

2011

Saskatchewan Curriculum

Science

4



Science 4

ISBN 978-1-926841-83-0

1. Science (Elementary school) - Saskatchewan - Curricula. 2. Competency-based education - Saskatchewan. Saskatchewan. Ministry of Education. Student Achievement and Supports Branch, Learning Program Unit - English.

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Acknowledgements

The Ministry of Education wishes to acknowledge the professional contributions and advice of the provincial curriculum reference committee members:

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The Ministry of Education also wishes to thank many others who contributed to the development of this curriculum:

- former Science Reference Committee members
- First Nations Elders and teachers
- university faculty members
- other educators and reviewers.

Introduction

Science is a Required Area of Study in Saskatchewan's Core Curriculum. The provincial requirement for science is 150 minutes of instruction per week at this grade level (*Core Curriculum: Principles, Time Allocations, and Credit Policy*).

The purpose of this curriculum is to outline the provincial requirements for science at this grade level, including the intended learning outcomes that students are expected to achieve by the end of the year. Indicators are included to provide the breadth and depth of what students should know and be able to do to achieve the learning outcomes.

This renewed curriculum reflects current science education research, updated technology, and recently developed resources, and is responsive to changing demographics within the province. This curriculum is based on the *Pan-Canadian Protocol for Collaboration on School Curriculum Common Framework of Science Learning Outcomes K to 12* (Council of Ministers of Education, Canada [CMEC], 1997).

The philosophy and spirit of science education in Saskatchewan is reflected in this curriculum, in the resources developed to support the new curriculum, and in materials designed and utilized to support curriculum implementation. In addition, the philosophy for science education builds on and supports the concept of Core Curriculum in Saskatchewan.

This curriculum includes the following information to support science instruction in Saskatchewan schools:

- connections to Core Curriculum, including the Broad Areas of Learning and Cross-curricular Competencies
- the K-12 aim and goals for science education
- characteristics of an effective science program
- outcomes and indicators for this grade level
- assessment and evaluation
- connections with other areas of study
- a glossary.

Inquiry into authentic student questions generated from student experiences is the central strategy for teaching science.

(National Research Council [NRC], 1996, p. 31)

Outcomes describe the knowledge, skills, and understandings that students are expected to attain by the end of a particular grade.

Indicators are a representative list of the types of things a student should know or be able to do if they have attained the outcome.

Using this Curriculum

Outcomes are statements of what students are expected to know and be able to do by the end of a grade in a particular area of study. The outcomes provide direction for assessment and evaluation, and for program, unit, and lesson planning.

Critical characteristics of an outcome:

- focus on what students will learn rather than what teachers will teach
- specify the skills and abilities, understandings and knowledge, and/or attitudes students are expected to demonstrate
- are observable, assessable, and attainable
- are written using action-based verbs and clear professional language (educational and subject-related)
- are developed to be achieved in context so that learning is purposeful and interconnected
- are grade and subject specific
- are supported by indicators which provide the breadth and depth of expectations
- have a developmental flow and connection to other grades where applicable.

Indicators are representative of what students need to know and/or be able to do to achieve an outcome. Indicators represent the breadth and depth of learning related to a particular outcome. The list of indicators provided in the curriculum is not an exhaustive list. Teachers may develop additional and/or alternative indicators, reflective of and consistent with the breadth and depth defined by the given indicators.

Within the outcomes and indicators in this curriculum, the terms “including,” “such as,” and “e.g.,” commonly occur. Each term serves a specific purpose.

- The term “including” prescribes content, contexts, or strategies that students must experience in their learning, without excluding other possibilities. For example, an indicator might state that students are to compare the characteristics of human and animal perceptions of sound, including the sense organs which detect sound and their range of hearing. This means that, although other characteristics can be explored and described, the inclusion of sense organs is mandatory.
- The term “such as” provides examples of possible broad categories of content, contexts, or strategies that teachers or students may choose, without excluding other possibilities. For example, an indicator might include the phrase “such as functionality, mineral

shape, cost, availability, and aesthetics” as examples of different characteristics and uses for rocks and minerals. This statement provides teachers and students with possible characteristics to consider, while not excluding other characteristics.

- The term “e.g.,” offers specific examples of what content, contexts, or strategies might look like. For example, an indicator might include the phrase “e.g., schoolyard, wildlife reserve area, and creek bank” to refer to examples of habitats within which plants and animals exist.

Although the outcomes and indicators in the science curriculum are organized by units, teachers may organize their instruction using disciplinary or interdisciplinary themes. Teachers are not required to structure instruction into four distinct science units.

Related to the following Goals of Education:

- *Basic Skills*
- *Lifelong Learning*
- *Positive Lifestyle*

Related to the following Goals of Education:

- *Understanding and Relating to Others*
- *Self-Concept Development*
- *Spiritual Development*

Related to the following Goals of Education:

- *Career and Consumer Decisions*
- *Membership in Society*
- *Growing with Change*

Core Curriculum

Core Curriculum is intended to provide all Saskatchewan students with an education that will serve them well, regardless of their choices after leaving school. Through its components and initiatives, Core Curriculum supports the achievement of the Goals of Education for Saskatchewan. For current information regarding Core Curriculum, please refer to *Core Curriculum: Principles, Time Allocations, and Credit Policy* on the Saskatchewan Ministry of Education website. For additional information related to the various components and initiatives of Core Curriculum, please refer to the Ministry website at www.education.gov.sk.ca/policy for policy and foundation documents.

Broad Areas of Learning

Three Broad Areas of Learning reflect Saskatchewan's Goals of Education. Science education contributes to student achievement of the Goals of Education through helping students achieve knowledge, skills, and attitudes related to these Broad Areas of Learning.

Lifelong Learners

Students who are engaged in constructing and applying science knowledge naturally build a positive disposition towards learning. Throughout their study of science, students bring their curiosity about the natural and constructed world, which provides the motivation to discover and explore their personal interests more deeply. By sharing their learning experiences with others, in a variety of contexts, students develop skills that support them as lifelong learners.

Sense of Self, Community, and Place

Students develop and strengthen their personal identity as they explore connections between their own understanding of the natural and constructed world and the perspectives of others, including scientific and Indigenous perspectives. Students develop and strengthen their understanding of community as they explore ways in which science can inform individual and community decision making on issues related to the natural and constructed world. Students interact experientially with place-based local knowledge to deepen their connection to and relationship with nature.

Engaged Citizens

As students explore connections between science, technology, society, and the environment, they experience opportunities to contribute positively to the environmental, economic, and social sustainability

of local and global communities. Students reflect and act on their personal responsibility to understand and respect their place in the natural and constructed world, and make personal decisions that contribute to living in harmony with others and the natural world.

Cross-curricular Competencies

The Cross-curricular Competencies are four interrelated areas containing understandings, values, skills, and processes which are considered important for learning in all areas of study. These competencies reflect the Common Essential Learnings and are intended to be addressed in each area of study at each grade level.

