal, natural gas, and petroleum.
   - 1.1 Relate the deposition or formation of the deposits to the geological periods involved.
   - 1.2 Describe how exploration uncovers the presence of these resources.
   - 1.3 Describe how the resources are extracted and refined.
   - 1.4 Assess the impact that the search for, extraction of, and refining of fossil fuels has on Saskatchewan and Canadian environments.
   - 1.5 Assess the impact that the search for, extraction of, and refining of fossil fuels has on Saskatchewan and Canadian societies.

2. Study the creation of demand for, and the patterns of use of, fossil fuels.
   - 2.1 Outline the uses which are made of the products of the refining process.
   - 2.2 Examine the distribution of these resources in Saskatchewan.
   - 2.3 Consider the infrastructure needed to support the industries related to these resources.
   - 2.4 Assess the impact that the use of fossil fuels has on Saskatchewan and Canadian environments.
   - 2.5 Assess the impact that the use of fossil fuels has on Saskatchewan and Canadian societies.

3. Identify and evaluate methods for the conservation of fossil fuels and energy derived from fossil fuels.
   - 3.1 Suggest and analyze measures to reduce demand for gasoline.
   - 3.2 Investigate ways to promote and to inhibit heat flows.
   - 3.3 Discuss the use of heat conservation techniques in building construction.
   - 3.4 Outline the process of conversion of chemical energy in coal to electrical energy.
   - 3.5 Recommend ways to reduce the demand for electricity.

4. Develop compassionate, empathetic and fair-minded students who can make positive contributions to society as individuals and as members of groups. (PSVS)
   - 4.1 Explore the consequences which individual and societal resource-use decisions have on all life.
   - 4.2 Recognize that balance is needed between the rights of the individual and the well-being of the group.
   - 4.3 Explore and develop empathy for all persons based on an understanding of human needs and an ability to imagine themselves in the situations of others.
   - 4.4 Recognize the importance of communication as a tool for maintaining respect and harmony in social situations.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Use the Saskatchewan Resource series module **Petroleum**.

  Factors: A2, B5, B15, C10, C12, D3, E2, F4
  Objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.1, 2.3, 2.4, 2.5, 3.1, 4.1, 4.2, 4.4
  Assessment Techniques: observation checklists, rating scales, written assignments, oral assessment
  Instructional Methods: mastery lecture, structured overview, case studies, simulations, research projects, discussion

- Use the video **Natural Gas – The Movie** along with the accompanying teacher's guide. This package was developed by SaskEnergy.

  Factors: A3, B12, B25, C10, C12, D3, F6, G6
  Objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.1, 2.3, 2.4, 2.5, 3.2, 3.3, 4.3, 4.4
  Assessment Techniques: written assignments, performance assessments
  Instructional Methods: learning activity package, reflective discussion

- A teacher package is available from the Coal Association of Canada in Calgary. It contains information about the mining, distribution, and use of coal in Canada.

  How much coal is mined in Saskatchewan each year? How does the heat energy available from this coal compare to the energy available from the natural gas produced in Saskatchewan? What is the primary use for the coal mined in Saskatchewan?

  Factors: A2, B12, B15, C9, D3, E2, F4, G6
  Objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.1, 2.3, 2.4, 2.5, 3.4, 3.5, 4.1, 4.2
  Assessment Techniques: extended open response test items, presentations, portfolios
  Instructional Methods: problem solving, didactic questions, research projects

- How does lignite coal form? How does it compare to bituminous and anthracite coals?

- Debate the proposition: Coal is the best way to generate electricity in Saskatchewan. A source of information is the **Saskatchewan Electrical Energy Options Final Report** and **Our Future Generation – Electricity for Tomorrow**, both available from SaskPower.

- Compare the use of natural gas, fuel oil, electricity, wood, and solar energy for heating houses. What are the advantages and disadvantages of each method? How much is each used in Saskatchewan today?

- Natural gas, fuel oil, and coal are all nonrenewable resources. What estimates do producers of these fuels have about the current available supply. What percentage of total use in Saskatchewan of each of these fuels is for home heating?

  Suppose that through conservation measures, 20% of the fuel used for home heating could be saved. By what percentage would that reduce the total consumption?

- Why isn't coal used to heat houses any more? Interview someone who used coal in a home furnace or a kitchen stove. What do they recall as the advantages and disadvantages of using coal as a fuel?

- Design a house which would require a minimum of fuel to heat. Explain how the various features of the house contribute to the goal of minimum fuel use. What energy sources would be used for heat? Explain why the source(s) you picked is best in your situation.

- Activity 7, "The Great Oil Crisis of 1999", from the CEPUP module **Plastics in Our Lives** is a simulation game in which students must make decisions on allocating scarce resources. Since all nonrenewable energy resources are scarce, this activity is an excellent choice for using during this unit.

- Design a controlled experiment to compare insulation values of various substances. Investigate such questions as: Does the temperature difference between the two sides of the insulating material make a difference? Does the increase in insulation value increase linearly with the thickness?

♦ Brainstorm to produce a list of all the appliances and devices that use electricity in our houses and schools.

Put the devices identified in a column on the left side of a piece of paper. Over the second column, write the heading "Substitute". In this column, list any substitutes that could be used for the item in the first column. In the third column estimate whether electricity would be saved by using the substitute. An example is found below.

Device	Substitute	Saving
microwave oven	electric oven	no
microwave oven	wood stove	yes
electric toothbrush	manual t.b.	yes

Once the chart has been completed assign lines of the chart to various groups to research and present an argument for the feasibility of making the substitution where possible savings were identified. Each group should make an oral presentation of their argument to the class.

♦ What is the principle behind the energy efficient lighting which was developed in the late 1980s? Why are fluorescent bulbs more efficient than incandescent bulbs? Why are low pressure sodium vapour and high pressure sodium vapour lights replacing mercury vapour street lights in urban situations?

♦ Activity 5 in the CEPUP module **Plastics in Our Lives** is an exploration of the insulating characteristics of polystyrene foam and a polysaccharide foam (popcorn). This activity fits in well with the focus in this unit on home and building insulation for the conservation of heat produced by burning natural gas.

The Earth and Space

Unit overview

Space exploration has an appeal which is hard to resist. The desire for knowledge of what is beyond the bounds of the Earth's atmosphere is strong. Radio-astronomy, the SETI project, the Apollo, Soyuz, Skylab and shuttle missions, the Venera, Pioneer, Voyager, and Mariner probes all have given people a glimpse of the extraterrestrial. Questions of the structure of space, the characteristics of stellar and planetary objects, and how humans inquire into these phenomena form the basis of this unit.

This unit is related to the core grade 6 unit Exploring Space. Some of the objectives follow from the objectives of that unit. The outline of the grade 6 unit should be read and the students' concepts assessed according to the objectives of that unit.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing helps students make sense of what they are seeing and reading, and helps them adjust the way they look at the world. Students come into science classes with an understanding of how things work. Often their understandings are not the same as the way scientists understand events or do not correspond to what they themselves observe. Reflective writing can help them reevaluate their ideas and schemata. Reading newspapers and journals is an important source of ideas, and reporting on the activities of science class by writing advertisements, reports, and stories are strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. Many of the suggested activities in this unit are Science challenge activities.

Factors of Scientific Literacy that should be emphasized

A1 public/private
A6 probabilistic

B5 perception
B13 energy-matter
B15 model
B17 field
B21 accuracy
B24 scale
B25 time-space

C3 observing and describing
C8 hypothesizing
C13 formulating models
C18 using time-space relationships

D6 resources for science and technology
D8 limitations of science and technology

E1 using magnifying instruments
E6 measuring distance

F3 search for data and their meaning
F7 demand for verification

G3 continuous learner
G7 vocation

Concept development

grade 3
- motions of the Earth and the Moon
- description of the planets of the solar system

grade 6
- technologies to explore and inhabit space
- monitoring earth from space

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the movements of the planets and other bodies in the solar system.
   1.1 Describe how the rotation of the Earth produces day and night.
   1.2 Account for the differences of day length in midsummer and in midwinter.
   1.3 Explain why the Sun has a stronger heating effect in summer than in winter in the northern hemisphere.
   1.4 Compare the speed and the length of path of the orbits of the planets.
   1.5 Explain the retrograde motion of the planets in the sky.
   1.6 Identify by sight the planets Venus, Jupiter, and Mars.

2. Recognize the conditions which govern life in space.
   2.1 Study the physiological and psychological experiences of astronauts and cosmonauts in the skylab and spacelab programs.
   2.2 Research the successes and failures of the space shuttle program.
   2.3 Consider the distances and times involved in interplanetary and interstellar space travel.
   2.4 Investigate ideas about space exploration expressed in science fiction.

3. Reflect on the matter of interstellar travel.
   3.1 Determine how distances to stars are estimated.
   3.2 Examine the distribution of stars in the sky.
   3.3 Identify the various types of objects and groupings of objects in interstellar space.

4. Provide for students' active involvement in decision-making about space exploration. (TL)
   4.1 Generate alternatives to technological innovations in the study of space.
   4.2 Participate in debate about the support of space exploration.
   4.3 Examine the place of space science and technology in North American science.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Build a model to show why Venus is sometimes seen as a bright "morning star", rising slightly ahead of the sun, sometimes as an "evening star" setting shortly after the sun but never high in the sky during the middle of the night.

Factors: B15, B24, C18, F7, G3
Objectives: 1.4, 1.5
Assessment Techniques: observation checklist, oral assessment
Instructional Methods: model building, concept formation

♦ Build a model that shows the tilt of the Earth with respect to the plane of its orbit. Use the model to show why there is stronger heating in the northern hemisphere during the summer than during the winter. Use the model to explain why the Tropic of Cancer is at 23° north latitude and why the Arctic circle is at 67° north latitude. Show why there is 24 hours per day of daylight north of the Arctic circle during the summer.

Factors: B15, B24, C18, F3, G3
Objectives: 1.1, 1.2, 1.3
Assessment Techniques: rating scale, oral presentation, short answer test items
Instructional Methods: model building, problem solving

- ♦ Start an astronomy club. Some activities of the club might be to:
  - develop a monthly astronomy newsletter;
  - build telescopes;
  - observe stars;
  - telecommunicate with others interested in astronomy;
  - plan field trips or special events;
  - photograph the moon; or,
  - invite guest speakers.

  This club could be operated as part of the regular instructional program or as an extracurricular activity open to students in other grades. If there is a local astronomy club, opportunities might exist for guest speakers and cooperative efforts.

  Factors: A1, C3, B5, B25, C18, D8, E1, F3, G7
  Objectives: 1.6, 3.2, 3.3, 4.1
  Assessment Techniques: self assessment, presentations
  Instructional Methods: field observations, reflective discussion, explicit teaching, problem solving

- ♦ Create a scale model of the distances between planets in the solar system. Assign students the responsibility to find out the distances involved, or use the values on the chart accompanying this activity.

Planet	**Distance (in A.U.)**	**Relative Diameter**
Mercury	0.39	4
Venus	0.72	9
Earth	1.00	10
Mars	1.52	5
Jupiter	5.20	112
Saturn	9.52	94
Uranus	19.60	37
Neptune	29.99	38
Pluto	39.37	5
Planet X	?	?

  Use string to represent the scaled distance from the sun to each planet. Tape a tag on the string to indicate where each planet would be located on the scale you are using. Use the actual distance between Pluto and the Sun to determine what scale should be used so that the model can fit within the room available to the students. This calculation is easier for students if they use the distance in astronomical units (A.U.) rather than the distance in metres. 1 A.U. is the mean distance of the Earth to the Sun.

  Make spheres to show the planets in their relative sizes. Again ask the students to calculate the scale needed so that the model of Jupiter is a reasonable size. Actual diameters in metres or the relative diameters from the chart can be used. How large would the diameter of the Sun be on a scale that places the Earth at a diameter of 10 units? Why is there a Planet X in the chart?

  These spheres can't be used with the string model of the distances between planets since the scales are different. Ask the students to calculate the size of the sphere models of the planets if they were built to the same scale as was used to make the distance model.

- ♦ In the previous activity, the value for the distance from the sun to Neptune, in astronomical units, is 29.99. The value given for Pluto is 39.37 astronomical units. During part of Pluto's orbit, the planet is inside the orbit of Neptune. In other words, it is closer to the sun than Neptune. If that is the case, ask students to research this to determine how the values of 29.99 and 39.37 are derived.

- ♦ Debate the issue "The development of the space shuttle has benefited human life on Earth."

- ♦ Calculate how long it would take the current space shuttle to reach the moon, Mars, Jupiter and the edge of the solar system. What are some of the problems associated with missions of these lengths?

- Investigate how the characteristics of the planets correspond to the names of the Roman gods after which they were named? Who was the god Mercury? Why was his name given to the planet?

  What are the names of Jupiter's moons? Why were they given these names? Is there a name for our moon, other than "Moon"?

- Where is the North Star? Why was the North Star important for the Aboriginal peoples of North America? Some people say that the North Star is in the constellation called the Little Dipper. Others say it is in the constellation called Ursa Minor (The Small Bear). Can a star be in two constellations at the same time?

- Research the construction and use of medicine wheels by the various Plains Indian peoples. What signposts in the sky did they rely on? What did these signposts point to?

- Why does the sun rise in the southeast during the winter, in the east during spring and fall and in the northeast during the summer? Does it ever change the direction in which it sets?

- Observe the position of the moon in the sky for at least one month. What patterns govern its motion and position?

- Why is there a full moon only when the moon rises as the sun sets? What is a "blue moon"? What makes a harvest moon appear to be red?

- Create a device to measure the apparent diameter of the moon as it rises. Compare this diameter to the diameter measured when the moon is high overhead in the south. How can you explain the results of your measurements?

- If you were outside during January, and saw the constellation Orion in the sky, which direction would you be facing? How could this information be of some use to you? Why isn't Orion visible in the sky during the summer?

Consumer Product Testing

Unit overview

Many manufacturers make claims about the performance of their products. The Advertising Standards Council has regulations which govern the type of claims that can be made and the degree of accuracy which must be inherent in the claims. Students are given an opportunity in this unit to identify the important characteristics of various products (identify the significant variables), devise comparative and absolute tests of those characteristics (design and conduct controlled experiments), and produce advertisements which communicate the results of those tests (report the results of their procedures).

The unit is intended to allow students to see how the principles of science are applied for purposes other than for pure understanding of how things work. It will give students an opportunity to be creative and critical thinkers, and to undertake an independent project.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. By writing about what they see, hear, and do, students can make better sense of all this sensory input, some of which contradicts what they already believe or feel intuitively. If they are simply asked to recall what they see, hear and read, they do not have to process the information. A variety of writing tasks is equally important in learning as a variety of input stimuli. Through reflective, narrative, and expository writing students refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. Science challenge activities are included in the activities suggested for use in this unit.

Factors of scientific literacy that should be emphasized

A4 replicable
A5 empirical
A8 tentative
A9 human/culture related

B8 quantification
B9 reproducibility of results
B10 cause-effect
B11 predictability
B19 probability
B21 accuracy
B24 scale

C3 observing and describing
C5 measuring
C6 questioning
C8 hypothesizing
C9 inferring
C11 controlling variables
C12 interpreting data
C16 designing experiments
C17 using mathematics

D3 impact of science and technology
D5 public understanding gap

E3 using equipment safely
E4 using audiovisual aids
E7 manipulative ability
E13 using quantitative relationships

F3 search for data and their meaning
F5 respect for logic
F7 demand for verification

G1 interest
G6 response preference

Concept development

Throughout all grades, students have been encouraged to identify characteristics of objects. They have also learned about controlling variables in experiments and about reporting the results of their investigations. These abilities are all required to test consumer products.