Developing Thinking

Learners construct knowledge to make sense of the world around them. In science, students develop understanding by building and reflecting on their observations and what already is known by themselves and others. By thinking contextually, creatively, and critically, students deepen their understanding of phenomena in the natural and constructed world.

Developing Identity and Interdependence

This competency addresses the ability to act autonomously in an interdependent world. It requires the learner to be aware of the natural environment, social and cultural expectations, and the possibilities for individual and group accomplishments. Interdependence assumes the possession of a positive self-concept and the ability to live in harmony with others and with the natural and constructed world. In science, students examine the interdependence among living things within local, national, and global environments, and consider the impact of individual decisions on those environments.

Developing Literacies

Literacies are multi-faceted and provide a variety of ways, including the use of various language systems and media, to interpret the world and express understanding of it. Literacies involve the evolution of interrelated knowledge, skills, and strategies that facilitate an individual's ability to participate fully and equitably in a variety of roles and contexts – school, home, and local and global communities. In science, students collect, analyze, and represent ideas and understanding of the natural and constructed world in multiple forms.

K-12 Goals for Developing Thinking:

- *thinking and learning contextually*
- *thinking and learning creatively*
- *thinking and learning critically.*

K-12 Goals for Developing Identity and Interdependence:

- *understanding, valuing, and caring for oneself*
- *understanding, valuing, and caring for others*
- *understanding and valuing social, economic, and environmental interdependence and sustainability.*

K-12 Goals for Developing Literacies:

- *developing knowledge related to various literacies*
- *exploring and interpreting the world through various literacies*
- *expressing understanding and communicating meaning using various literacies.*

K-12 Goals for Developing Social Responsibility:

- *using moral reasoning*
- *engaging in communitarian thinking and dialogue*
- *taking social action.*

Developing Social Responsibility

Social responsibility is how people positively contribute to their physical, social, cultural, and educational environments. It requires the ability to participate with others in accomplishing shared or common goals. This competency is achieved by using moral reasoning processes, engaging in communitarian thinking and dialogue, and taking social action. Students in science examine the impact of scientific understanding and technological innovations on society.

Aim and Goals

The aim of K-12 science education is to enable all Saskatchewan students to develop scientific literacy. Scientific literacy today embraces Euro-Canadian and Indigenous heritages, both of which have developed an empirical and rational knowledge of nature. A Euro-Canadian way of knowing about the natural and constructed world is called science, while First Nations and Métis ways of knowing nature are found within the broader category of Indigenous knowledge.

Diverse learning experiences based on the outcomes in this curriculum provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment (STSE) that will affect their personal lives, careers, and future.

Goals are broad statements identifying what students are expected to know and be able to do upon completion of the learning in a particular area of study by the end of Grade 12. The four goals of K-12 science education are to:

- **Understand the Nature of Science and STSE Interrelationships:** Students will develop an understanding of the nature of science and technology, their interrelationships, and their social and environmental contexts, including interrelationships between the natural and constructed world.
- **Construct Scientific Knowledge:** Students will construct an understanding of concepts, principles, laws, and theories in life science, physical science, earth and space science, and Indigenous knowledge of nature, then apply these understandings to interpret, integrate, and extend their knowledge.
- **Develop Scientific and Technological Skills:** Students will develop the skills required for scientific and technological inquiry, problem solving, and communicating; for working collaboratively; and for making informed decisions.

- **Develop Attitudes that Support Scientific Habits of Mind:**

Students will develop attitudes that support the responsible acquisition and application of scientific, technological, and Indigenous knowledge to the mutual benefit of self, society, and the environment.

Inquiry

Inquiry learning provides students with opportunities to build knowledge, abilities, and inquiring habits of mind that lead to deeper understanding of their world and human experience. Inquiry is more than a simple instructional method. It is a philosophical approach to teaching and learning, grounded in constructivist research and methods, which engages students in investigations that lead to disciplinary and interdisciplinary understanding.

Inquiry builds on students' inherent sense of curiosity and wonder, drawing on their diverse backgrounds, interests, and experiences. The process provides opportunities for students to become active participants in a collaborative search for meaning and understanding.

Elementary students who are engaged in inquiry in science should be able to:

- ask questions about objects, organisms, and events in the environment
- plan and conduct a simple investigation
- employ simple equipment and tools to gather data and extend the senses
- use data to construct a reasonable explanation
- communicate investigations and explanations.

(NRC, 1996, p. 122-123)

An important part of any inquiry process is student reflection on their learning and the documentation needed to assess learning and make it visible. Student documentation of their inquiries in science may take the form of works-in-progress, reflective writing, journals, reports, notes, models, arts expressions, photographs, video footage, or action plans.

Inquiry learning is not a step-by-step process, but rather a cyclical process with various phases of the process being revisited and rethought as a result of students' discoveries, insights, and construction of new knowledge. Experienced inquirers will move back and forth among various phases as new questions arise and as students become more comfortable with the process. The following graphic shows various phases of the cyclical inquiry process.

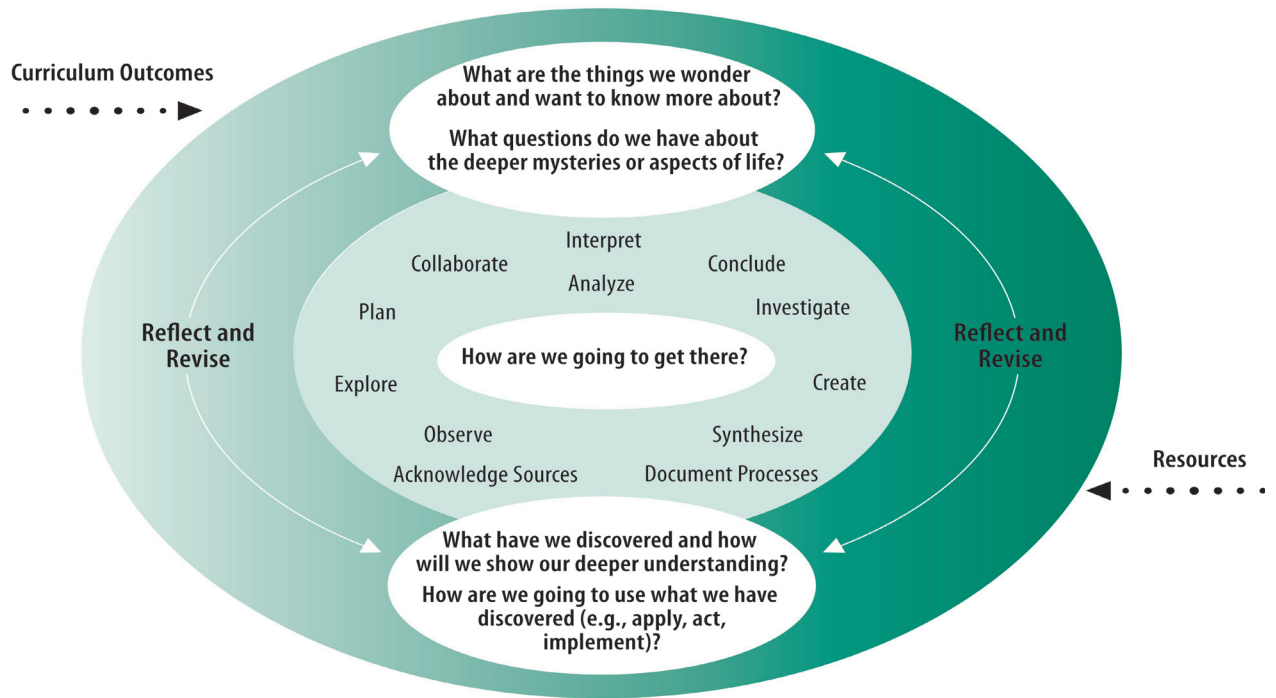
Inquiry is intimately connected to scientific questions – students must inquire using what they already know and the inquiry process must add to their knowledge.