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the principles of product design, test design, and report design.
   - 1.1 Identify the important uses of the product.
   - 1.2 Match characteristics of the product which make it appropriate for each use.
   - 1.3 Devise criteria-referenced tests for each characteristic.
   - 1.4 Design comparative tests to rank competitive products.
   - 1.5 Conduct tests on products.
   - 1.6 Write "scientific, objective" reports to give the results of the tests done.
   - 1.7 Write advertising based on the testing results.
2. Practice different ways of communicating information. (COM)
   - 2.1 Explore and express the purpose behind product testing.
   - 2.2 Identify the message and its purpose in product advertising.
   - 2.3 Ask pertinent questions about the validity of product testing.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Select a product to test. List criteria which define the use of that product. A good place to find these criteria is in advertisements for the product. The manufacturers will often define the use and conditions of use of their products.

Design and conduct controlled investigations which evaluate the product on the criteria identified. Write the script for a radio commercial or design a magazine advertisement which communicates the information which the product evaluation has revealed.

Factors: A4, A9, B8, B9, B21, C5, C11, C16, D5, E13, F3, F7, G6
Objectives: 1.1, 1.3, 1.6, 2.1
Assessment Techniques: observation checklist, written reports, oral assessment
Instructional Methods: research projects, conducting experiments

♦ Do all varieties of crispy rice cereal (Kellogg's Rice Krispies and clones) stay crunchy when they are in milk? Does adding sugar to them in the bowl affect how well they stay crunchy? Design an investigation to answer these questions. Identify variables which must be controlled, establish criteria for evaluation of crispness, and develop tests which can control for the identified variables.

Factors: A4, A5, B8, B9, B10, B21, C11, C16, C17, D3, E13, F5, G6
Objectives: 1.4, 1.5, 2.3
Assessment Techniques: written reports, oral assessment, rating scales
Instructional Methods: conducting experiments, problem solving

♦ In a variety of media, find advertisements which are presented as a scientific report or as supported by scientific reports. Analyze the ways the products were tested and the ways the results were presented.

Factors: A5, A8, B10, B19, B24, C6, C9, C16, D3, E4, F5, G1
Objectives: 2.1, 2.2
Assessment Techniques: oral assessments, presentations, anecdotal records
Instructional Methods: case studies, research projects

- Get a book of household hints. Investigate the truth of some of the claims, such as removing rust stains from fabric with sour milk.

- As a whole class group, brainstorm ideas about evaluating cookies. What characteristics do you look for in a cookie? How should they be packaged, and labelled? How should they be advertised?

  From the ideas you have brainstormed, compile a checklist you could use to evaluate cookies, their packaging, and their advertising. Test the checklist by evaluating several brands of cookies.

  From a cookie cookbook, select an interesting recipe. Cooperate among your group members to acquire the ingredients and to make the cookie your group has selected.

  Develop a marketing campaign to sell the rest of the class on the excellence of your cookie. Devise a label to use on the package of cookies, and an advertising campaign (of at least one advertisement) to convince people how good your cookies are.

  Develop a package that you feel meets the criteria of the evaluation sheet developed by the class. Exchange a package of four of your cookies, the label you have designed, and the copy for the advertising campaign with another group in the class. Evaluate the label, the package, the cookies, and the advertising campaign based on the checklist developed by the whole class.

  Are there suggestions for changes to the evaluation checklist after you have evaluated the other group's cookies?

- As a class project conduct a survey to determine whether people in your community have been influenced to buy a product because it has been endorsed by a sports, entertainment or other celebrity. Find out what products these are. Categorize the products. Are there any categories that predominate? Discuss on what basis product purchasing decisions should be made. How much a role does advertising play in our decisions? How much of this role is helpful?

- Student Activity Sheet 5.3 in the CEPUP module **Plastics in Our Lives** is a survey form to help discovers people's ideas about the debate between the use of disposable or cloth diapers. Activity 6 continues from this starting point to compare characteristics such as absorbency, production costs, and recyclability.

Plant Growth

Unit overview

Plants are essential to life. Not only do they supply oxygen to the air and act as the base of many food pyramids, but in Saskatchewan, they are an integral part of the economic base of the province. How much oxygen do plants produce? Why do some plants grow more quickly than others? Why won't some plants grow at all in Saskatchewan? If using fertilizers helps plants grow, will using more fertilizers help them even more? How does saline soil inhibit plant growth?

These are some of the questions which can be considered during this unit. Encourage your students to go beyond the information in the resources and the bounds of the classroom walls to find out about plant growth, and the importance of plants to our lives.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal reflective journals, reading from newspapers, and reporting on the activities of science class in various formats such as essays, newspaper articles, posters, and letters are strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. Investigating how varying one factor influences plant growth is a science challenge activity.

Factors of Scientific Literacy that should be emphasized

A2 historic
A3 holistic
A5 empirical

B4 organism
B9 reproducibility of results
B16 system
B18 population
B20 theory

C1 classifying
C11 controlling variables
C13 formulating models
C14 problem solving
C16 designing experiments

D3 impact of science and technology

E2 using natural environments
E13 using quantitative relationships

F4 valuing natural environments
F6 consideration of consequence

G2 confidence
G5 avocation

Concept development

grade 1
- characteristics and basic needs of plants

grade 2
- conditions important for optimum plant growth

grade 3
- adaptive nature of plant structures

grade 4
- diversity of plant species

grade 5
- functions of specialized plant tissues and organs
- the place of agriculture in Saskatchewan

grade 6
- plant response to external stimuli

grade 7
- consideration of plants as living organisms
- how plants are adapted to the Saskatchewan environment

grade 8
- how plants alter the abiotic and biotic conditions they encounter

Foundational and learning objectives for Science and the Common Essential Learnings

1. Explore the factors which influence plant growth.
   - 1.1 Identify factors important for plant growth.
   - 1.2 Classify factors as external or internal to the plant.
   - 1.3 Consider the ease of regulation of growth factors.
   - 1.4 Investigate methods of manipulating factors.
   - 1.5 Design and conduct experiments to compare effects of alteration of growth conditions.

2. Understand the relationship between plant growth and agricultural practice.
   - 2.1 Examine the effects of irrigation on both plants and soil.
   - 2.2 Explain how fertilizers and herbicides affect growth patterns.
   - 2.3 Describe selective plant breeding.
   - 2.4 Consider how the technologies of cloning and genetic alteration influence the evolution of species.

3. Develop an understanding that technology both shapes society and is shaped by society. (TL)
   - 3.1 Explore the relationship between the natural and the constructed worlds.
   - 3.2 Investigate how human needs shape the direction and development of technological innovations in modifying plant growth.
   - 3.3 Examine how technological innovations produce change in the natural world.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

- Go to a location in your area where the soil is saline. Determine what plant species are growing in the soil. Describe and measure the plants. Talk to some farmers to gather their observations about the effect of saline soils on growth of grain crops, forage crops, and weeds.

  Find a location with a similarly-structured nonsaline soil. Record a description of the species growing there. Compare the observations made at the two locations. Perhaps a regional extension agrologist can suggest some good sites for the observations. Be sure to obtain permission before entering private land. How does saline soil inhibit plant growth?

  Factors: A3, A5, B4, B16, C1, C13, E2, F4
  Objectives: 1.1, 3.2
  Assessment Techniques: short answer test items, presentations, anecdotal records
  Instructional Methods: field trips, interviews, discussion, explicit teaching

- A recent study stated that seedlings which were touched as they grew developed stockier stems than those which were not touched. Germinate some field peas or lentils in peat pots and divide the pots into three experimental groups. In one group the leaves will be stroked by hand or with popsicle sticks for 30 seconds once an hour during the school day. Another group will be exposed to the breeze of a fan during the school day, and the third will be left alone. Plastic or mulch cover may be needed to prevent drying in the pots on which the fan blows.

  Under what conditions in nature would the seedlings of plants be touched as they grew? How would having stockier stems under these conditions help the plants to survive?

  Factors: A5, B20, C11, C16, E13, F6, G2
  Objectives: 1.5, 3.2
  Assessment Techniques: rating scales, presentations, oral assessment
  Instructional Method: problem solving

- Design an experiment to test the effects of various strengths of fertilizer solution on the growth of canola seedlings in peat pots.

  Factors: A5, B9, C11, C16, D3, E13, F6
  Objectives: 1.5, 2.2, 3.3
  Assessment Techniques: extended open response test items, performance assessment, rating scales
  Instructional Methods: conducting experiments, reports

- How much oxygen do plants produce? How many grass plants would it take to produce enough oxygen per day to supply one person?

- Why do some plants grow more quickly than others?

- Why won't some plants grow at all in Saskatchewan? Get a seed catalogue from McFadyen's in Brandon. Determine the hardiness zone in which your school is located. How many plant varieties are listed as hardy for the area of your school. How do hardy plants differ from others?

  Prepare a questionnaire which you can use to structure interviews of gardeners in your area. What experiences have they had with trying to grow plants which were rated as not hardy enough for the area? What suggestions do they have for growing plants to the earliest possible maturity? What other comments can they make about gardening?

- If using fertilizers helps plants grow, will using more fertilizers help them even more?

Energy and Machines

Unit overview

Complex machines are most often a set of simple applications of simple machines, organized and sequenced to complete a job which has multiple tasks. An example of this is a seed drill for planting wheat. Each row is seeded after a wedge attached to the end of a lever has opened the soil, the seed has been inserted, and the soil closed by a wheel and axle. A number of these components ganged together produces the bulk of the operating system. The control of the seed flow, depth that the soil openers run, and a host of other variables are controlled by other applications of pulleys, levers, and other simple machines.

This unit gives students a chance to review the principles of the simple machines, analyze the construction of complex machines, and design some machines of their own.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word. Examples of activities which contain a writing or reading components are found in the **Suggested activities** section of this unit.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. The **extension** phase of each lesson is an ideal place for students to create their own challenge opportunities or to choose from opportunities suggested to them.

Factors of scientific literacy that should be developed

A4 replicable
A5 empirical
A9 human/culture related

B6 symmetry
B7 force
B10 cause-effect
B15 model
B24 scale

C4 working cooperatively
C8 hypothesizing
C11 controlling variables
C14 problem solving
C18 using time-space relationships

D1 science and technology
D2 scientists and technologists are human
D3 impact of science and technology
D5 public understanding gap
D8 limitations of science and technology

E3 using equipment safely
E7 manipulative ability

F2 questioning
F5 respect for logic
F6 consideration of consequence

G1 interest
G5 avocation

Concept development

grade 4
- conversion of energy from one form to another
- relationship between force and motion

grade 5
- principles and advantages of simple machines

grade 7
- examination of constructed and natural structures

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the principles of machines.
   1.1 Review the types of simple machines.
   1.2 Describe how each class of simple machine transfers energy.
   1.3 Devise ways to measure the force delivered by a machine.
   1.4 Analyze the relationship between force input and force output.
   1.5 Identify the advantages produced by using simple machines.

2. Combine knowledge of the principles of design with the principles of simple machines.
   2.1 Design machines which use a combination of simple machines.
   2.2 Design machines which will accomplish a particular task.
   2.3 Devise machines which are intended to entertain.
   2.4 Create a working model from one of the designs.

3. Develop an understanding that technology both shapes society and is shaped by society. (TL)
   3.1 Explore the impact of machines on the immediate environment.
   3.2 Explore the impact of machines on past and present family and community life.
   3.3 Understand how the use of machines influences occupational roles within society.
   3.4 Examine how the demands from society and individual members of society influence what machines are developed.

Suggested activities

♦ Fantastic mechanical devices involving a complex series of simple machines (levers, wheels and axles, pulleys) linked to accomplish a simple or mundane task are often called Rube Goldberg machines. An example is found in the Eggo™ TV advertisement where a boy has a machine to get the waffle from the toaster in the kitchen downstairs before his father gets it.

In small groups, brainstorm to produce a list of such mechanical devices which could be used around home or at school. Select several and produce sketches of such machines. Can you identify any machines that actually exist that come close to falling in the category of Rube Goldberg machines?

Factors: A9, B6, B10, C4, C14, D2, E3, F5, G1
Objectives: 2.1, 2.2, 2.3,
Assessment Techniques: peer assessment, rating scale, presentations
Instructional Method: problem solving

♦ Devise, sketch, and build a machine which will remove the plastic wrapping from a three pack of juice boxes. Is such a machine a necessity? If one was produced, would anyone buy it? Create a marketing/advertising campaign for the product.

Can you think of any product that two or three years ago you had never heard of, but now is considered something you need. Ask your parents or grandparents if they can think of any devices that fit in this category.

Factors: A9, B7, B15, C11, D3,
Objectives: 2.2, 3.2, 3.4
Assessment Techniques: self and peer evaluations, rating scales, presentations, oral assessment
Instructional Methods: cooperative group learning, model building, problem solving

- Activities 5 to 24 from *Evidence of Energy – An Introduction to Mechanics (Book Two)*, (Gartrell, 1990) deal with the physicist's conception of work and how machines enhance the ability to do work. The book includes an extensive reading section with background information on each of the activities and concepts, written for a teacher who is not a science specialist. Lists of all materials needed to do the activities and a glossary are included. The book is produced and published by the National Science Teachers' Association in the U.S.A. Permission is granted by that organization for reproduction of any of the materials in the book for classroom use. One copy, at a 1991 price of US$16.50, is sufficient for each classroom.

- Bring a bicycle (or several) into the classroom. How many different simple machines can you find on the bike? How do these machines interact to make the bicycle move? If the bicycle is a multi-speed bike with a number of different sprockets on both front and back wheels, figure out how the various combinations of pedal sprockets to drive wheel sprockets give you the range of rear wheel speeds from low to high.

- Mills for producing flour from grains were very early users of machines. Trace the use of machines to turn millstones from the earliest recorded time to the present. Are actual stones still used to grind grains in mills?

- Create a bulletin board display illustrating the three classes of levers. Use both posters diagramming each type, and pictures or drawings of machines, appliances, and devices that use each type.

- Physicists define work as being done when a force is exerted and the object on which the force is exerted moves. Work continues to be done as long as the force is still being exerted on the object. When you throw a ball, you are doing work on the ball while your arm is moving forward. Once you release the ball, you are no longer doing work on the ball. If you push as hard as you can on a wall, and the wall doesn't move, you aren't doing any work on the wall.

  Physicists calculate the amount of work done by multiplying the force applied by the distance in metres over which the force is exerted. Force is measured in units of newtons. 1 newton (1 N) of force is the amount of force required to lift a mass of 100 grams. 1 newton exerted over a distance of 1 metre is called 1 joule (1 J) of work. To calculate work done you must be able to measure both the force applied and the distance over which the force was applied.

  Gravity exerts a force on all objects. The downwards force on a mass of 100 grams at the surface of the earth is 1 newton. This downwards force is called weight. How much downwards force is there on a mass of 500 grams? On a mass of 4.5 kg? On your mass? If you were to be transported to the moon, your mass would stay about the same, but your weight would be a lot less. Why would this be?

  Make a device that can measure the amount of force applied to an object. Standard masses for calibrating your instrument can be made by adding sand to empty 35 mm film canisters or baby food jars. If these standard masses are produced in fractions or multiples of 100 grams, then the forces to lift them will be in fractions or multiples of 1 N.

  Use your device to measure force inputs and outputs of various simple machines and household items. How much force does it take to depress the arm of a equal-arm first class lever (like a teeter-totter) loaded with a 500 gram mass? To raise a 100 gram mass with a pulley? To pull down a window blind? To turn on a light switch? To open a drawer?

- Mass is an amount of matter; weight is a force applied by gravity to matter. Do bathroom scales measure mass or weight? What are the standard units of mass? What are the standard units of weight? Create a conversion chart so that your bathroom scale measurements can be reported in newtons.

- Build a model car, boat, or airplane powered by a rubber band. All vehicles must be able to travel a distance of at least two metres with one charge of the band. Enter your finished vehicle in one of the following categories:
  - lightweight- mass of vehicle in grams
  - lightweight efficient- time of vehicle's trip divided by mass of vehicle
  - distance- distance travelled
  - time- time elapsed from first to last motion
  - speed- maximum average speed over any 5 second period
  - workhorse- load multiplied by distance moved
  - innovative design- poster describing innovative features to be rated by peers
  - other categories you wish to create

Science 9

Saskatchewan – The Environment

Unit overview

In their chapter of the book ***Endangered Spaces***, David Henry and David Gauthier begin by quoting Adrian Forsyth:

> Within one human lifetime, the prairies have passed from wilderness to become the most altered habitat in this country and one of the most disturbed, ecologically simplified and overexploited regions in the world. (Hummell, 1989)

This unit is designed to allow students to examine the ecosystem in which they live, to compare that system to other environments in Saskatchewan, and to appreciate both how much and why human habitation has changed the face of the province. The optional unit **Diversity of Life** may be integrated with this unit.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. When students read from a variety of sources – newspapers, magazines, both narrative and expository nonfiction – and when they are given opportunity to use reflective, narrative, and expository writing in various formats to express what they are learning, students refine their understanding of the concepts of science and develop their ability to communicate through the written word. It is critical not to confine science reading to textbooks and science writing to structured laboratory reports. Each of these is important, but is only one component of a well-rounded science program. Several suggestions for appropriate writing and reading assignments are found in the **Suggested activities** section of this unit.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning. With topics such as ecology and the environment there is lots of scope for student-initiated science challenge activities in this unit. These may involve student research, writing or action to help them understand and preserve their environment.

Factors of scientific literacy that should be emphasized

A2 historic
A3 holistic
A5 empirical
A7 unique

B1 change
B2 interaction
B10 cause-effect
B12 conservation
B14 cycle

B16 system
B18 population
B22 fundamental entities
B24 scale
B26 evolution

C2 communicating
C3 observing and describing
C8 hypothesizing
C12 interpreting data
C13 formulating models
C15 analyzing
C19 consensus making

D2 scientists and technologists are human
D4 science, technology, and the environment
D5 public understanding gap
D7 variable positions

E2 using natural environments
E7 manipulative ability
E13 using quantitative relationships

F2 questioning
F4 valuing natural environments
F6 consideration of consequence

G3 continuous learner
G6 response preference

Concept development

grade 2

- different habitats for different organisms

grade 6

- how and why ecosystems develop

grade 7

- food, water, shelter, space as requirements of life
- diversity of Saskatchewan topography

grade 8

- extraction, refining, and distribution of resources
- driving forces in succession

grade 9

- diversity of species in any ecosystem

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize the diversity of the ecological regions of Saskatchewan.
   - 1.1 Map the distribution of the regions throughout the province.
   - 1.2 Compare the geological history, the climate, the terrain, and native plants and animals of the regions.
   - 1.3 Examine past and current land use in each of the regions.
   - 1.4 Observe and describe the characteristics of the local area.
   - 1.5 Examine the relation between agricultural activities and the physical characteristics of the regions.

2. Explore the effects of human activity on the landscape of Saskatchewan.
   - 2.1 List the various ways that the original landscape has been altered.
   - 2.2 Describe the effects that the infrastructure for agriculture has on the landscape.
   - 2.3 Describe the effects that the practice of agriculture and other resource industries have on the landscape.
   - 2.4 Describe the effect that the practice of agriculture has on the quality of the soil in Saskatchewan.
   - 2.5 Outline the effect that urbanization has on the landscape and on the practice of agriculture.

3. Develop compassionate, empathetic and fair-minded students who can make positive contributions to society as individuals and as members of groups. (PSVS)
   - 3.1 Recognize that the behaviour of an individual can affect the quality of an experience for others.
   - 3.2 Reflect upon the benefits of cooperative, respectful, or empathetic behaviours in actions which influence the biosphere.
   - 3.3 Recognize that a balance is needed between the rights of an individual and the well-being of both the human group and all lifeforms.
   - 3.4 Understand the need for some forms of authority in social situations, and the role of the individual in questioning authority where there appears to be a violation of fundamental moral values.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Write a script for a video which describes the features of the area of Saskatchewan in which you live. Include commentary about the types of vegetation and animal life common in the area, as well as the prominent landforms, bodies of water, and terrain. Describe the impact that human activity has had on the land. Show examples which illustrate this effect.

Produce the video and exchange it with a class in another region of the province. Include written and pictorial documentation with the video.

Factors: A2, A3, B1, B12, C2, C12, D4, E2, F3, F4, G6
Objectives: 1.4, 2.1, 3.3, 3.4
Assessment Techniques: peer assessment, rating scales, homework
Instructional Methods: case studies, field observations, circle of knowledge

♦ Obtain a set of maps which detail the wind erosion risk, water erosion risk, salinity and pH of Saskatchewan soils and the classification of soils by type (chernozemic, podzolic, solonetzic, regosolic, etc.). One set per class is available free from:
Saskatchewan Soil Survey Unit
#210 John Mitchell Building
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0

The series "Soil Capability for Agriculture", done as part of the Canada Land Inventory is available for purchase from:
Canada Map Office
Energy, Mines, Resources Canada
Ottawa, Ontario
K1A 0E9

Use the maps to create a soil description of the region in which you live. How much of the soil in the region is suited for growth of grain crops? How much is suited for growth of forage crops? How much is suited for unimproved pasture and range? How do the estimates of land for these uses in your area compare with the province as a whole?

Factors: A7, B12, B24, C3, C15, E13, F3, G3
Objectives: 1.5, 3.1
Assessment Techniques: written assignments, oral assessments
Instructional Method: research projects

♦ Create a plant inventory of your area, or of a specific site in your area. Use a field guide to identify the species present. Collect one or two leaves from species that are not abundant or that are too large to permit collecting more than a leaf. For abundant species of small size, collect a sample of a branch, stem with branches, or the whole plant (roots included). Make sure that this collecting is done so that it causes least disruption to the site and plants.

Press-dry these samples and mount them together on a large display card, including the name, location where the sample was taken, niche, and growth habit of the plant on the card. Indicate as well where each plant can be seen *in situ* by those who are interested.

An extension of this would be to create a field guide to the area. Using the guide, people would be able to follow a fixed course, reading a commentary on the plants along the course. The guide could contain sketches and keys to help people identify the plants.

Factors: A3, A7, B1, B18, B26, C3, D5, F3
Objectives: 1.4, 3.2
Assessment Techniques: observation checklists, performance assessments, short answer test items
Instructional Methods: research project, structured overview, reading for meaning

♦ Various series broadcast on the PBS TV network give teachers permission to videotape programs for use in their classrooms. Among these series are the *National Geographic* specials, *Scientific American Frontiers*, and the *Infinite Voyage* series. Watch for announcements about such series in science teachers' magazines such as *Science Scope* and *The Science Teacher*. Many of these series have a strong emphasis on the environment.

- Build classroom ponds or use aquaria to create a saline pond and a freshwater pond environment. One way to create the pond is to use a plywood box draped with a liner of 6 mil polyethylene. Fasten the liner on the outside of the box by tying a rope over the plastic around the perimeter of the rim. The bottom of the pond may be contoured by using sand in the box before the plastic liner is applied. Make sure that the plastic liner conforms fairly well to the space inside the box. If there is not enough plastic, the weight of the water will stretch and possibly rip the plastic.

  Collect water, soil, and organisms from local sources to stock the pond. What part do these bodies of water play in the local ecosystem?

- Design an animal which will be well-suited to survive in the habitat of your area. You might want to take characteristics from an assortment of animals which live there plus other real or fictitious characteristics. Be prepared to explain why your animal would be adapted to the area.

- What are wetlands? How do they form? How can they be destroyed? What is their value? What are their disadvantages? What is the effect of the loss of wetlands on animal (especially waterfowl) populations? on agricultural producers' lives? on the climate of the areas where the wetlands were? on the groundwater in the area?

  Write either a narrative description of wetlands and their place in the Saskatchewan ecosystem, or a 'first-person' account of some organism (plant, animal, microbe) living in a wetland environment. Deal with some or all of the above questions in your writing.

- What birds nest in your area? Choose one of the birds. Prepare a report to inform and entertain the other students in your class about the life of that bird.

  You might include such things as a videotape of the bird, its song, and its flight. Videotape the bird's nest – location, design, construction, and use. How many eggs does the bird lay? How and for how long are the eggs incubated? How are the baby birds fed? Are the birds precocial or altricial? What social organization is there among the birds? What do the birds eat? What predators attack these birds?

- Environment Canada has developed a series of publications called *State of the Environment Reporting*. Resources are as varied as a fact sheet series, bulletins monitoring trends in environmental variables, and detailed reports on various issues. The series also includes a comprehensive book *The State of Canada's Environment*. For information on this reporting series contact

  SOE Reporting
  Environment Canada
  Ottawa, ON
  K1A 0H3

  Using materials from Environment Canada gives students a chance to read materials written for the general public rather than targeted at fourteen year old students. This type of material will be one of their major sources of information about the environment once they leave school. (Few publishers print textbooks designed to give 22 year old adults everything they need to know about science and the environment.) They can also use these materials as models for reporting the results of their own research.

- The kits *Agriculture* and *Energy and the Environment*, two of the six kits in the Saskatchewan Resource Series, are recommended for use with this unit. These kits support a strong Saskatchewan emphasis in the classroom and make the point that environmental problems are not limited to tropical rain forests, industrial areas of eastern Canada, or third world countries. These kits were sent during 1992 and 1993 to all schools in Saskatchewan that had grade 9 students enrolled.

Chemistry and You

Unit overview

In this unit, students can apply many of the concepts introduced in previous grades. They should observe chemical reactions, distinguishing chemical change from physical change by both the characteristics of the reaction and by the changes in the composition of the substances involved. Writing word equations for the reactions observed, and writing formulas for simple molecules should be attempted. Students should be able to read some formula equations used to describe chemical reactions, and should understand the purpose of such equations.

Students should also identify the chemical names of substances used in everyday life, and appreciate the dependence that Canadian society has on both natural and synthetic chemicals. The trend from total reliance on natural chemicals to the dependence on both synthesized and natural chemicals should be investigated.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Through reading from a wide variety of sources, students are exposed to differing viewpoints, differing modes and styles of explanation, and the underlying message that there is not one book where one can find all the information one needs. Magazines, student science journals, and narrative nonfiction are all sources for student readings. Through writing in a wide variety of modes and formats, students refine their understanding of the concepts of science and develop their ability to communicate through the written word. Offer your students the opportunity to write as often as possible.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. Many of the suggested activities in this unit are science challenge activities or provide opportunities for extensions which challenge the students. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A1 public/private
A2 historic
A4 replicable
A6 probabilistic
A9 human/culture related

B1 change
B6 symmetry
B8 quantification
B9 reproducibility of results
B10 cause-effect
B13 energy-matter
B14 cycle
B15 model
B20 theory

C3 observing and describing
C4 working cooperatively
C7 using numbers
C10 predicting
C12 interpreting data
C16 designing experiments

D3 impact of science and technology
D6 resources for science and technology
D8 limitations of science and technology

E3 using equipment safely
E8 measuring time
E13 using quantitative relationships

F2 questioning
F5 respect for logic
F7 demand for verification

G1 interest
G2 confidence

Concept development

grade 1
- investigating matter and its properties

grade 3
- observe states of matter and changes of state
- combustion involves chemical change and a release of heat or light energy

grade 4
- energy can be converted from one form to another
- chemical reactions convert chemical energy into heat, light, and electricity
- regular arrangements of crystalline form of matter
- regularities of chemical properties

grade 5
- physical properties and chemical properties of matter
- particle theory of matter
- relation between heat and the motion of particles

grade 6
- elements and the use of symbols to represent the elements
- characteristics of chemical reactions

grade 8
- distinctions between solutions and colloids

grade 10
- variables which influence chemical reactions
- communicating information about chemical reactions through formula equations

Foundational and learning objectives for Science and the Common Essential Learnings.

1. Understand that all materials have a chemical composition.
   - 1.1 Identify products which have been synthesized from raw materials.
   - 1.2 Group chemical products according to a variety of criteria.
   - 1.3 Appreciate the prevalence of synthesized chemicals.
   - 1.4 Investigate how the production of chemical products has an impact on our lives.
   - 1.5 Investigate how the production of these chemical products has an impact on the environment.
   - 1.6 Recognize or identify the chemical composition of common materials.
   - 1.7 Find examples of chemical change in the events that we encounter daily.
   - 1.8 Discuss ways of inhibiting or promoting chemical reactions, as is appropriate for the situation.

2. Describe some chemical reactions.
   - 2.1 Observe and describe a variety of chemical reactions.
   - 2.2 Recognize that a chemical reaction involves reactants and products.
   - 2.3 Recognize those characteristics which indicate that a chemical reaction has taken place.
   - 2.4 Investigate the effect of temperature on the rate of a chemical reaction.
   - 2.5 Develop operational definitions of acids and bases.
   - 2.6 Use chemical indicators to identify whether a solution is acidic, basic, or neutral.

3. Develop an understanding of how knowledge is created, evaluated, refined and changed within science. (CCT)
   - 3.1 Make careful observations during active involvement in constructing knowledge.
   - 3.2 Discuss observations and conceptions with others.
   - 3.3 Focus attention on knowledge of chemical reactions and identify gaps in knowledge of these reactions.
   - 3.4 Participate in scientific inquiry by identifying, clarifying, and investigating problems.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Collect labels from various containers: foods; household cleaners; pesticides; and, other products. Create a master list of all ingredients listed on the labels. First organize the list alphabetically. Identify the function of each substance on the list (e.g., nutrient, additive, preservative, neurotoxin, solvent, etc.) Some of these groups can then be broken down into smaller groups. Keep the groups posted on a bulletin board, and challenge students to keep on making additions to the groups.

Factors: A9, B1, C4, C12, D3, F2, G3
Objectives: 1.1, 1.2, 1.4, 1.8, 3.4
Assessment Techniques: self assessment, extended open response test items
Instructional Methods: reflective discussion, research projects, explicit teaching, reading for meaning

♦ As a whole class, brainstorm a list of all plastic products or components of products the students have used or encountered during the last week. Create another list of the properties of plastics which make them so useful. What materials could be substituted for the plastics in the uses identified? What materials were used for these purposes before plastics were developed?

Factors: A9, B14, C4, C10, F2, G1
Objectives: 1.1, 1.3, 1.4, 1.5, 3.2
Assessment Techniques: peer assessment, homework, written assignments
Instructional Methods: brainstorming, research projects

♦ Ask the students to find out the names of as many different types of plastic as possible before the next class. Polyethylene (high density and low density), polyvinylchloride, vinyl, polycarbonate, polystyrene, polypropylene, polyethylene terephthalate, and polyurethane foam are the major types which will be reported. From the list that the students generate, supplemented from this list if necessary, assign each working group one of the types of plastic to research. They report their findings in an oral presentation, with a summary sheet of their presentation to hand out. The report should include the raw materials used in the synthesis, where it is produced, the characteristics of the plastic, the recycle code for that type of plastic, and major uses. Samples of the plastic and an actual example of the recycle code for that type of plastic should be displayed, if available.