(NRC, 2000, p. 13)

Students do not come to understand inquiry simply by learning words such as "hypothesis" and "inference" or by memorizing procedures such as "the steps of the scientific method".

(NRC, 2000, p. 14)

Constructing Understanding Through Inquiry



Good science inquiry provides many entry points – ways in which students can approach a new topic – and a wide variety of activities during student work.

(Kluger-Bell, 2000, p. 48)

Creating Questions for Inquiry in Science

Inquiry focuses on the development of driving questions to initiate and guide the learning process. Students and/or teachers formulate questions to motivate inquiries into topics, problems, and issues related to curriculum content and outcomes.

Well-formulated inquiry questions are broad in scope and rich in possibilities. Such questions encourage students to explore, observe, gather information, plan, analyze, interpret, synthesize, problem solve, take risks, create, conclude, document, reflect on learning, and develop new questions for further inquiry.

In science, teachers and students can use the four learning contexts of Scientific Inquiry, Technological Problem Solving, STSE Decision Making, and Cultural Perspectives (see Learning Contexts on p.17 for further information) as curriculum entry points to begin their inquiry. The process may evolve into interdisciplinary learning opportunities reflective of the holistic nature of our lives and interdependent global environment.

Developing questions evoked by student interests have the potential for rich and deep learning. These questions are used to initiate and guide the inquiry and give students direction for investigating topics, problems, ideas, challenges, or issues under study.

The process of constructing questions for deep understanding can help students grasp the important disciplinary or interdisciplinary ideas that are situated at the core of a particular curricular focus or context. These broad questions lead to more specific questions that can provide a framework, purpose, and direction for the learning activities in a lesson or series of lessons.

Questions give students initial direction for uncovering the understandings associated with a unit of study. Questions can help students grasp the big disciplinary ideas surrounding a focus or context and related themes or topics. They provide a framework, purpose, and direction for the learning activities in each unit and help students connect what they are learning to their experiences and life beyond the classroom. Questions also invite and encourage students to pose their own questions for deeper understanding.

Students should recognize science is generally unable to answer “why” questions; in these instances, scientists rephrase their inquiries into “how” questions.

Essential questions that lead to deeper understanding in science should:

- *center on objects, organisms, and events in the natural world*
- *connect to science concepts outlined in the curricular outcomes*
- *lend themselves to empirical investigation*
- *lead to gathering and using data to develop explanations for natural phenomena.*

(NRC, 2000, p. 24)

An Effective Science Education Program

An effective science education program supports student achievement of learning outcomes through:

- incorporating all foundations of scientific literacy
- using the learning contexts as entry points into student inquiry
- understanding and effectively using the language of science
- engaging in laboratory and field work
- practising safety
- choosing and using technology in science appropriately.

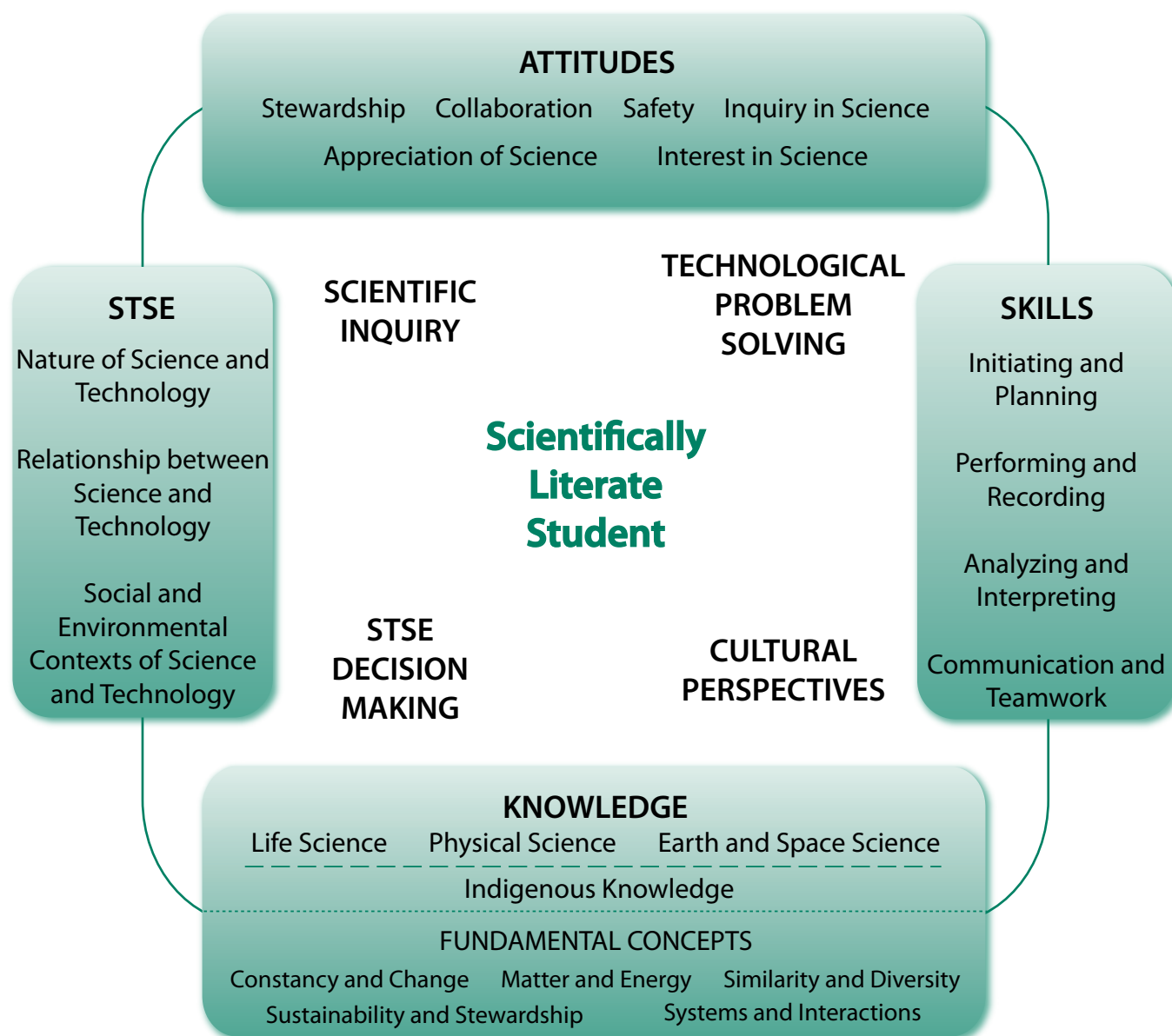
All science outcomes and indicators incorporate one or more foundations of scientific literacy; these are the “what” of the curriculum. The learning contexts represent different processes for engaging students in achieving curricular outcomes; they are the “how” of the curriculum. The four units of study at each grade are an organizing structure for the curriculum.