Factors: A1, B13, C4, C12, D3, F5, G2
Objectives: 1.1, 1.4, 1.6, 3.2
Assessment Techniques: rating scales, presentations, peer assessments
Instructional Methods: research projects, reading for meaning

♦ Plastics industry recycle codes are found inside the recycle symbol on many plastic products.

Code	Product
1	polyethylene terephthalate (PETE)
2	high density polyethylene (HDPE)
3	vinyl and polyvinylchloride (V)
4	low density polyethylene (LDPE)
5	polypropylene (PP)
6	polystyrene (PS)
7	other

Use the codes on containers to help create a list of uses of each type of plastic. (A starter – 4 LDPE bread bags) Create a display with samples of the various types and formulations of plastics.

Why do so many of the names of plastics use the prefix *poly*? Why do the names of so many end in *ene*?

♦ Collect enough 4 litre HDPE (recycle code 2) plastic jugs so that each working group has two bottles. Each bottle should be autographed by the teacher using a permanent marker. Challenge each group to create some useful product(s) from their bottles. Challenge them as well to create as little waste plastic as possible. The product may be fabricated from parts of one or both bottles. They must give the product a name and create an advertisement which explains and promotes its use. The autograph (or recognizable portion of it) must appear on the final product.

Creativity, usefulness, aesthetic appeal, amount of waste plastic produced, the advertisement, and the name given to the product are the criteria by which the products will be judged. Recruit another science class to come and judge the objects. Each object should be displayed together with an advertisement which explains and promotes the use of the object.

A sample evaluation sheet which the students of the other class can use to grade the objects is included here. If one judging form is given to each pair of students, discussion of the criteria is promoted.

Judging sheet: Fantastic plastic creations "From monomers to polymers to you"	
Group name:	
Product name:	
Creativity (maximum 5 points)	
Usefulness (maximum 10 points)	
Aesthetic appeal (maximum 5 points)	
Amount of waste produced (maximum 10 points)	
Advertisement (maximum 5 points)	
Creative name for product (maximum 2 points)	
Total points –	

- Black plastic garbage bags have lines running through the plastic. Pick up two squares which have been cut so that the lines are parallel to two of the edges of the square. Hold your 15 cm square pieces up to the light to see which direction the lines run. From one square, cut 6 strips of equal width parallel to the lines. From the other square cut six equal width strips perpendicular to the lines.

  Devise an investigation to determine whether the direction of the lines has an effect on how the plastic stretches. Identify as many pertinent variables as possible, so that your experimental design can account for them. Obtain another square. Devise an investigation to determine how the temperature of the plastic affects how it stretches.

- As a class, brainstorm a list of properties of garbage bag plastic in addition to its ability to stretch or resist stretching. Apportion those properties to working groups to test these properties using garbage bags, bread bags, grocery bags, water softener salt bags, and any other plastic bags available.

- How does acetone affect various types of plastics? Design an investigation to test its reaction to HDPE, LDPE, PETE, styrofoam, and other plastics.

- Collect styrofoam cups and plates after they have been used. Rinse them so they are reasonably clean. Break them into small fragments. Design an investigation to test the effectiveness of styrofoam chips as an insulator, compared to Styrofoam SM™ or Fibreglas Pink™.

- Liquid latex polymerizes in vinegar. Dip finger in latex. Then dip finger in vinegar. Once latex has polymerized, use a pencil to make a hole in the latex at the tip of the finger. Roll the latex from the hole downward on the finger to form a latex ring. Carefully remove the ring and let cure for 1-2 hours. Test the properties of the cured bands.

- Liquid latex and tempera paint make a good t-shirt paint. Paint a science related design on a t-shirt, using a paper towel backing to prevent bleed-through to the other side of the shirt. Dip the shirt in a vinegar bath to initiate polymerization. Then rinse carefully in cool water. Don't allow the painted areas to touch each other as the latex polymerizes. Lay the t-shirt flat on cloth towels and pat dry.

- Paper clips can be used to create an analogy of polymers and polymerization. Each clip represents a monomer (basic unit). The polymerizing agent is the hands of the linker. Join the paper clips together to form long chains. Put one or two chains in a jar and pour out slowly to illustrate why polymers are more viscous than their monomer forms. Cross link long chains with paper clips to illustrate that form of linkage.

  Another way to illustrate the polymerization of ethylene to polyethylene is to have students standing in pairs with both hands joined. Ask the students to start walking around an open area. When they bump into another pair or group they must drop one hand link and join it to one member of the other group, each end of this new groups leaves a hand unattached to link to the next group to bump into the chain. If you wish, the teacher can act as a polymerizer, when the teacher touches two groups simultaneously, they must polymerize.

- Borax plus polyvinylalcohol = slime. Try mixing the reactants in different proportions. Keep track of the properties of the mixture that is produced from each trial.

- To insert a bamboo skewer or a knitting needle into an inflated balloon, slightly moisten the tip of the skewer or needle with canola oil. Insert it with a quick twisting motion. The skewer should enter the balloon without breaking it. Discuss the results.

- Survey the vehicles in the parking lot at the school. How many exhibit signs of corrosion on the painted areas? How does the frequency of corrosion correlate with the age of the vehicle? with the manufacturer of the vehicle?

  Look under the car at the exposed chassis. Do you see any evidence of corrosion there? How does the prevalence of corrosion there compare with the prevalence of corrosion on the painted areas of the vehicle?

- Pour liquid latex to a depth of about 5 cm in a baby food jar, and the same depth of vinegar in another jar. Dip a finger into the latex and immediately into the vinegar. The vinegar starts the polymerization process, turning the liquid latex into a sheet of rubber.

  After a minute, take a pencil point and poke a small hole in the latex at the tip of the finger. Then roll the latex upwards along the finger to form a band of latex. Remove this band and let it cure for several hours.

  Next class, design tests to determine the elasticity and strength of the latex bands formed. Conduct those tests. Can a way of producing stronger or more elastic bands be developed?

- Find the largest coffee filters possible for use as chromatography paper. Try both the white and the brown unbleached types to see if the brown causes any interference in the results of this test.

  Cut the filters into rectangles about twice as long as they are wide, with the width such that it is about two-thirds to three quarters of the height of a wide mouthed clear glass jar. Medium to large sized canning sealers work well for this activity. Tape or staple the paper to form a cylinder.

  Devise a suspension system to hold the paper cylinder inside the jar, 1 cm above the bottom of the jar, without touching the sides of the jar.

  Along the bottom of the paper cylinder, put dots from a variety of colours of water-soluble markers. Keep the dots at least 2 cm from each other, each 3 cm from the bottom of the paper. Put water to a depth of 2 cm in the jar so that the paper cylinder will be immersed about 1 cm in the water when suspended. It is important that the water does not directly touch the dots.

  Record the results. Why does the water soak upward through the paper? What would happen if you used notebook paper or paper towel instead of coffee filter paper? What would happen if you substituted a 1% salt solution for the water in the jar. Use the knowledge gained from this investigation to help solve one or both of the following mysteries.

- Suppose you are having a big party and decide to serve grape Kool-Aid™. One of your friends says he is allergic to blue food colouring. If the grape Kool-Aid has blue food colouring in it, he won't be able to drink any. Use paper chromatography to determine if there is blue food colouring in grape Kool-Aid. (Hint: Add three drops of water to a bit of unsweetened Kool-Aid powder to make a highly concentrated solution for making the chromatography dots.)

- The Consumers Association of the Prairies has hired your consulting firm to do tests to determine which flavours of Kool-Aid have blue dye in them. Design a test procedure, carry out the tests, and submit a written report of your findings to the CAP.

♦ Use concentrated Kool-Aid™ or water soluble markers to create a design or picture on a rectangle of coffee filter. Predict what the design or picture will be like after putting it in the chromatography apparatus. Try it and see.

♦ Use sandpaper or steel wool to clean three 5 cm to 8 cm uncoated nails. Use two 30 cm pieces of 18 gauge wire to connect one nail to each terminal of a 9 volt battery. Make sure that there is good electrical contact between the wire and the nail. Half-fill a baby food jar with salt water and put the nails in the solution on opposite sides of the jar. Record observations of the system for five minutes.

Remove the nails and describe their appearance. Compare them to the third nail which has been sitting on the desk beside the apparatus. What is the experimental terminology used to describe the third nail? What chemical reaction(s) took place during this activity? What evidence do you have that the reaction(s) took place?

♦ Some companies claim that their shampoos are "pH balanced". What does the pH scale measure? What is the pH of some shampoos? What difference does the pH of a shampoo make to your hair? Some manufacturers make shampoo for oily, normal, and dry hair. For the shampoos from one manufacturer, is the pH of the shampoo recommended for oily hair the same as the pH of the shampoo that is recommended for dry hair?

♦ Prepare some natural chemical indicators and test them with a variety of household substances to determine whether those substances are acidic, basic, or neutral.

Tea, red cabbage juice, and turmeric are all acid/base indicators. Prepare these substances in advance. Make a strong solution of orange pekoe or black tea. (Herbal teas might be tried also to see if they are indicators as well.) Shredded red cabbage with water in a 3:1 by volume ratio processed in a blender produces a mash that can be filtered to yield juice to use in this activity. Experiment with various strengths of aqueous turmeric solutions.

Combine the indicator with substances which are known to be acidic, neutral, and basic. Record the colour of the indicator in each case. Keep these standard samples for reference when other tests are made.

Have students bring in a variety of household substances to test. Some examples include orange juice, grapefruit juice, lemon juice, apple juice, vitamin C tablets, antacid tablets, ASA tablets, egg shells, hand soap, baking powder, ammonia, ashes, laundry detergent, dish washing detergent, cleansers, toothpaste, mouth wash, vinegar.

Make sure that students bring the samples in their original containers, if it is practical to do so. Students should read the labels on the containers to see if there are any warnings about how the material should be handled or used. This is particularly important for any cleaners or detergents.

Compare the mixture of the indicator and the sample being tested with a control sample of the indicator alone. Hold each up against a white surface, or shine a light through each to assist in determining the relative colour. The use of an overhead projector may be helpful in this regard.

After the results have been obtained, have students search for patterns and generalizations. Have them develop operational definitions for acids and bases.

- Boil steel wool in vinegar. Allow the solution to cool. Filter the solution. Save some of the filtrate for the next activity. The filtrate should be colourless.

  Add a few drops of hydrogen peroxide to some of the filtrate. The solution turns brown as ferric acetate is produced. (Use fresh hydrogen peroxide. It is available in drug stores, and can be stored in a cool place for a few weeks. Always handle peroxides with care.)

  Add the ferric acetate to tea. Ferric tannate is produced. This is the dye that was used in inks years ago. Use some of the dye to make drawings.

  Another pigment that can be made is Prussian Blue. Dissolve some copper (II) sulphate (also called bluestone and available in farm supply stores or in Secondary Level chemistry labs) in water. Add ammonia. The solution turns a deep blue colour.

  Students investigate several chemical changes in this activity. Chemicals have many uses. The production of dyes illustrates one practical application of chemistry by the chemical industry.

- Boil steel wool with vinegar and filter as in the previous activity. Add ammonia to the filtrate. Green ferrous oxide is produced. Add some hydrogen peroxide to produce red ferric hydroxide.

  Repeat, adding the peroxide before the ammonia and note any differences in the results. When the peroxide is added first, ferric acetate forms. Save a small amount of this before adding ammonia to the remainder. Prepare a tartaric acid solution by adding some cream of tartar to water and allowing it to stand for several minutes. Add some of the tartaric acid solution to the ferric acetate. A green precipitate forms. Filter and dry the precipitate. Examine its structure with hand magnifiers. Substitute a squashed raisin/water mixture for the tartaric acid and repeat.

- Find out how many different types of plastic are used for packaging goods. Describe the components and the characteristics of each type identified.

Using Electricity

Unit overview

Static electricity is a common phenomenon. Whether using it to shock friends on dry winter days or watching displays of summer lightning, or even walking around with a sock stuck to the back of our shirt, we have all seen and experienced static electricity. What causes static cling? Why are gasoline transport trucks 'grounded' before they load or unload? Why do balloons stick to the walls after they have been rubbed on a sweater? Why is there a market for anti-static pads to put under computers? How do anti-static pads work?

In contrast with static electricity, which seems to have more annoyance value than practical use, current electricity has a number of functional applications. This unit introduces students to some of the basics of electrical circuits and to the phenomena of static electricity.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal, reflective journals, reading from newspapers, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge are included in the Suggested activities section of this unit. By giving students an opportunity to investigate the questions that arise from the investigations they have done, any activity can be extended to become a challenge activity. Science challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A4 replicable
A5 empirical
A9 human/culture related

B5 perception
B7 force
B8 quantification
B9 reproducibility of results
B11 predictability

B13 energy-matter
B16 system
B17 field
B23 invariance
B24 scale

C5 measuring
C9 inferring
C11 controlling variables

C14 problem solving
C16 designing experiments
C19 consensus making

D1 science and technology
D3 impact of science and technology
D6 resources for science and technology

E3 using equipment safely
E4 using audiovisual aids
E12 using electronic instruments

F1 longing to know and understand
F5 respect for logic
F6 consideration of consequence

G5 avocation
G6 response preference

Concept development

grade 4
- forms of energy and conversions from one to another
- principles of electrical circuits
- static attraction and repulsion

grade 6
- use of electricity in our daily lives

grade 8
- production, distribution, and conservation of electricity

Foundational and learning objectives for Science and the Common Essential Learnings

1. Recognize the properties of static electricity.
   - 1.1 Explore ways of producing, preventing production of, and removing static electrical charges.
   - 1.2 Describe the characteristics and effects of static charges.
   - 1.3 Explain static charges in terms of electron transfer.

2. Inquire into the principles of electric circuits.
   - 2.1 Investigate the concept of a conductor.
   - 2.2 Construct simple circuits which use various combinations of conductors, dry cells, switches, and bulbs.
   - 2.3 Identify parallel branches and series branches within a circuit.
   - 2.4 Discuss the measurement of the rate of flow and the potential for work in electric circuits.
   - 2.5 Determine how to use meters to measure the voltage and amperage in various parts of a circuit.

3. Explore the relationship between electricity and magnetism.
   - 3.1 Observe and describe the effects of magnetic fields and electrical fields.
   - 3.2 Compare the characteristics of static and current electricity.
   - 3.3 Examine the production of electric currents by interactions between moving magnetic fields and copper wire coils.

4. Develop students' appreciation of the value and limitations of technology within society. (TL)
   - 4.1 Explore the prevalence and uses of electricity and electrical devices in the home, school, and community.
   - 4.2 Identify the benefits and risks of electricity and electrical devices within the home, school, and community.
   - 4.3 Assess how the use of electricity and electrical devices has shaped our society and our lives.

Suggested activities

♦ Create a device to detect static electric charges. Consider ways to calibrate it to estimate the magnitude of the charge.

  Determine as many ways as possible to produce a measurable static charge. Use the static detector developed in the first part of the activity to determine whether a charge is produced.

  Factors: A5, B7, B8, B9, C5, C14, D1, F1
  Objectives: 1.1, 1.2
  Assessment Techniques: rating scales, presentations, short answer test items
  Instructional Methods: problem solving, model building

♦ In groups of two or three students, brainstorm for about five minutes to produce a list of what they know about lightning and questions they have about lightning. Collect these ideas and questions to form a class list. Generate more questions from the ideas on the list. Assign one question to each group. Have the group produce a poster which supplies some information about the question. Post these on the bulletin board around the question list. Encourage students to add new questions to the list.

  Factors: B5, B13, C9, C14, E4, F1, G6
  Objectives: 1.2
  Assessment Techniques: rating scales, written assignments
  Instructional Method: research projects

- Using a 1.5 volt dry cell and a 20 cm piece of 18 gauge wire, make a flashlight bulb light. Once students have mastered that, distribute bulb holders. Ask the students to experiment with using 2, 3, and 4 cells connected in a variety of ways to light one bulb, seeing how many bulbs can be lit with one cell, and other combinations of the four components. Have them diagram each set of connections.

  Factors: A4, B13, B16, C11, C16, D3, E3, F5
  Objectives: 2.1, 2.2
  Assessment Techniques: observation checklists, performance assessment
  Instructional Methods: problem solving, conducting experiments, explicit teaching

- Design a machine in which an electrical circuit is a functional part. The machine can perform a useful function or it may have entertainment value (or both).

- Invent ways of determining if electrical fields or magnetic fields are present.

- Refer to questions in the unit overview. Find out some answers, ideas, or explanations.

- Brainstorm, in groups of three or four, for five minutes to create a list of all the ways electricity has been used by the members of the group since they got up in the morning. Then, for each instance listed for the use of electricity, propose a substitute means of accomplishing that task without electricity.

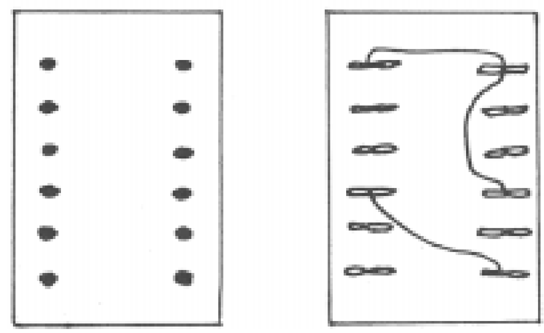
  Use the list of substitutes to create a story about the day in the life of a student in an "electricity-less" world.

- Form student pairs and ask each pair to make a concept map or web about the concept 'electricity'. Then form groups of two or three pairs to compare, discuss, and explain the concept maps. For each concept map, ask the large group to identify one area where the map could be enhanced or expanded.

- Through each long edge of a 30 cm by 15 cm strip of corrugated cardboard, evenly space 5 brass paper fasteners. Splay the arms on the backside of the cardboard so that none contact the others.

  Use insulated wire or aluminum foil to make one or more circuits connecting some of the fasteners. Not all fasteners need be included in a circuit. If aluminum foil is used, masking tape can be used to isolate one circuit from another. Tape a piece of paper over the back to prevent the circuits from being seen. Exchange circuit boards with another person or group.

  Construct a circuit tester to determine which fasteners are connected. By making connections between the heads and the fasteners on the front of the board, deduce where the connections have been made. Draw a diagram of what the back side of the board would look like. Front and back views of a sample board are drawn below.

  This idea can be adapted to produce a question and answer board, where the connection of the terminal beside a question with the terminal beside the correct answer will cause a light bulb to glow.

- Examine the wires inside a lightbulb which has had the glass removed. Is there a filament connecting the two heavy wires? Do the heavy wires come from the same place at the bottom of the bulb? Draw a diagram of how the electricity might flow through the bulb.

- Use paper clips and brass paper fasteners to make a switch in a circuit. Find out how to make a parallel circuit and a series circuit. Experiment to discover the ways that switches work to control these circuits.

- How do fuses and circuit breakers work? Why are they important parts of electrical circuits? Design a fuse to use in a circuit. Make a poster to explain to grade 4 level students how your fuse works.

- Make a device which can be used to test whether a substance will conduct electricity. Demonstrate to your teacher that the device works. Can you find any non-metallic conductors or any metallic insulators?

- ♦ Make a flashlight, complete with switch, two dry cells in series and a bulb with a reflector. The flashlight may have a similar design to a regular tubular flashlight or it may be of an innovative design. Make it sturdy enough so that it can be carried around.

- ♦ Make a dynamometer to detect small currents. Cut the bottom 1 cm from a styrofoam coffee cup. Put a small inexpensive compass in the bottom section. Make 20 to 30 wraps of 24 gauge or 28 gauge insulated wire around the cup base so that the wire goes across the open end of the cup. Leave about 30 cm of each end of the wire loose, to make connections to the power source. Strip the last 2 cm of each loose end so that electrical connections can be made to a straightened paper clip.

  Turn the top part of the styrofoam cup upside down. Place the base of the cup (open side up so that the compass is visible) on top of this base.

  Test the dynamometer by holding one paper clip on the positive terminal of a battery and then touching the other clip **very briefly** to the negative terminal. What happens to the compass needle when the second clip touches the terminal? What happens if the first clip is held on the negative terminal and the second clip is touched to the positive?

  Insert one paper clip into a potato. Watch the compass needle to see what happens when the second paper clip is jabbed into the potato. Remove the second clip and jab in again, observing the compass needle as you do this.

  Connect two potatoes with a straightened paper clip. Put the first clip into potato 1 and the second clip into the other potato. What happens? Try substituting a lemon, an orange, an apple, a green tomato, a red tomato, a cucumber, and a carrot for the potato(s).

- ♦ Obtain 70 cm, 1 m, 3 m, 4.5 m, and 6 m lengths of insulated wire and five 10 cm to 15 cm long 5 mm bolts. (It can be done with one bolt if the wire is removed and the next length wrapped on after each trial.) A 6 volt battery is best for this activity, although 1.5 volt dry cells may be used. The 1.5 volt cells may run down quickly when used as power sources for electromagnets.

  Wrap one length of wire around each bolt, leaving 25 cm of each end of the wire to make connections to the battery. With the lengths of wire suggested, 20 cm, 50 cm, 2.5 m, 4 m and 5.5 m will be the length of wrap forming the electromagnet. Connect the free ends of the wire to the battery, and record the strength of the magnet produced by the number of straight pins or paper clips the magnet will hold. Graph the results of the investigation. Predict how many clips could be picked up with 7.5 m or 10 m of wire.

- ♦ Some fax machine paper is thermal paper, sensitive to heat. Use the roll ends of such fax paper as a heat indicator. Does the paper change gradually with increasing heat or is the change very quick at some particular temperature? Lay a 10 cm piece of nichrome wire and a 10 cm piece of copper wire nichrome and copper wires across a piece of the paper, so that the wire is in constant contact with the paper. Use tape to hold the wire in contact with the paper if necessary. Apply a current to each wire and observe the effects on the paper. What uses are made of nichrome wire and copper wire?

  What other uses can you think of for the heat sensitive fax paper?

- ♦ Design and construct an alarm system which will detect whether a door, window or a lunch box is being opened. The alarm may be audible, visible, or both. It should use a 9 volt battery as a power source.

- ♦ Collect some old radios, toasters, electric mixers, and other small appliances. Distribute these for the students to dissemble in the laboratory. Ask them to produce a poster or set of diagram to explain how the appliance works. Take the components and reassemble them in a line which indicates the sequence of electrical flow through the device. Caution students not to plug the appliances in at any time. The external part of the power supply cords might be cut off to discourage this. **Do not use old television sets for this activity**. The picture tube may implode, showering the class with glass fragments.

- ♦ **Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.**

Risks and Limits

Unit overview

Life is full of risks. When we walk along the sidewalk or across the street, we run the risk of a vehicle striking us, tripping on a crack, or having a meteorite fall on our heads. Each of those hazards has a different probability of occurrence. On particular streets in any city, it is more likely that you will be struck by a vehicle than on other streets. On the streets of a city, the probability of being struck by a vehicle is greater than if you were on the streets of a small town.

There are probably some towns in Saskatchewan where no one has ever been struck by either a vehicle or a meteorite. That doesn't mean that those events have the same probability. In any urban area of Saskatchewan, it is less probable that you will be struck by a meteorite than by a car. If you are boating on Besnard Lake, it is more likely that you will be struck by a meteorite than by a car.

Another set of probabilities expresses the likelihood of injury resulting from an incident. How great a danger is produced depends on many factors. If you are struck by a vehicle, the speed of the vehicle, the type of vehicle, your physical condition and agility, and the surface on which you land are all pertinent variables. Fewer variables are important if you are struck by a meteorite. These are some of the concepts which will be considered by students in this unit. They will explore the meaning and determination of probability. They will analyze their lifestyles to determine the risks
which they are assuming in both voluntary and involuntary activities.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing helps students assimilate what they have seen, heard, and read. It gives them a chance to reconcile their ideas with what they have encountered in the activities, reading and discussions of science class. The phrase 'writing to learn' indicates the purpose for including many opportunities for students to write during and about science classes. Vary the modes and formats assigned. Give them an opportunity to read from a wide variety of sources so that they can be exposed to many ideas and different ways of expressing ideas, and as a model for their own writing. The best model for an assignment to write a newspaper editorial on a topic is an actual newspaper editorial on a similar topic.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge are included in the Suggested activities section of this unit and should be incorporated into science lessons. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A3 holistic
A6 probabilistic
A8 tentative
A9 human/culture related

B5 perception
B8 quantification
B10 cause-effect
B15 model
B19 probability
B21 accuracy

C2 communicating
C10 predicting
C12 interpreting data
C15 analyzing
C17 using mathematics

D5 public understanding gap
D7 variable positions

F1 longing to know and understand
F5 respect for logic
F7 demand for verification

G1 interest

Concept development

No related concepts dealt with in K-8 science have been identified. However factors B19 and C10 relate to the concepts, as does preparatory work in mathematics.

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand that risks are associated with all activities.
   - 1.1 Understand and demonstrate the concepts of probability and chance.
   - 1.2 Relate the concept of probability to the concept of risk.
   - 1.3 Compare risks of various voluntary and involuntary activities.

2. Recognize that activities have risks and benefits.
   - 2.1 Consider how risk is assessed.
   - 2.2 Assess significance of contaminants in water supplies.
   - 2.3 Recognize how scientists estimate toxicity levels from experimental data.
   - 2.4 Discuss how the value one places on an activity influences the amount of risk one is willing to accept.

3. Support students in coming to a better understanding of the personal, moral, social, and cultural aspects of the study of life. (PSVS)
   - 3.1 Understand the natural environment and the conditions putting it at risk.
   - 3.2 Understand the potential narrowness in adopting a single perspective in judging the impact or influence of objects, experiences, or events.
   - 3.3 Explore how moral values influence behaviour and assessment of risk and benefit.
   - 3.4 Recognize the importance of fact-finding, prior experience, and open dialogue in the development of reasoned arguments.
   - 3.5 Establish arguments based upon human rights, human needs, or needs of the environment when examining social issues.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Consult the model unit starting on page 56 in this guide. It is based on the objectives of this unit.

♦ Debate the topic "Nuclear power generation poses an unacceptable risk to the environment and to life."

From the background research done by both sides for the debate, construct a poll which will assess people's level of knowledge about radiation, how radiation is used to generate electric power, and the issues which are important in the discussion of the use of nuclear energy to generate electricity.

Select a sample to answer the questions, administer the poll, analyze the answers and present the results. Devise a program which will educate the public about nuclear power generation and the issues surrounding it.

Factors: A3, A8, B5, B19, C2, C17, D5, D7, F5, F7, G3
Objectives: 1.2, 2.4, 3.1, 3.2, 3.3, 3.4, 3.5
Assessment Techniques: peer assessment, anecdotal records, oral assessments
Instructional Methods: debate, research project, surveys

♦ Other debate topics are:
- Fluoridation of drinking water should be required.
- The use of drugs as routine treatment for humans is unacceptable.
- Experimental drugs which will be used to treat humans should not be tested on animals.

♦ In a well-shuffled deck of 52 cards, what is the chance of drawing a face card? a king? a five of hearts? What must one know in order to be able to compute the chance?

In Canada, the 1986 death rate for females was 486.9 per 100 000 population. This means that 1 of 205 females in Canada died that year. If you took a sample of 205 Canadian females living on January 1, 1986, does this statistic mean one and only one of that sample will die during the year? Explain what the statistic means. What influences whether one particular person will die during a specific year?

The death rate for females dying of influenza and pneumonia in 1986 in Canada was 17.3. What percentage of females who died in Canada during 1986 died of pneumonia? If there were 13.5 million females living in Canada during 1986, how many died of influenza? If you took a sample of 1000 women living in Canada on January 1, 1986 how many of them would die of influenza or pneumonia during the year?

Factors: A6, B8, B19, C10, C17, D5, F5, G1
Objectives: 1.1, 2.1
Assessment Techniques: written assignments, short answer test items
Instructional Methods: explicit teaching, problem solving, reflective discussion

♦ Supply a penny to each pair in the class. Ask one member of the pair to act as recorder and one to act as the flipper. Record the data on a chart similar to the one illustrated below.

Flip number	1	2	3
Result (H or T)			

Toss the coin fifty times, recording the result of each flip. Draw a line graph to show the percentage of heads which have been recorded after 5, 10, 15, 20, 25, 30, 40 and 50 flips.

Trade jobs within each pair and repeat. Graph the data for the second round of flipping on the same graph as the first, using a different colour. How do the shapes of the curves compare. Submit the number of heads produced from the pair's 100 flips to the teacher so that a class report and results can be compiled.

Predict the shape of the graph and the number of heads if you were to flip the coin 200, 300 or 1000 times. Why is it unreasonable to use the result of the first three flips to predict the final percentage of heads which will be produced?

Factors: A6, B5, C10, C15, D5, F5, G3
Objectives: 1.1
Assessment Techniques: written assignments, presentations, short answer test items
Instructional Method: didactic questions

♦ Distribute the "Foodborne Diseases in Canada, 1983", page 921, chart to each student group. Ask them to discuss the following questions:
- Where was the most dangerous place in Canada to eat during 1983?
- Where was the safest place to eat in Canada during 1983?

Predict the number of cases and the frequencies during 1984. Then hand out the 1984 chart (also page 921) so that students can check their predictions. How reliable are predictions based on one set of data?

What was the percentage increase in foodborne diseases in New Brunswick from 1983 to 1984. See if you can find out what happened in Saskatchewan in 1983 to make the rate for that year so high? Try to find more up-to-date data.

Write a newspaper editorial explaining the use of statistics to predict events. Explain how the variability in the event and the size of the population from which the information is taken make a difference.

♦ In the USA, there is an average of 13 deaths per year from football-related injuries among high school football players. In US pro football, the average indicates that one person dies every nine years from football-related causes. Which level of the sport appears to be more dangerous? Why do you think it would be this way?

If the above data is expressed as risk data, the rate of deaths from high school football is 10 deaths per million players. The rate for pro football is 800 deaths per million players. From these data, which sport appears to be the more dangerous? What is the difference between the appearance in the total number of deaths and the rate per million participants?

♦ In the USA, the rate of death caused by lightning is 0.5 persons per million. Given this rate, how many people would be killed by lightning in the USA each year? If this rate is the same for Canada, how many people would be killed in Canada each year by lightning? See if you can find out how many people are killed each year in Canada by lightning. Calculate the rate per million. Is the probability of being struck and killed by lightning higher or lower than the probability of winning the jackpot in the 649 draw?