Scientists construct models to support their explanations based on empirical evidence. Students need to engage in similar processes through authentic investigations. During the investigations, students must follow safe practices.

Technology serves to extend our powers of observation and support the sharing of information. Students should use a variety of technology tools for data collection and analysis, visualization and imaging, and communication and collaboration throughout the science curriculum.

To achieve the vision of scientific literacy outlined in this curriculum, students increasingly must become engaged in the planning, development, and evaluation of their own learning activities. In the process, students should have the opportunity to work collaboratively with others, initiate investigations, communicate findings, and complete projects that demonstrate learning.

Scientific Literacy Framework



Foundations of Scientific Literacy

The K-12 goals of science education parallel the foundation statements for scientific literacy described in the *Common Framework of Science Learning Outcomes K to 12* (CMEC, 1997, p. 6-18). These four foundation statements delineate the critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Foundation 1: Science, Technology, Society, and the Environment (STSE) Interrelationships

This foundation is concerned with understanding the scope and character of science, its connections to technology, and the social and environmental contexts in which it is developed. This foundation is the driving force of scientific literacy. Three major dimensions address this foundation.

Nature of Science and Technology

Science is a social and cultural activity anchored in a particular intellectual tradition. It is one way of knowing nature, based on curiosity, imagination, intuition, exploration, observation, replication, interpretation of evidence, and consensus-making over this evidence and its interpretation. More than most other ways of knowing nature, science excels at predicting what will happen next, based on its descriptions and explanations of natural and technological phenomena.

Science-based ideas continually are being tested, modified, and improved as new ideas supersede existing ideas. Technology, like science, is a creative human activity concerned with solving practical problems that arise from human and social needs, particularly the need to adapt to the environment and fuel a nation's economy. Research and development leads to new products and processes through the processes of inquiry and design.

Relationships between Science and Technology

Historically, the development of technology has been strongly linked to advances in science, with each making contributions to the other. Where the focus of science is on the development and verification of knowledge, in technology, the focus is on the development of solutions, involving devices and systems that meet a given need within the constraints of the problem. The test of science knowledge is that it helps explain, interpret, and predict; the test of technology is that it works, enabling us to achieve a given purpose.

Social and Environmental Contexts of Science and Technology

The history of science shows that scientific development takes place within a social context that includes economic, political, social, and

cultural forces, along with personal biases and the need for peer acceptance and recognition. Many examples demonstrate how cultural and intellectual traditions have influenced the focus and methodologies of science, and how science, in turn, has influenced the wider world of ideas. Today, societal and environmental needs and issues often drive research agendas. As technological solutions emerge from previous research, many new technologies give rise to complex social and environmental issues which increasingly are becoming part of the political agenda. The potential of science, technology, and indigenous knowledge to inform and empower decision-making by individuals, communities, and society is central to scientific literacy in a democratic society.

Foundation 2: Scientific Knowledge

This foundation focuses on the subject matter of science including the theories, models, concepts, and principles that are essential to an understanding of the natural and constructed world. For organizational purposes, this foundation is framed using widely accepted science disciplines.

Life Science

Life science deals with the growth and interactions of life forms within their environments in ways that reflect the uniqueness, diversity, genetic continuity, and changing nature of these life forms. Life science includes the study of topics such as ecosystems, biological diversity, organisms, cell biology, biochemistry, diseases, genetic engineering, and biotechnology.

Physical Science

Physical science, which encompasses chemistry and physics, deals with matter, energy, and forces. Matter has structure, and its components interact. Energy links matter to gravitational, electromagnetic, and nuclear forces in the universe. Physical science also addresses the conservation laws of mass and energy, momentum, and charge.

Earth and Space Science

Earth and space science brings local, global, and universal perspectives to student knowledge. Earth, our home planet, exhibits form, structure, and patterns of change, as do our surrounding solar system and the physical universe beyond. Earth and space science includes geology, hydrology, meteorology, and astronomy.

Traditional and Local Knowledge

A strong science program recognizes that modern science is not the only form of empirical knowledge about nature and aims to broaden student understanding of traditional and local knowledge systems. The dialogue between scientists and traditional knowledge holders has an extensive history and continues to grow as researchers and

practitioners seek to understand our complex world. The terms “traditional knowledge”, “indigenous knowledge”, and “traditional ecological knowledge” are used by practitioners worldwide when referencing local knowledge systems which are embedded within particular worldviews. This curriculum uses the term “indigenous knowledge” and provides the following definitions to show parallels and distinctions between indigenous knowledge and scientific knowledge.

Indigenous Knowledge

“Traditional [Indigenous] knowledge is a cumulative body of knowledge, know-how, practices, and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview” (International Council for Science, 2002, p. 3).

Scientific Knowledge

Similar to Indigenous knowledge, scientific knowledge is a cumulative body of knowledge, know-how, practices, and representations maintained and developed by people (scientists) with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations, and meanings are part and parcel of cultural complexes that encompass language, naming and classification systems, resource use practices, ritual, and worldview.

Fundamental Ideas – Linking Scientific Disciplines

A useful way to create linkages among science disciplines is through fundamental ideas that underlie and integrate different scientific disciplines. Fundamental ideas provide a context for explaining, organizing, and connecting knowledge. Students deepen their understanding of these fundamental ideas and apply their understanding with increasing sophistication as they progress through the curriculum from Kindergarten to Grade 12. These fundamental ideas are identified in the following chart.

Constancy and Change	The ideas of constancy and change underlie understanding of the natural and constructed world. Through observations, students learn that some characteristics of materials and systems remain constant over time whereas other characteristics change. These changes vary in rate, scale, and pattern, including trends and cycles, and may be quantified using mathematics, particularly measurement.
Matter and Energy	Objects in the physical world are comprised of matter. Students examine materials to understand their properties and structures. The idea of energy provides a conceptual tool that brings together many understandings about natural phenomena, materials, and the process of change. Energy, whether transmitted or transformed, is the driving force of both movement and change.
Similarity and Diversity	The ideas of similarity and diversity provide tools for organizing our experiences with the natural and constructed world. Beginning with informal experiences, students learn to recognize attributes of materials that help to make useful distinctions between one type of material and another, and between one event and another. Over time, students adopt accepted procedures and protocols for describing and classifying objects encountered, thus enabling students to share ideas with others and to reflect on their own experiences.
Systems and Interactions	An important way to understand and interpret the world is to think about the whole in terms of its parts and, alternately, about its parts in terms of how they relate to one another and to the whole. A system is an organized group of related objects or components that interact with one another so that the overall effect is much greater than that of the individual parts, even when these are considered together.
Sustainability and Stewardship	Sustainability refers to the ability to meet our present needs without compromising the ability of future generations to meet their needs. Stewardship refers to the personal responsibility to take action to participate in the responsible management of natural resources. By developing their understanding of ideas related to sustainability, students are able to take increasing responsibility for making choices that reflect those ideas.

Foundation 3: Scientific and Technological Skills and Processes

This foundation identifies the skills and processes students develop in answering questions, solving problems, and making decisions. While these skills and processes are not unique to science, they play an important role in the development of scientific and technological understanding and in the application of acquired knowledge to new situations. Four broad skill areas are outlined in this foundation. Each area is developed further at each grade level with increasing scope and complexity of application.

Initiating and Planning

These are the processes of questioning, identifying problems, and developing preliminary ideas and plans.

Performing and Recording

These are the skills and processes of carrying out a plan of action, which involves gathering evidence by observation and, in most cases, manipulating materials and equipment. Gathered evidence can be documented and recorded in a variety of formats.

Both scientific and Indigenous knowledge systems place value on attitudes, values, and ethics. These are more likely to be presented in a holistic manner in Indigenous knowledge systems.

Analyzing and Interpreting

These are the skills and processes of examining information and evidence, organizing and presenting data so that they can be interpreted, interpreting those data, evaluating the evidence, and applying the results of that evaluation.

Communication and Teamwork

In science and technology, as in other areas, communication skills are essential whenever ideas are being developed, tested, interpreted, debated, and accepted or rejected. Teamwork skills also are important because the development and application of ideas rely on collaborative processes both in science-related occupations and in learning.

Foundation 4: Attitudes

This foundation focuses on encouraging students to develop attitudes, values, and ethics that inform a responsible use of science and technology for the mutual benefit of self, society, and the environment. This foundation identifies six categories in which science education contributes to the development of scientific literacy.

Appreciation of Science

Students will be encouraged to critically and contextually appreciate the role and contributions of science and technology in their lives and to their community's culture, and be aware of the limits of science and technology and their impact on economic, political, environmental, cultural, and ethical events.

Interest in Science

Students will be encouraged to develop curiosity and continuing interest in the study of science at home, in school, and in the community.

Inquiry in Science

Students will be encouraged to develop critical beliefs concerning the need for evidence and reasoned argument in the development of scientific knowledge.

Collaboration

Students will be encouraged to nurture competence in collaborative activity with classmates and others, inside and outside of the school.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Safety

Students engaged in science and technology activities will be expected to demonstrate a concern for safety and doing no harm to themselves or others, including plants and animals.

Learning Contexts

Learning contexts provide entry points into the curriculum that engage students in inquiry-based learning to achieve scientific literacy. Each learning context reflects a different, but overlapping, philosophical rationale for including science as a Required Area of Study:

- The **scientific inquiry** learning context reflects an emphasis on understanding the natural and constructed world using systematic empirical processes that lead to the formation of theories that explain observed events and facilitate prediction.
- The **technological problem-solving** learning context reflects an emphasis on designing, constructing, testing, and refining prototypes to solve practical human problems using an engineering approach.
- The **STSE decision-making** learning context reflects the need to engage citizens in thinking about human and world issues through a scientific lens to inform and empower decision making by individuals, communities, and society.
- The **cultural perspectives** learning context reflects a humanistic perspective on examining and understanding the knowledge systems that other cultures use, and have used, to describe and explain the natural world.

These learning contexts are not mutually exclusive; thus, well-designed instruction may incorporate more than one learning context. Students need to experience learning through each learning context at each grade; it is not necessary, nor advisable, for each student to attempt to engage in learning through each learning context in each unit. Learning within a classroom may be structured to enable individuals or groups of students to achieve the same curricular outcomes through different learning contexts.

A choice of learning approaches also can be informed by recent well-established ideas on how and why students learn:

- Learning occurs when students are treated as a community of practitioners of scientific literacy.
- Learning is both a social and an individual event for constructing and refining ideas and competences.

Each learning context is identified with a two-or three-letter code. One or more of these codes are listed under each outcome as a suggestion regarding which learning context(s) most strongly support the intent of the outcome.

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.

(NRC, 1996, p. 23)

Technological design is a distinctive process with a number of defined characteristics; it is purposeful; it is based on certain requirements; it is systematic; it is iterative; it is creative; and there are many possible solutions.

(International Technology Education Association, 2000, p. 91)

- Learning involves the development of new self-identities for many students.
- Learning is inhibited when students feel a culture clash between their home culture and the culture of school science.

Scientific Inquiry [SI]

Inquiry is a defining feature of the scientific way of knowing nature. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Inquiry is a multi-faceted activity that involves:

- making observations, including watching or listening to knowledgeable sources
- posing questions or becoming curious about the questions of others
- examining books and other sources of information to see what is already known
- reviewing what is already known in light of experimental evidence and rational arguments
- planning investigations, including field studies and experiments
- acquiring the resources (financial or material) to carry out investigations
- using tools to gather, analyze, and interpret data
- proposing critical answers, explanations, and predictions
- communicating the results to various audiences.

By participating in a variety of inquiry experiences that vary in the amount of student self-direction, students develop competencies necessary to conduct inquiries of their own – a key element to scientific literacy.

Technological Problem Solving [TPS]

The essence of the technological problem-solving learning context is that students seek answers to practical problems. This process is based on addressing human and social needs, and typically is addressed through an iterative design-action process that involves steps such as:

- identifying a problem
- identifying constraints and sources of support
- identifying alternative possible solutions and selecting one on which to work
- planning and building a prototype or a plan of action to resolve the problem
- testing and evaluating the prototype or plan.

By participating in a variety of technological and environmental problem-solving activities, students develop capacities to analyze and resolve authentic problems in the natural and constructed world.