Foodborne Diseases in Canada, 1983.

Province	Number of Cases	Frequency of cases (per 100 000 persons)
BC	482	17.1
AB	495	21.0
SK	798	80.4
MB	143	13.7
ON	3 186	36.1
PQ	726	11.1
NB	0	0
NS	23	2.7
PE	0	0
NF	101	17.5
YK	0	0
NT	1	2.1
Canada	5 955	23.9

Foodborne Diseases in Canada, 1984

Province	Number of Cases	Frequency of cases (per 100 000 persons)
BC	813	28.3
AB	228	9.7
SK	154	15.3
MB	146	13.8
ON	4 589	51.3
PQ	900	13.7
NB	51	7.1
NS	112	12.1
PE	0	0
NF	135	23.3
YK	21	96.3
NT	8	16.2
Canada	9 857	39.2

- In Regina, the average hours of sunshine during the year is 2330. If we assume that approximately half the hours during a year are daylight hours, what is the chance that any one of those hours during the year will be sunny?

  Although December and July both have 31 days, the average amount of sunshine during December is 83.9 hours and in July is 342.2 hours. What factors would be responsible for this difference?

  What is the chance that the hour between 7 p.m. and 8 p.m. on December 22 will be sunny? What is the chance that the hour between 7 p.m. and 8 p.m. on July 22 will be sunny?

  Sunlight hours in Regina accumulate during an average of 320 days of the year. What is the chance that there will be some sunshine next February 17? What is the chance there will be no sunshine on February 17 next year?

- When water is treated in urban areas for domestic consumption, chlorine gas ($Cl_2(g)$) is used to kill bacteria and other microorganisms. Some of the chlorine will combine with hydrocarbons in the water to form chemicals which are capable of causing cancer. How is the risk that these contaminants in the water will cause cancer determined and expressed?

- Distribute one copy of the "Rank the risk of death..." form (see page 923) to each student. Ask the students to work individually to rank the risks from greatest (#1) to least (#9). Page 923 has three copies of the form so you need only photocopy one-third as many copies of that page as you have students. Create a class data chart where they can enter the rank number for each risk. Total the class data to produce a class ranking.

  Distribute the Risk Data sheet (page 924). Calculate the numerical risk per 100 000 persons, using the Statistics Canada data given. Rank the hazards according to the risk as expressed by this number. Compare this ranking with the rankings done in the first part of this activity.

  Why isn't the estimated population at risk the same value for each risk listed?

  Heart disease is a lower risk for the 10-19 year age group than for the population as a whole. What other event or activities might pose a lower risk for this age group? Which might pose a higher risk? Be prepared to give reasons to support your statement.

- Complete the blank Numerical Risk chart on page 925 using data from the completed charts on that page.

  Discuss the reasons for the variations which show up in the Risk chart. Suppose that the numerical risk of injury from jumping from a car moving at 30 kph is expressed as 50 000 in 100 000. Express that risk as a probability for each person jumping from the car.

  Numerical risks that are expressed in the form "1 chance in 2" are called risk probabilities. They can be calculated from the numerical risk data. Calculate risk probabilities to fill in the Risk Probability chart, using data from the Numerical Risk chart. Several cells are completed for you to be able to check your method of calculation.

- Of 6 651 persons injured while riding in motor vehicles involved in accidents during 1990, 5 053 were wearing seat belts. 1070 were not wearing seat belts. It is not known whether the other 528 people were wearing seat belts or not. The estimated compliance rate with the mandatory seat belt use law in Saskatchewan in 1990 was 94%. Could these statistics be used to argue that wearing seat belts causes people who are in motor vehicle accidents to be injured?

  The injuries to these people were categorized as minor, moderate, or major. Of those injuries to people wearing seatbelts, 1 750 were minor, 2 824 were moderate, and 479 were major. Of those injuries to people not wearing seatbelts, 214 were described as minor, 549 as moderate, and 307 as major. Present this data in a table showing both absolute numbers of casualties and the risk probability statistics for each group of people.

  Write a paragraph summarizing your conclusions and recommendations from analysis of this data.

- Discuss the concept of cost-benefit analysis in making decisions about what activities to participate in and how to conduct our lives.

Compare the benefits and costs of an activity they voluntarily assume, such as riding in or driving a motor vehicle, or playing a sport. Discuss how the number and relative worth of costs and benefits can be changed.

Then compare the costs and benefits of an involuntary activity such as the risk of homicide. How can the number and relative worth of the costs and benefits be changed?

Finally, use data from the Deaths in Canada table and Accidental Deaths in Canada table to complete the numerical risk and risk probability equivalents of those charts. Discuss some of the questions that arise from the data. Why do the numerical risks vary so much from cause to cause and from group to group? Why are 15 to 19 year-old males 9 times more likely to die accidentally than 10 to 14 year-old females? Why is cancer more prevalent in males?

♦ Read the article titled "Study Claims" (Guide, page 926). Write a two paragraph review of this article. Find a magazine article or advertisement to use to illustrate some of the ideas presented in this article. Analyze the presentation in the advertisement.

Rank the risk of death in Canada from each of these events.

___ choking

___ drowning

___ falling

___ fire

___ heart disease

___ homicide

___ motor vehicle accidents

___ pedestrian accidents

___ accidental poisoning

Rank the risk of death in Canada from each of these events.

___ choking

___ drowning

___ falling

___ fire

___ heart disease

___ homicide

___ motor vehicle accidents

___ pedestrian accidents

___ accidental poisoning

Rank the risk of death in Canada from each of these events.

___ choking

___ drowning

___ falling

___ fire

___ heart disease

___ homicide

___ motor vehicle accidents

___ pedestrian accidents

___ accidental poisoning

Risk Data

Risk	Estimated Population at Risk	Deaths per year	Numerical Risk per 100 000 persons
Choking	26 500 000	299	
Drowning	8 000 000	385	
Falling	26 500 000	1 944	
Fire	26 500 000	419	
Heart disease (all Canadians)	26 500 000	57 861	
Heart disease (10-19 years old Canadians)	3 800 000	26	
Homicide	26 500 000	654	
Motor vehicle accidents	26 000 000	4 355	
Pedestrian accidents (SK data)	850 000	10	
Poisoning (accidental)	26 500 000	523	

** data from Statistics Canada, 1988 and 1990

Deaths in Canada

Cause of death*	all males**	age: 10-19 years	all females**	age: 10-19 years
accidental	6 051	727**	2 908	226**
cancer	28 104	91	22 552	61
heart disease	31 969	13	25 892	13
respiratory disease	9 460	28	6 519	19
stroke	5 571	5	7879	5

* 1988 data from Statistics Canada
** estimated populations females: 13.4 million, males: 13.1 million
*** see also chart below

Accidental Deaths in Canada

age group	f 10-14	m 10-14	f 15-19	m 15-19
estimated population	920 000	990 000	920 000	970 000
# of accidental deaths	61	136	165	591

* data from Statistics Canada, 1988

Numerical Risk* for Deaths in Canada

Cause of death	all males	age: 10-19 years	all females	age: 10-19 years
accidental				
cancer				
heart disease				
respiratory disease				
stroke				

* risk per 100 000 population

Numerical Risk* of Accidental Death in Canada

age group	f 10-14	m 10-14	f 15-19	m 15-19
accidental death				

* risk per 100 000 population

Risk Probabilities for Deaths in Canada

Cause of death	all males	age: 10-19 years	all females	age: 10-19 years
accidental		1 in 2700		
cancer				
heart disease			1 in 520	
respiratory disease	1 in 1390			
stroke				

Risk Probabilities of Accidental Death in Canada

age group	f 10-14	m 10-14	f 15-19	m 15-19
accidental death		1 in 7300		

Study Claims

News from nutrition studies is everywhere - TV, radio, newspapers, magazines and even food packages. Just because a study is reported, doesn't mean it applies to you. But, how do you tell if such claims are the "truth"?

A study can refer to any research test. Every year tens of thousands of nutrition studies are published in English Alone. Major journals in the medical and nutrition fields review any article submitted to them. This helps to limit any overstated or unproven claims. Even when a study appears in a respected journal, it doesn't mean something has been "proven". One study, on its own, cannot prove or disprove anything. To be valid, anyone anywhere should be able to conduct the same research and get the same results.

Many studies are announced as major breakthroughs. Yet, "astounding" advances are rare. A study may be too small or too short to mean a lot. It is simply another small piece of a big puzzle. Consider a 6-month study of 12 men which showed that eating Food "X" increased their risk of cancer. There are several reasons for caution that surface when assessing the impact of this study. Six months may be too short a time period to show an increased risk. A study of a small number of people may show need for further research more than cause and effect. We cannot assume that several million people, both male and female, will react in the same way as these 12 men. Lastly, there could be many other reasons why these men had increased risks. What known risk factors did they have? Did the study check into their smoking habits, occupational hazards, or dietary fat and fibre intakes?

Scientific studies are written using words such as "may" rather than "will", "suggests" rather than "proves" and "is linked to" rather than "causes". Changing daily habits because of a single study is not a good idea. On the other hand, guidelines for healthy eating from major agencies such as the Heart & Stroke Foundation, Cancer Society or government health departments are based on many studies which support their advice.

When you hear of new nutrition research findings, there are a few things to keep in mind. No matter how much hoopla surrounds a report, wait to see what the experts say in the coming weeks and months. Remember that results from single studies will not stand on their own but must be repeated by others for confirmation. (Remember all the fuss about generating nuclear power in a jug of water on your kitchen table? No one else could repeat it.) Also, beware of any research finding that is used to sell a product whether in ads, on labels or by word-of-mouth.

This doesn't mean that all studies are faulty or that research is not to be trusted. Many reported studies have merit but are of interest only to other researchers. Results may not be enough on which to base lifestyle changes. In short, it is unwise to generalize from a single study. Scientific progress is slow and steady, not a series of dramatic breakthroughs.

Written by the Public Health Nutritionists of Saskatchewan. Reprinted with permission.

The Atmosphere

Unit overview

The atmosphere is the medium in which Canada's weather and climate develop and unfold. The atmosphere is our source of life-giving oxygen. We breathe the atmosphere with its essential components and its impurities. Without the atmosphere fire, sound, sucking pop up a straw, and airplane flight are all impossible.

This unit looks at the weather and climate which we experience, and at how human activity alters the atmosphere's composition.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing is an important way for students to reduce cognitive dissonance between their view of the world and scientists' views of the world. Writing in personal reflective journals and reporting on the activities of science class in a variety of ways are strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word. Reading from a variety of sources reinforces the idea that they are capable of learning on their own and that there are a number of legitimate ways to present and interpret knowledge.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A6 probabilistic
A8 tentative
A9 human/culture related

B2 interaction
B9 reproducibility of results
B11 predictability
B13 energy-matter
B15 model

B16 system
B19 probability

C6 questioning
C8 hypothesizing
C10 predicting
C12 interpreting data
C13 formulating models

D4 science, technology, and the environment
D5 public understanding gap
D8 limitations of science and technology

E1 using magnifying instruments
E2 using natural environments

F1 longing to know and understand
F3 search for data and their meaning
F8 consideration of premises

G3 continuous learner
G8 explanation preference

Concept development

grade 2
- importance of a supply of clean air
- impact of weather

grade 4
- predicting weather patterns

grade 5
- components (natural and pollutant) of air

grade 6
- influence of landforms and large bodies of water on climate
- recognizing evidence of climatic change

grade 7
- effect of heat and temperature changes on behaviour of substances

grade 8
- role of the atmosphere in establishing conditions suitable for life on earth

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand the dynamic nature of the atmosphere.
   - 1.1 Discover how weather information is gathered.
   - 1.2 Examine how weather systems develop and move.
   - 1.3 Describe the Saskatchewan climate.

2. Recognize the effects of human activity on the atmosphere.
   - 2.1 Identify some air pollutants.
   - 2.2 Describe the effects of air pollutants.
   - 2.3 Distinguish between local effects and global effects of pollutants.
   - 2.4 Investigate how levels of air pollutants are monitored.
   - 2.5 Discuss proactive and reactive methods of reducing air pollution.

3. Understand and use the vocabulary, structures and forms of expression which characterize the study of science. (COM)
   - 3.1 Incorporate the vocabulary of climatology and atmospheric study into talk and writing.
   - 3.2 Use a variety of strategies to interpret the meaning of what is read.
   - 3.3 Develop understanding through identifying cause and effect, and comparing and contrasting.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Invite a person from the Atmospheric Environment Service of Environment Canada to come to your classroom and discuss how forecasts are made. Alternatively, visit a weather forecasting office.

Factors: A9, B11, B13, B19, C13, D5, F3, G8
Objectives: 1.1, 1.2, 3.1
Assessment Techniques: written assignments, oral assessments
Instructional Methods: structured overview, discussion

♦ Investigate the development of microclimates. What characteristics of a city make possible the development of a climate in that city which is measurably different from the surrounding area? How does the presence of a large treed area (park or forest) influence the climate of the region? What aspects of climate are subject to influence by human activity and which are not?

Factors: A6, A9, B2, B11, B15, C8, C13, D4, D8, E2, F3, G8
Objectives: 1.2, 1.3
Assessment Techniques: presentations, extended response test items
Instructional Methods: research projects, compare and contrast, reading for meaning

- Contact the Atmospheric Environment Service (AES) of Environment Canada. Ask for weather statistics from a station close to your school. They may be able to provide temperature, atmospheric pressure, relative humidity, wind direction, and wind velocity hourly readings for a monthly period. Analyze the data for trends. Correlate the data to newspaper accounts of what the weather was like during that month. Graph one set of data points every hour for a week. Does this give better information than if you had graphed the same set of data but selected only every sixth hour for plotting?

  Inquire about a source for satellite photos of weather systems. Does the computer lab in your school have the capability of going online to receive data from the NOAA weather satellites. Through wide-area computer networks such as Internet, you may be able to gain access to this type of data.

  Factors: A8, B13, B15, B16, C6, C12, D4, F1, F8, G3, G8
  Objectives: 1.1, 1.2, 3.1, 3.3
  Assessment Techniques: anecdotal records, performance assessments, short answer test items
  Instructional Methods: concept formation, problem solving

- As a class activity watch the national forecast section of the Weather Channel's presentation. Make a list of any terms which the students do not understand. See if the class can use the satellite images to forecast the weather for their region.

  Ask those students with access to the Detroit channels on cable TV to watch the "big picture" weather forecasts. By watching the upper left hand portion of the screen, one can usually see what the animations are predicting for Saskatchewan. Record what they observe on the big picture and compare that forecast to local forecasts.

- What are the major air pollutants of concern to Saskatchewan? How and where are these pollutants produced? What effects do they have? How can the pollutants or their effects be reduced?

- What are the major air pollutants of concern to Canada? How and where are these pollutants produced? What effects do they have? How can the pollutants or their effects be reduced?

- What are the major air pollutants of concern to the world? How and where are these pollutants produced? What effects do they have? How can the pollutants or their effects be reduced?

- Oceans and large bodies of water influence the climate and weather of a region. Do the climate and weather of a region influence the oceans and large lakes? How do the ocean and large lakes interact with the atmosphere?

- Without the greenhouse effect, the earth would be a frozen ball of rocks and ice. With too much greenhouse effect, earth may become an arid wasteland. Discuss the processes that tend to keep the level of greenhouse effect at an appropriate one.