STSE Decision Making [DM]

Scientific knowledge can be related to understanding interrelationships among science, technology, society, and the environment. Students also must consider values or ethics when addressing a question or issue. STSE decision making involves steps such as:

- clarifying an issue
- evaluating available research and different viewpoints on the issue
- generating possible courses of action or solutions
- evaluating the pros and cons for each action or solution
- identifying a fundamental value associated with each action or solution
- making a thoughtful decision
- examining the impact of the decision
- reflecting back on the process of decision making.

Students may engage with STSE issues through research projects, student-designed laboratory investigations, case studies, role playing, debates, deliberative dialogues, and action projects.

Cultural Perspectives [CP]

Students should recognize and respect that all cultures develop knowledge systems to describe and explain nature. Two knowledge systems emphasized in this curriculum are First Nations and Métis cultures (Indigenous knowledge) and Euro-Canadian cultures (science). In their own way, both of these knowledge systems convey an understanding of the natural and constructed worlds, and they create or borrow from other cultures' technologies to resolve practical problems. Both knowledge systems are systematic, rational, empirical, dynamically changeable, and culturally specific.

Cultural features of science, in part, are conveyed through the other three learning contexts, and when addressing the nature of science. Cultural perspectives on science also can be taught in activities that explicitly explore Indigenous knowledge or knowledge from other cultures.

Addressing cultural perspectives in science involves:

- recognizing and respecting knowledge systems that various cultures have developed to understand the natural world and the technologies they have created to solve human problems

To engage with science and technology toward practical ends, people must be able to critically assess the information they come across and critically evaluate the trustworthiness of the information source.

(Aikenhead, 2006, p. 2)

For First Nations people, the purpose of learning is to develop the skills, knowledge, values and wisdom needed to honour and protect the natural world and ensure the long-term sustainability of life.

(Canadian Council on Learning, 2007, p. 18)

For the Métis people, learning is understood as a process of discovering the skills, knowledge and wisdom needed to live in harmony with the Creator and creation, a way of being that is expressed as the 'Sacred Act of Living a Good Life'.

(Canadian Council on Learning, 2007, p. 22)

- recognizing science, as one of those knowledge systems, evolved within Euro-Canadian cultures
- valuing place-based knowledge to solve practical problems
- honouring protocols for obtaining knowledge from a knowledge keeper and taking responsibility for knowing it.

By engaging in explorations of cultural perspectives, scientifically literate students begin to appreciate the worldviews and belief systems fundamental to science and Indigenous knowledge.

The Language of Science

Science is a way of understanding the natural world using internally consistent methods and principles that are well-described and understood by the scientific community. The principles and theories of science have been established through repeated experimentation and observation and have been refereed through peer review before general acceptance by the scientific community. Acceptance of a theory does not imply unchanging belief in a theory or denote dogma. Instead, as new data become available, previous scientific explanations are revised and improved or rejected and replaced. There is a progression from a hypothesis to a theory using testable, scientific laws. Many hypotheses are tested to generate a theory. Only a few scientific facts are considered natural laws (e.g., the Law of Conservation of Mass).

Scientists use the terms “law”, “theory”, and “hypothesis” to describe various types of scientific explanations about phenomena in the natural and constructed world. These meanings differ from common usage of the same terms.

- Law – A law is a generalized description, usually expressed in mathematical terms, that describes some aspect of the natural world under certain conditions.
- Theory – A theory is an explanation for a set of related observations or events that may consist of statements, equations, models, or a combination of these. Theories also predict the results of future observations. A theory becomes a theory once the explanation is verified multiple times by different groups of researchers. The procedures and processes for testing a theory are well-defined within each scientific discipline, but they vary between disciplines. No amount of evidence proves that a theory is correct. Rather, scientists accept theories until the emergence of new evidence that the theory is unable to explain adequately. At this point, the theory is discarded or modified to explain the new evidence. Note that theories never become laws; theories explain laws.

The terms “law”, “theory”, and “hypothesis” have special meaning in science.

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- Hypothesis – A hypothesis is a tentative, testable generalization that may be used to explain a relatively large number of events in the natural world. It is subject to immediate or eventual testing by experiments. Hypotheses must be worded in such a way that they can be falsified. Hypotheses are never proven correct, but are supported by empirical evidence.

Scientific models are constructed to represent and explain certain aspects of physical phenomenon. Models are never exact replicas of real phenomena; rather, models are simplified versions of reality, generally constructed to facilitate study of complex systems such as the atom, climate change, and biogeochemical cycles. Models may be physical, mental, or mathematical, or contain a combination of these elements. Models are complex constructions that consist of conceptual objects and processes in which the objects participate or interact. Scientists spend considerable time and effort building and testing models to further understanding of the natural world.

When engaging in the processes of science, students constantly are building and testing their own models of understanding the natural world. Students may need help in learning how to identify and articulate their own models of natural phenomena. Activities that involve reflection and metacognition are particularly useful in this regard. Students should be able to identify the features of the physical phenomena their models represent or explain. Just as importantly, students should identify which features are not represented or explained by their models. Students should determine the usefulness of their model by judging whether the model helps in understanding the underlying concepts or processes. Ultimately, students realize that different models of the same phenomena may be needed to investigate or understand different aspects of the phenomena.

Laboratory and Field Work

Laboratory work often is at the centre of scientific research; as such, it also should be an integral component of school science. The National Research Council (2006, p. 3) defines a school laboratory investigation as an experience in the laboratory, classroom, or field that provides students with opportunities to interact directly with natural phenomena or with data collected by others, using tools, materials, data collection techniques, and models. Laboratory experiences should be designed so that all students – including students with academic and physical challenges – are able to participate authentically in and benefit from those experiences.

Laboratory activities help students develop scientific and technological skills and processes including:

- initiating and planning

Ideally, laboratory work should help students to understand the relationship between evidence and theory, develop critical thinking and problem-solving skills, as well as develop acceptable scientific attitudes.

(Di Giuseppe, 2007, p. 54)

Safety cannot be mandated solely by rule of law, teacher command, or school regulation. Safety and safe practice are an attitude.

- performing and recording
- analyzing and interpreting
- communication and teamwork.

Laboratory investigations also help students understand the nature of science, specifically that explanations and predictions must be consistent with observations. Similarly, student-centered laboratory investigations help to emphasize the need for curiosity and inquisitiveness as part of the scientific endeavour. The National Science Teachers Association [NSTA] position statement, *The Integral Role of Laboratory Investigations in Science Instruction* (2007), provides further information about laboratory investigations.

A strong science program includes a variety of individual, small, and large group laboratory and field experiences for students. Most importantly, these experiences need to go beyond conducting confirmatory “cook-book” experiments. Similarly, computer simulations and teacher demonstrations can support, but should not replace, hands-on student activities.

Assessment and evaluation of student performance must reflect the nature of the laboratory experience by addressing scientific and technological skills. Students should document their observations and processes using science journals and narrative lab reports. The narrative lab report enables students to tell the story of their process and findings by addressing four questions:

- What was I looking for?
- How did I look for it?
- What did I find?
- What do these findings mean?

Student responses may be written in point form or essay format. For some investigations, teachers may decide that writing a paragraph describing the significance of their findings is sufficient.

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. Creating a safe classroom requires that a teacher be informed, aware, and proactive, and that the students listen, think, and respond appropriately.

Safe practice in or out of the classroom is the joint responsibility of the teacher and students. The teacher’s responsibility is to provide a safe environment and ensure that students are aware of safe practice. The students’ responsibility is to act intelligently based on the advice which is given and which is available in various resources.

Kwan and Texley (2003) suggest that teachers, as professionals, consider the four Ps of safety: prepare, plan, prevent, and protect. The following points are adapted from those guidelines and provide a starting point for thinking about safety in the science classroom:

Prepare

- Keep up-to-date with personal safety knowledge and certifications.
- Be aware of national, provincial, division, and school level safety policies and guidelines.
- Create a safety contract with students.

Plan

- Develop learning plans that ensure all students learn effectively and safely.
- Choose activities that are best suited to the learning styles, maturity, and behaviour of all students, and that include all students.
- Create safety checklists for in-class activities and field studies.

Prevent

- Assess and mitigate hazards.
- Review procedures for accident prevention with students.
- Teach and review safety procedures with students, including the need for appropriate clothing.
- Do not use defective or unsafe equipment or procedures.
- Do not allow students to eat or drink in science areas.

Protect

- Ensure students have sufficient protective devices such as safety glasses.
- Demonstrate and instruct students on the proper use of safety equipment and protective gear.
- Model safe practice by insisting that all students and visitors use appropriate protective devices.

The definition of safety includes consideration of the well-being of all components of the biosphere, such as plants, animals, earth, air, and water. From knowing what wild flowers can be picked to considering the disposal of toxic wastes from chemistry laboratories, the safety of our world and our future depends on our actions and teaching in science classes. Students also must practise ethical, responsible behaviours when caring for and experimenting with live animals. For

WHMIS regulations govern storage and handling practices of chemicals in schools.

The Chemical Hazard Information Table in Safety in the Science Classroom (Alberta Education, 2005) provides detailed information including appropriateness for school use, hazard ratings, WHMIS class, storage class, and disposal methods for hundreds of chemicals.

Technology should be used to support learning in science when:

- *it is pedagogically appropriate*
- *it makes scientific views more accessible*
- *it helps students to engage in learning that otherwise would not be possible.*

(Flick & Bell, 2000)

further information, refer to the NSTA position statement, *Responsible Use of Live Animals and Dissection in the Science Classroom* (2008).

Safety in the science classroom includes the storage, use, and disposal of chemicals. The *Workplace Hazardous Materials Information System* (WHMIS) regulations under the *Hazardous Products Act and Hazardous Product Regulations* govern storage and handling practices of chemicals in schools. All school divisions must comply with the provisions of the act. Chemicals should be stored in a safe location according to chemical class, not just alphabetically. Appropriate cautionary labels must be placed on all chemical containers, and all school division employees using hazardous substances should have access to appropriate *Safety Data Sheets* (SDSs). Under provincial WHMIS regulations, all employees involved in handling hazardous substances must receive training by their employer. Teachers who have not been informed about or trained in this program should contact their Director of Education. Further information related to WHMIS is available through WorkSafe Saskatchewan.

Technology in Science

Technology-based resources are essential for instruction in the science classroom. Technology is intended to extend our capabilities and, therefore, is one part of the teaching toolkit. Individual, small group, or class reflection and discussions are required to connect the work with technology to the conceptual development, understandings, and activities of the students. Choices to use technology, and choices of which technologies to use, should be based on sound pedagogical practices, especially those that support student inquiry. These technologies include computer technologies, as described below, and non-computer based technologies.

Some recommended examples of using computer technologies to support teaching and learning in science include:

Data Collection and Analysis

- Data loggers, such as temperature probes, permit students to collect and analyze data, often in real-time, and to collect observations over very short or long periods of time, enabling investigations that otherwise would be impractical.
- Graphing software can facilitate the analysis and display of student-collected data or data obtained from other sources.

Visualization and Imaging

- Students may collect their own digital images and video recordings as part of their data collection and analysis, or they may access digital images and video online to help enhance

understanding of scientific concepts.

- Simulation and modeling software provide opportunities to explore concepts and models which are not readily accessible in the classroom, such as those that require expensive or unavailable materials or equipment, hazardous materials or procedures, levels of skills not yet achieved by the students, or more time than is possible or appropriate in a classroom.

Communication and Collaboration

- Students can use word-processing and presentation tools to share the results of their investigations with others.
- The Internet can be a means of networking with scientists, teachers, and other students by gathering information and data, posting data and findings, and comparing results with students in different locations.
- Students can participate in authentic science projects by contributing local data to large-scale web-based science inquiry projects such as Journey North (www.learner.org/north) or GLOBE (www.globe.gov).

Outcomes and Indicators

Life Science – Habitats and Communities (HC)

HC4.1 Investigate the interdependence of plants and animals, including humans, within habitats and communities.

HC4.2 Analyze the structures and behaviours of plants and animals that enable them to exist in various habitats.

HC4.3 Assess the effects of natural and human activities on habitats and communities, and propose actions to maintain or restore habitats.

Physical Science – Light (LI)

LI4.1 Investigate the characteristics and physical properties of natural and artificial sources of light in the environment.

LI4.2 Analyze how light interacts with different objects and materials to create phenomena such as shadows, reflection, refraction, and dispersion.

LI4.3 Assess personal, societal, and environmental impacts of light-related technological innovations including optical devices.

Physical Science – Sound (SO)

SO4.1 Explore natural and artificial sources of sound in the environment and how those sounds are detected by humans and animals.

SO4.2 Draw conclusions about the characteristics and physical properties of sound, including pitch and loudness, based on observation.

SO4.3 Assess personal, societal, and environmental impacts of sound-related technologies.

Earth and Space Science – Rocks, Minerals, and Erosion (RM)

RM4.1 Investigate physical properties of rocks and minerals, including those found in the local environment.

RM4.2 Assess how human uses of rocks and minerals impact self, society, and the environment.

RM4.3 Analyze how weathering, erosion, and fossils provide evidence to support human understanding of the formation of landforms on Earth.

Life Science: Habitats and Communities (HC)

All outcomes in this unit contribute to the development of all K-12 science goals.