- Chinooks often sweep down from the foothills of the Rockies across Alberta and southwestern Saskatchewan, raising the temperature by 20°C to 30°C in a few hours. How do these winds originate? Why doesn't all the heat disappear when the air rises up from the Pacific Ocean to cross the mountains? Do other areas in the world have these same type of winds?

Fluids and Pressure

Unit overview

What is a fluid? Why do fluids act as they do? Most people would agree that liquid water and air are fluids. Are sand and wheat fluids? What are the critical attributes or characteristic properties of fluids? Is the ability to transmit pressure equally in all directions such a property?

The sea and the air are the fluid media in which much of human activity takes place. Students have an opportunity to investigate the general properties of fluids, and how these properties influence how we conduct our lives during this unit.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. When combined with the experiences students gain while working with hands-on activities in a cooperative small group setting, a variety of reading and writing activities create an environment where the opportunities for both receiving stimuli and reflecting upon those stimuli are maximized.

Writing in personal reflective journals, reading from newspapers, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. Students should be given a chance to identify and pursue topics of their own choosing within the context of the overall theme and structure of the unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A4 replicable
A5 empirical

B5 perception
B6 symmetry
B7 force
B10 cause-effect
B20 theory

C7 using numbers
C9 inferring
C11 controlling variables
C13 formulating models
C16 designing experiments

D1 science and technology

E9 measuring volume
E10 measuring temperature
E13 using quantitative relationships

F1 longing to know and understand
F8 consideration of premises

G2 confidence
G6 response preference
G8 explanation preference

Concept development

grade 3
- characteristic properties, general properties, and phase changes of matter

grade 5
- relationship between the particle theory of matter and physical properties of matter

grade 7
- application of force to objects

Foundational and learning objectives for Science and the Common Essential Learnings

1. Broaden knowledge of the characteristics of fluids.
   - 1.1 Develop a model of fluids using the particle theory of matter.
   - 1.2 Examine the concept of density.
   - 1.3 Investigate the relationships among floating, density, displacement, volume, and buoyant force.
   - 1.4 Investigate resistance to the flow of fluids and to the motion of objects in fluids.

2. Recognize how pressure is transmitted by fluids.
   - 2.1 Understand the nature of pressure.
   - 2.2 Develop ways to measure pressure.
   - 2.3 Interpret transfer of pressure in fluids using the particle theory.
3. Strengthen understanding of physical properties of objects by applying knowledge of numbers and their interrelationships. (NUM)
   - 3.1 Collect, organize, and analyze quantitative information.
   - 3.2 Develop ability to read meters and scales.
   - 3.3 Use benchmarks as referents for estimation.
   - 3.4 Discuss with peers how estimates are made.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Wheat can be used to simulate some properties of fluids. The grains of wheat would represent the particles of matter in a liquid. When it is poured it flows. If it is confined in a box, pressure applied across the whole open surface causes the wheat to resist the pressure. Pressure applied on a point on the open surface (with a pencil for example) causes the particles to spread to allow the object exerting the pressure to enter. Ask the students to consider what happens if they do a belly flop off a diving board compared to what happens if they hit the water perpendicularly with the fingertips first.

Factors: B7, B20, C13, E13, F8, G8
Objectives: 1.1, 1.4
Assessment Techniques: written assignments, short answer test items
Instructional Methods: demonstrations, didactic questions, reflective discussion, model building

♦ What are the forces that hold the particles of wheat together in a pile? Why won't water pile up like wheat? Will water pile up at all? Fill a small beaker or jar so that it is level full of water. Estimate how many more drops of water can be added after it is level full. Try it. What is the final shape of the surface of the water? Then carefully add paper clips to the container. How many can be added until the water overflows?

Get a small piece of aluminum foil and a small piece of waxed paper. Put a drop of water on each? Describe the shape of the drop. To 10 mL of water in a jar add five drops of dishwashing detergent. Put a drop of this water about 1 cm away from the drops already on the foil and waxed paper. Compare the shapes of the drops.

Factors: A5, B5, B10, C11, f1, G2, G6
Objectives: 1.1, 1.4
Assessment Techniques: self assessment, written assignments, oral assessment
Instructional Methods: conducting experiments, reflective discussion

- Get an ice cube or block of ice (freeze water in 250 mL milk containers). Tie weights to the ends of a thin wire (about 28 gauge) so that there is enough length of wire to go across the block and down past the sides with the wire. Set the block on a stand so that the weights can hang free when the wire is placed across the block or cube of ice.

  Record observations over the next few minutes. What is happening? Predict how long it will be before the effect is complete? Repeat but sprinkle salt on top of the ice along the path of the wire. Predict the effect. Repeat by changing variables such as the amount of the weight and the thickness of the wire.

  Factors: A4, B7, B10, C9, F1, G8
  Objectives: 1.4, 3.1
  Assessment Techniques: observation checklists, presentations
  Instructional Methods: demonstrations, model building, inquiry, discussion

- Drill holes in the side of a large metal juice can. so that the holes are spaced at the quarter, half, and three-quarter points on the side. Make sure that all holes are the same size. Shape corks so that they fit in the holes.

  Fill the can with water. Predict what will happen when the corks are removed. Remove all corks at the same time. Describe the shape of the flow from each hole. How far from the bottom of the can does each flow hit?

  Predict whether the shape and distance produced by the flow from each hole will vary from the original trial if that is the only hole open. How about if one hole is plugged and two remain open?

  What applications could make use of knowledge about water flow from holes in sides of containers?

  Predict what would happen if this experiment were repeated with the following fluids: molasses, corn syrup, alcohol, 5-20 motor oil, transmission fluid, compressed air.

- Design a device which makes use of fluid properties in its operation. Be prepared to explain how the fluid properties influence its operation.

- Design a water pistol. How can the force be transmitted to the water? How can the distance the water shoots be maximized?

- Get fifteen BBs and a 100 mL cylinder filled with corn syrup. Measure and record the temperature of the syrup. Measure how long it takes for a BB to fall through the syrup. Repeat the BB drop five times and calculate the average time. Measure the final temperature of the syrup and record that value.

  Trade cylinders with a group that has syrup of a different temperature range. There are three sets of cylinders: cold, room temperature, and warm. Repeat the procedure in the first paragraph.

  Trade cylinders once again and repeat the process.

  Mark all three sets of results (average time, average temperature) on the class chart. Draw a graph of your own results. Get a copy of the class results sheet from your teacher and graph them on the same axes as your own data.

  (Note to teachers: If you have 12 lab groups, prepare four cylinders at 2°C - 5°C by putting them in the fridge overnight. Prepare four cylinders with syrup at about 45° - 50°C by heating the syrup in a water bath and filling the cylinders when students are ready to begin the activity. Fill the other four cylinders with syrup at room temperature. If different size BBs or other spheres are available, the effect of size of particle on time of fall could be measured.)

- With the mass of modelling clay you have been given, design and build a boat which will hold a cargo of pennies. Which designs hold the maximum loads? If you get double the mass of clay will the boat hold twice the cargo? What would happen with half the mass of clay?

- What causes water pressure? Build a device to determine whether water pressure is different at various depths.

- Here is a pool or lake activity. Inflate a balloon so that it is about 15 cm across. Hold the balloon under the surface of the water. Does it change shape or size? Lower the balloon in the water so that it is between 1 m and 2 m under the surface. Do you notice any change? Dive to as low as you can get with the balloon. Is there any change?

- Get a set of cubes of identical size but of different materials. Measure the mass and dimensions of each cube. Calculate the volume. Arrange them in order from least massive to most massive. Place each cube in water and sketch a diagram to show how it floats with respect to the water's surface. What is the mass of the volume of water that is equal to the volume of the cubes used in this activity? Where does water fit into the range from least massive to most massive? Would water float in water?

  Why does an ice cube float? What would happen if you put a bottle of full of water in a freezer overnight?

  (Note to teacher: Substances appropriate for cubes are styrofoam, balsa wood, oak, cork, spruce, pine, aluminum, steel, lead, copper, modelling clay, and so on.)

- Build a cube of modelling clay so that the cube will float.

- Demonstrate air pressure with an aluminum pop can. Boil a small amount (10 mL) of water in the can. When the steam is coming out of the hole remove the can from the heat and stretch a piece of heavy plastic seal across the top of the can. As the can cools, the plastic wrap should seal the hole. The condensing of the steam in the can should cause the can to collapse under the pressure of the air. Rubbing the walls of the can with an ice cube can accelerate the effect.

- Investigate the force of surface tension in water. How can a paper clip float on the surface of water? Why does a drop of water on a piece of waxed paper or on aluminum foil have a greater curvature than when the drop is on a piece of white note paper? How many drops of water can be placed on the surface of a penny?

Diversity of Life

Unit overview

Too often we walk past the wonders of nature, never noticing them until a companion points them out. So many things we take for granted or ignore are vital links in the web of life which makes this earth habitable. This unit encourages students to observe what is around them by asking them to locate, compare, and categorize organisms.

This theme is developed throughout the grade 1 to grade 8 curriculum. Students use their skills of observation and classification to identify and discuss diversity.

Science writing and reading activities, as discussed on pages 3 to 6 of this Guide, should be incorporated into each lesson. Writing in personal reflective journals, reading from newspapers, and reporting on the activities of science class in a variety of ways are only three strategies through which students may refine their understanding of the concepts of science and develop their ability to communicate through the written word.

Science challenge, as described on page 7 of this Guide, is meant to extend students' critical and creative thinking abilities in the context of the science concepts being studied. Activities involving science challenge should be incorporated into science lessons in each unit. The challenge is intended to give each student a chance to investigate an area of interest in more depth than would be possible for all students in a class to do. Science challenge is a key strategy for bringing the Adaptive Dimension to the classroom, and for encouraging independent learning.

Factors of scientific literacy that should be emphasized

A3 holistic
A7 unique
A9 human/culture related

B2 interaction
B4 organism
B12 conservation
B13 energy-matter
B14 cycle
B16 system
B18 population
B26 evolution

C1 classifying
C6 questioning
C9 inferring
C14 problem solving

D2 scientists and technologists are human
D5 public understanding gap

E2 using natural environments

F3 search for data and their meaning
F8 consideration of premises

G5 avocation

Concept development

grade 1
- characteristics of plants and animals

grade 2
- adaptations of plants and animals to their habitats

grade 3
- food webs
- diversity in plant structures

grade 4
- characteristics and interrelationships of vertebrates and invertebrates

grade 6
- how ecosystems work

grade 7
- common characteristics of living things

grade 8
- structural interrelationships in ecosystems
- adaptive characteristics of organisms

Foundational and learning objectives for Science and the Common Essential Learnings

1. Understand how classification systems are created.
   - 1.1 Identify and describe the appearance, behaviour, and habitat of organisms in the locality of the school.
   - 1.2 Group organisms native to Saskatchewan in several different ways.
   - 1.3 Use a dichotomous key to identify some organisms.

2. Recognize the adaptive value of species diversity.
   - 2.1 Discuss the origins and adaptive value of a diversity of species.
   - 2.2 Compare intraspecies diversity and interspecies diversity.
   - 2.3 Identify those factors which tend to reduce diversity.
   - 2.4 Debate the implications of human alteration of the ecosystems.

3. Develop abilities to access knowledge. (IL)
   - 3.1 Identify and get help in using resources which are not familiar.
   - 3.2 Use resources individually, in a one-to-one relationship with another person, and in small groups.
   - 3.3 Contribute to a catalogue of available resources, such as people, equipment, sites, or experiences.
   - 3.4 Acquire information at one level and apply it in a different context.

Suggested activities

Note: Many of the resources listed in *Science: An Information Bulletin for the Middle Level – Key Resource Correlations* describe activities or ideas for activities.

♦ Investigate how the Aboriginal peoples of North America classified plants and animals. Compare that system to the one created by scientists trained in the science developed in western Europe.

Factors: A7, A9, B16, B18, C1, C6, D2, E2, F3
Objectives: 1.2, 3.1
Assessment Techniques: written assignments, presentations, extended open response test items
Instructional Methods: research project, reading for meaning

♦ List the plant and animal species that class members identify in their community. Keep updating this list as the students become more proficient in identifying and more observant in noticing species. Initial or rare sightings might be annotated with the location, conditions, and other information about the sighting.

Factors: B4, B18, C1, E2, G5
Objectives: 1.1, 1.2, 1.3, 3.3
Assessment Techniques: anecdotal records, performance assessments
Instructional Methods: field trips, homework, reading for meaning

♦ Select a plant or animal native to your area. Keep in mind all sizes and types of organisms – not just the large or common ones.

Prepare a poster showing a sketch or picture of the plant or animal you have picked. Include on the poster brief descriptions of the organism's habitat, place in the food web, special adaptations that help it survive, and any information you think is of special interest. Mount the posters in the classroom to help others become acquainted with the organism you picked.

Factors: B2, B4, C9, F3, F8
Objectives: 2.1, 3.4
Assessment Techniques: presentations, peer assessment, extended open response test items
Instructional Methods: research projects, reading for meaning

♦ Ploughing prairie and planting wheat on the land decreases the diversity of plant life in that area. Why does it also decrease the diversity of animal life? What are the positive aspects of the conversion of huge amounts of land in Saskatchewan from prairie to land for growing grain? What are the negative aspects?

♦ Antibiotics used to fight infections gradually become less effective over a period of time. Members of the species targeted by the antibiotic show resistance to being affected. How does this happen?

- Design a plant that you think would be ideally suited to life in your area. Sketch a picture of what the plant would look like and explain why it has each of the characteristics you gave it.

  Repeat the above task for an animal.

- Select an area of the schoolyard or an accessible area near the schoolyard that has some plant growth, and is familiar to most students. Estimate the number of plant species that can be distinguished in that area. Go to the area and do a species count.

- For some public area near your school, create an interpretive guidebook. The book should contain sketches and names of the common plants and animals that can be identified in the area, along with tips on how to recognize them. The book could be structured as a nature path book, with a fixed starting point, path through the area, and ending point or it could be a wanderer's guide to the area.

- Bring as many different leaves as you can from home. Put your leaves together with the leaves your partners bring and sort them to determine the number of species of plants represented. Then classify them in a dichotomous key. Identify as many species as possible.

- During the fall collect several pizza boxes or shoeboxes full of poplar or aspen leaves. (They can be used right away or stored until this unit is done. If they are to be stored, fill any empty space in the box with old newspapers so that there is pressure on the leaves to keep them from curling up as they dry.) Decide what dimensions are appropriate to measure to compare the diversity in size of leaf. Measure each leaf and create a class chart that indicate the size diversity. On what factors does size of leaf depend? Is it the age of the tree, or the location the leaf forms on the tree? Is it the environmental conditions of the year or specific conditions that affect a particular tree?

- Read the article "Two Ways of Knowing" from the *Caribou News*, included as Appendix 4 in this Guide. Make a two column chart that summarizes the contrasts and similarities between the knowledge of the Inuit and the biologist. Write a paragraph discussing how the hunter's knowledge might be useful to the biologist and how the biologist's knowledge might be useful to the hunter.

Appendices

Appendix 1

Writing to Inform

Writing that reports information to others can vary greatly in content and format. Many learning experiences culminate in expository or informative writing activities. Students must have opportunities to read a variety of resources and printed materials for information. During writing, students can apply their knowledge of the structures and formats of these materials to organize and convey information.

Purposes

- to develop students' awareness of the organizational structures of informative text
- to develop students' abilities to use writing to organize, sequence, record and report knowledge and experience
- to increase students' ability to read and comprehend informative or expository text

Procedure

- Introduce expository structures to students by reading various resources in all subject areas.
- When reading informative text, focus students' attention on the structure and organization of ideas.
- A shared experience, students' interests, or a unit or topic of study in any subject area should provide the topic for collaborative writing and reporting activities.
- With students, determine an appropriate topic.
- **Brainstorm, categorize** and **web** what is known about the topic.
- Have students consider the audience to determine the appropriate content and format of the report.
- **Sequence** main ideas and supporting details, incorporating sub-headings if appropriate.
- Collaboratively prepare a draft by developing charted ideas into sentences and paragraphs.
- Read the draft and discuss the clarity of the information conveyed.
- Revise the draft incorporating students' suggestions.
- Have students consider the audience and purpose of the writing as they prepare the final draft or copy.
- Have students prepare any accompanying visuals.
- Share, display or present the final version to appropriate audiences.

Teacher Note:

- Classroom resource collections should include expository text.
- Daily **reading to students** sessions should include expository as well as narrative selections.
- Elementary students should gradually become aware of the structures and language of expository text. Common organizational patterns of expository text include:
  - **Description** -- features or characteristics of the topic are described. Some examples may be provided.
  - **Sequence** -- events or items are listed or ordered chronologically.
  - **Comparison** -- the subject or topic is compared and contrasted with other things or events.
  - **Cause and Effect** -- the author explains the cause of an event and the result.
  - **Problem and Solution** -- a question is presented and solutions are proposed.
- Students should have opportunities to orally express ideas and understandings before being expected to convey information in writing.
- During the Emerging Phase, students should have opportunities to inform others by dictating, drawing and writing their ideas.

Assessment

- Observe students' ability to organize and convey information through writing.
- Note students' use of their knowledge of text structures to read informative materials for meaning.

What Students Learn about Language

- Writing can be used to inform others.
- Language is used to organize thoughts and ideas.
- Comprehension is aided by an awareness of text structure.
- Narrative and expository text differ in structure.

Adaptations and Applications

- Writing to inform may include the following strategies:
  - **Brainstorming**
  - **Categorizing**
  - **Co-operative learning**
  - **Experience charts**
  - **Making books and charts**
  - **Researching**
  - **Webbing**

THE SOLAR SYSTEM

The solar system has a circular shape. It is only a tiny part of a galaxy called the Milky Way. The Milky Way consists of more than 100 billion stars that are probably very similar to the sun. The Milky Way which also has a circular shape, is about 100,000 light years across and about 16,000 light years thick in its center.

Many stars in the Milky Way are the centers of solar systems. Some astronomers think many of these systems may have some form of life. The nearest solar system that might have intelligent life is about 100 light years away. It would take 100 years for a radio message sent from the earth at the speed of light to reach this solar system, and another 100 years for a reply to reach the earth.

I hope there is somekind of life form out there,

do you?

a report by Tania, grade 5

Appendix 2

Journal Writing

A journal contains students' thoughts, feelings and reflections on various topics or experiences. Journal writing is rarely done to communicate with others. It is used to explore ideas and to communicate with oneself. Journal writing is often referred to as personal or free writing. This activity is appropriate for writers at all levels of development.

Purposes

- to use writing to explore ideas and record observations, experiences and understanding
- to encourage students to take risks in manipulating language and in structuring meaning
- to provide opportunities for students to reflect upon their growth and development as writers

Procedure

- Students could construct their own journal booklets.
- Model journal writing for students, demonstrating the process of reflection, idea exploration and writing.
- Schedule journal writing sessions daily or as frequently as possible.
- To introduce students to journal writing, brief discussions about topics or experiences may be necessary to focus students' thoughts.
- Allow time for silent reflection and idea exploration.
- Some journal writing sessions may focus on the description of a particular object, place, event or person, on experimenting with specific patterns to create poems, rhymes, songs and stories, or on responding to literature selections.
- Once students are familiar with the routine of journal writing, they should be encouraged to explore topics of their choice.
- Journal entries should be dated.
- Students may choose to discuss specific journal entries during conferences.

Assessment

- Review students' writing folders.
- Review journal entries with students to identify their interests and concerns, their writing abilities, and the skills and knowledge needed for further growth and achievement.
- Discuss students' writing strengths, growth profile, and specific frustrations or weaknesses during writing conferences.

Teacher Note:
- Create a classroom environment that stimulates thought and wonder and provides students with writing ideas and topics.
- Display a **brainstormed** list of writing topics.
- Avoid editing or grading journal entries.
- Respond to, and assist students with, the entries they wish to share.
- The entries of emerging writers may contain more drawing than text.
- Understand that prior to writing, students often need time to discuss ideas

What Students Learn about Language

- Personal, expressive writing can be used to develop self-awareness and to clarify thoughts, feelings and experiences.

Adaptations and Applications

- **Silent sustained writing** (S.S.W.) sessions can incorporate journal writing.
- Journal entries may occasionally be shared in **author's chair** sessions.
- **Daily records** or personal diaries can be used to record classroom experiences.
- Students may keep learning logs in which they record their understandings, feelings and attitudes about particular subjects areas.
- **Dialogue journals** encourage and extend students' reading and writing efforts. Teachers, the most common audience for these journals, write responses to each journal entry. The teacher's shared insights, comments, questions or suggestions are read by the student who then responds in the form of another journal entry and the dialogue continues.
- Students could respond to the journal entries of the teacher or their peers.
- **Reading logs** can be used to clarify thoughts as students read or listen to selections.

Appendix 3

Guided Reading and Thinking

During this reading strategy, students' comprehension of a selection is guided and developed by teacher questions. The focus is on the use of context to predict meaning. As students gain practice and confidence in using this strategy, the teacher will monitor or confer with small groups or individual readers.

Purposes

- to enable students to establish and verbalize purposes for reading
- to develop students' story sense (story sequence or story grammar), and the practice of monitoring for meaning while reading
- to encourage students to use past experiences, their knowledge of language and context clues to aid comprehension
- to develop independent reading skills

Procedure

Reading Narrative Text:

- Have students predict story contents using the title and cover illustration or information.
- List and display predictions (a story grid or outline as described in **story grammar** may be useful to organize ideas and story elements).
- Read, or have students read, introductory pages.
- Ask students for their perceptions of what has occurred and what will follow.
- Continue to read portions of the text, stopping to compare and verify predictions.
- Record students' inferences and predictions for the story conclusion.
- Complete the selection.
- Compare students' predictions to story events.
- Relate the story to students' personal experiences and to other stories.

Reading Expository Text:

- Prior to reading, list or make a **webbing** of what students know about the topic.
- **Brainstorm** and list questions students have about the topic.
- Have students view the resource to identify possible clues to the content.
- Focus students' attention on the table of contents, illustrations, headings and sub-headings.
- Encourage students to predict the content.
- Read, or have students read, portions of the text.
- Have students recall significant details.
- Compare students' predictions to the information contained in the text.
- Add new ideas and understandings to students' initial list or **webbing**.

Assessment

- Use reading **conferences** to assess students' application of this strategy during independent reading.
- Assess students' abilities to comprehend narrative and expository text.

Teacher Note:

- Sincere predictions should be accepted without evaluation. Describe them as "ideas much like the author's," or "ideas that would make a very different story."

What Students Learn about Language and Literature

- To construct meaning from print, efficient readers:
  - reflect upon and question illustrations and text
  - predict or hypothesize possible answers, events or information, basing inferences and predictions on context, previous reading experiences, their sense of story and knowledge of the topic
  - read to validate predictions
  - form conclusions.
- Expository and narrative reading materials differ in format and purpose.
- Most narratives follow a predictable pattern.

Adaptations and Applications

- Students could write their own story endings using the list of predicted conclusions.
- Students could use a self-directed reading and thinking strategy during independent reading.
- Guided reading and thinking can be incorporated with:
  - **Literature study**
  - **Story grammar**
  - **Story mapping**
  - **Storytelling**

Appendix 4

Two Ways of Knowing

- Roy Vontobel of the *Caribou News*

People of different cultures tend to acquire knowledge about the world in which they live in different ways. The reason is that their *purpose* for acquiring such knowledge is very different. This fact, which may seem obvious, helps explain why two persons - an Inuit hunter born and raised in Eskimo Point and a biologist born and raised in Toronto, say - can look at the same thing and not see it the same way at all.

For example, both the hunter and the biologist may know a great deal about caribou. But what they know may appear contradictory (and sometimes is) because what the hunter and the scientist want or need to learn about caribou are not the same. So, in many cases, one kind of knowledge is not simply better or worse than another - it is different. More than that, the hunter and the scientist do not "learn" in the same way. A little more background will help make this point clear.

Over countless generations, what people such as Inuit, Chipewyans, Crees or Europeans (who became the main non-natives in North America) learned about their part of the world enabled them to survive there. In this way, the many different people in the world have come to know their own regions intimately. This collective knowledge, derived from their own living experiences, affects how they see and interpret their surroundings.

The scientists who explain the "cultural" differences among people in this way (as well as those who study animals) see and interpret their surroundings according to European-derived traditions of learning. Their "way of knowing" is based on science. This scientific approach is so alien to traditional Inuit and Indian attitudes that it is little wonder that biologists and native people often have difficulty understanding one another when they are discussing caribou.

To a native hunter, who has to learn about caribou in order to hunt them, the biologist's methods often seem ineffective or aimed at acquiring useless information. The hunter needs to know, for example, how to hunt caribou at different seasons of the year, how hunting on cold clear days is different from hunting when a light storm masks the sounds of walking or the smell of the hunter, how to tell the sex and health of individual animals from great distances. He must be able to predict where the caribou are likely to be days in advance, whether they are migrating or not. The hunter has not taken a course at a university to learn such things. And, while he does learn by practice, he doesn't learn by experimenting in the way a scientist does.

The native hunter, taught such things by his elders since he was a boy accepts them as facts. He does not question this basic knowledge. In the past, his survival and that of his family depended on his learning and performing his tasks well. Thus the native hunter has grown up learning about caribou by participating in the use of that knowledge, and he is expected to pass on that knowledge to his children.

The biologist, on the other hand was raised in a culture where students are taught to question knowledge. In this culture, he is taught basic principles or rules about the relationships of various things and is expected to take those and use them to learn more. Yet even the basic principles are not utterly beyond questioning. In this system, it makes sense to ask a question and suggest ways to answer it if only to see where the exercise leads. It is a kind of mental exploration. And, the survival at stake is that of the biologist's reputation and possibly his job, but not his life.

It is easy to see how these different approaches to knowledge cause misunderstanding. Each person, the hunter and the biologist, learns "facts" about caribou, but learns what is important to his own way of life. In a certain sense, the hunter learns from the inside and the biologist from the outside. An Inuit hunter learns about caribou by experience, by doing what his father has taught him to do, and a biologist applies to caribou the same basic system of learning that he would apply to learning anything.

There are some similarities. Both of these "ways of knowing" are built upon and develop over time, and both make sense in their own cultural context. Moreover, while the biologist's explanation of science may seem foreign to an Inuit hunter, concepts of organizing knowledge should not. For example, Inuit have their own ways of categorizing animals and the relationships between them.

An example will show that while the biologist's approach produces results, it is often not the only useful way to learn about caribou. In the 1960s and 1970s, there was growing concern among biologists because the Kaminuriak herd appeared to be declining. Many native hunters said there was no problem and that the caribou would come back, that they were merely somewhere else. In late 1981, Inuit at Repulse Bay were saying that Kaminuriak caribou were showing up in the vicinity of Wager Bay. Biologists, because they had not actually seen Kaminuriak caribou moving north-eastward and had seen no signs to suggest that they were, doubted that it could be so.

But Repulse Bay people were adamant, saying that many caribou in their area were not the same as the animals they were used to - they looked different and they *tasted* different. This did not qualify as scientific information, so biologists tended to reject the idea. Since calving ground surveys in recent years have shown much greater numbers of Kaminuriak caribou, biologists have had to reconsider what Inuit had been saying. And some may be willing to admit that, to some degree at least, the Repulse Bay people had been right.

Caribou News. Vol. 9, No. 2, August 1989. Reprinted with permission of the author.

Appendix 5

The Invitation of Elders

All cultures are enriched by certain valuable and unique individuals. Such individuals possess a wide range of knowledge – knowledge that once shared, can expand students' insight beyond the perspectives of the teacher and classroom resources.

Indian and Métis Elders in particular, are integral to the revival, maintenance, and preservation of Aboriginal cultures. Elder participation in support of curricular objectives develops the positive identity of Indian and Métis students and enhances self-esteem. All students may acquire a heightened awareness and sensitivity that inevitably promotes anti-racist education. It is important to note that the title "Elder" does not necessarily indicate age. In Aboriginal societies, one is designated an Elder after acquiring significant wisdom and experience.

When requesting guidance or assistance there is a protocol used in approaching Elders, which varies from community to community. The district chiefs' office, tribal council office, or a reserve's band council or education committee may be able to assist you. Prior to an Elder sharing knowledge, it is essential that you and your students complete the cycle of giving and receiving through an appropriate offering. This offering represents respect and appreciation for knowledge shared by an Elder. One must ascertain the nature of the offering prior to an Elder's visit as traditions differ throughout Aboriginal communities. In addition, should your school division normally offer honoraria and/or expense reimbursement to visiting instructors, it would be similarly appropriate to extend such considerations to a visiting Elder.

To initiate the process of dialogue and participation, a letter should be sent to the local band council requesting Elder participation and indicating the role the Elder would have within the program. The band council may then be able to provide the names of persons who have the recognized knowledge and skills that would meet your specific needs. It is recommended that prior consultation occur with the Elder to share expectations for learning outcomes.

Friendship Centres across the province are active at the community level and often present culturalworkshops and activities in co-operation with Elders and other recognized resource people. Teachers and schools may wish to contact the following to initiate discussions.

Director of Education
Meadow Lake Tribal Council
Box 1360
Meadow Lake, S0M 1V0 236-5654

Director of Education
Yorkton Tribal Administration
P.O. Box 790
Broadview, S0G 0K0 794-2170

Director of Education
Prince Albert Tribal Council
P.O. Box 1437
Prince Albert, S6V 5S9 953-7234

Director of Education
Saskatoon District Tribal Council
226 Cardinal Crescent
Saskatoon, S7L 6H8 956-6130
244-1101

Director of Education
Battlefords Tribal Council
691 - 109nd Street
North Battleford, S9A 2C5 445-1383

Education Coordinator
Confederation of Tribal Nations
91 23rd Street West
Bag 5000
Battleford, S0M 0E0 445-5838

Director of Education
Touchwood/File Hills/Qu'Appelle
Tribal Council
Box 178
Lebret, S0G 2Y0 332-8224

Director of Education
Agency Chiefs Tribal Council
P.O. Box 550
Debden, S0J 0S0 724-4555

Gabriel Dumont Institute of Native
Studies and Applied Research

- 121 Broadway Avenue East
  Regina, S4N 0Z6
  1-800-667-9851
  (306) 522-5691
  Fax: (306) 565-0809

or

- 48 12th Street East
  Prince Albert, S6V 1B2
  (306) 764-1797
  Fax: (306) 764-3995

Saskatchewan Indian Federated College
Room 127
College West
University of Regina
Regina, S4S 0A2
(306) 584-8333
Fax: (306) 584-0955

Saskatchewan Indian Cultural Centre
401 Packham Place
Saskatoon, S4N 2T7
(306) 244-1146
Fax: (306) 665-6520