Outcomes	Indicators
<i>HC4.1 Investigate the interdependence of plants and animals, including humans, within habitats and communities.</i> <i>[CP, SI]</i>	<ul style="list-style-type: none">a. Identify the plants and animals which can be found in the communities (e.g., house, village, farm, reserve, and city) in which students live.b. Differentiate between populations, communities, and habitats using local and regional examples.c. Predict and research the populations of plants and animals that exist in various habitats (e.g., desert, farmland, meadow, tree, forest, rain puddle, seashore, lake, river, tropical forest, tundra, river delta, and mountains).d. Discuss stories that demonstrate the interdependence of land, water, animals, plants, and the sky in traditional worldviews.e. Draw upon facets of Indigenous worldviews, such as the Medicine Wheel or circle of life, to examine understanding about the interdependence of plants and animals in various habitats and communities.f. Classify plants and animals, including humans, according to their role(s) (e.g., producer, consumer, herbivore, omnivore, carnivore, predator, prey, scavenger, and decomposer) in food chains and food webs.g. Construct a visual representation of a specific food chain that exists within a habitat or community.h. Analyze food webs as representations of multiple food chains.i. Describe how both traditional methods and modern technologies (e.g., time-lapse photography, high-speed photography, and radio collar tracking) enable humans to increase their knowledge of plants and animals within habitats and communities.j. Conduct a simulation or role play to demonstrate the interdependence of plants and animals in a habitat or community.k. Predict how the removal of a specific plant or animal population may affect a community in the short- and long-term.l. Observe and maintain a habitat such as a terrarium, aquarium, mealworm box, ant farm, pond in a bottle, or vermiculture to examine interactions between plants and animals, and their environments.

Outcomes

Indicators

HC4.1 continued

- m. Show concern and respect for the safety of self, others, plants and animals when maintaining a habitat.

HC4.2 Analyze the structures and behaviours of plants and animals that enable them to exist in various habitats.

[SI]

- a. Generate questions to investigate about the structures (e.g., beak shape, colour markings, type of feet, and thorny branches) and behaviours (e.g., seasonal migration, living in groups, and growing towards light) of plants and animals that enable them to exist within various habitats (e.g., schoolyard, wildlife reserve area, and creek bank).
- b. Recognize that each plant and animal depends on a specific habitat to meet its needs.
- c. Identify factors (e.g., availability of food, water, and shelter, weather conditions, and available living space) that influence the ability of plants and animals to meet their needs within a specific habitat.
- d. Develop and carry out a plan to investigate safely and respectfully the structures and behaviours of plants and animals within natural (e.g., school yard, meadow, forest, and park) and constructed (e.g., sports field, aquarium, and terrarium) habitats.
- e. Record observations and information about plant and animal structures and behaviours within natural and constructed habitats using words, diagrams, graphs, photographs, audio and video recordings, and other appropriate technologies.
- f. Compile and display data collected during a habitat study using tallies, tables, pictographs, and/or bar graphs; compare results obtained with those of other class members; and propose explanations for differences in results.
- g. Use gathered information to explain how the structures and behaviours of animals and plants enable them to meet their basic needs (e.g., food, water, air, movement, nutrients, reproduction, and light) in their habitat.
- h. Compare the structural features of plants that enable them to thrive in different kinds of habitats (e.g., bog, forest, grassland, school yard, garden, and sports field).
- i. Design and carry out a simulation to explore how the appearance of a plant or animal affects its visibility.
- j. Predict the structural and behavioural adaptations required for a real or imagined animal to live in a particular habitat, either real or imagined.

Outcomes

HC4.3 Assess the effects of natural and human activities on habitats and communities, and propose actions to maintain or restore habitats.

[CP, DM]

Indicators

- a. Recognize and discuss the role of traditional knowledge in learning about, valuing, and caring for plants and animals within local habitats and communities.
- b. Identify stakeholders who are likely to adopt different points of view on issues (e.g., sewage treatment, urban expansion, deforestation, water pollution, pipeline construction, grassland stewardship, climate change, and pesticide usage) that are highlighted in the media related to habitat protection, restoration, and management.
- c. Categorize human activities by the effects they have or may have on habitats and communities.
- d. Assess intended and unintended consequences of natural and human-caused changes to specific habitats.
- e. Relate habitat loss to the endangerment and extinction of plants and animals within habitats and communities in Saskatchewan and elsewhere.
- f. Explore how human impact on habitats and communities has been represented through traditional and contemporary music, dance, drama, and visual arts.
- g. Investigate how both scientists' and traditional knowledge keepers' knowledge of plant growth and development has led to the development of agricultural methods and techniques (e.g., tillage, hydroponics, nutrient management, pest control, crop rotation, companion plants, and plant breeding) that affect habitats and communities.
- h. Create dramatic, visual, musical, or other representations to show how personal actions can help conserve, honour, and respect natural and constructed habitats.
- i. Collaboratively develop and carry out (if feasible) a plan to preserve or restore one or more components of a local habitat.
- j. Identify local, provincial, and national organizations that work to preserve, restore, and provide education about habitats and communities.

Physical Science: Light (LI)

All outcomes in this unit contribute to the development of all K-12 science goals.

Outcomes

LI4.1 Investigate the characteristics and physical properties of natural and artificial sources of light in the environment.

[CP, SI]

Indicators

- a. Differentiate between natural (e.g., fire, sun, star, lightning, aurorae, fireflies, and bioluminescent fungi) and artificial (e.g., light bulb, street light, glow stick, LED, tanning lamp, and laser) sources of light in the environment.
- b. Examine relationships between the light energy and heat energy emitted from light sources.
- c. Examine the significance of light in First Nations and Métis stories, legends, and spirituality, including the role of fire, lightning, aurorae, and Thunderbird.
- d. Investigate the characteristics of light beams in air and water, including determining that light travels in straight lines, that light travels away from a source in all directions, and that light beams may change direction upon entering or leaving water.
- e. Distinguish, through observation, between objects that emit their own light (e.g., sun, glow stick, match, star, and light bulb) and those that reflect light from another source (e.g., moon, mirror, paper, clothing, and roadways).
- f. Identify positive (e.g., increased vitamin D production, happiness, and increased productivity) and negative (e.g., sunburn, skin cancer, and light pollution) consequences of exposure to natural and artificial sources of light.
- g. Predict changes in a shadow's location, shape, and relative size when an object is placed in different positions and orientations relative to a light source and surface (e.g., flashlight and puppet, and overhead projector and screen).
- h. Collaboratively plan and carry out a procedure to determine changes in a shadow's location, shape, and relative size when an object is placed in different positions and orientations relative to a light source and screen.
- i. Record and communicate results of investigations of the characteristics and physical properties of light using formats suitable to the task.

Outcomes

LI4.2 Analyze how light interacts with different objects and materials to create phenomena such as shadows, reflection, refraction, and dispersion.

[SI]

Indicators

- a. Pose questions about the interaction of light with different materials (e.g., How are shadows formed? How can we change the direction of light? What colours are in light?).
- b. Investigate how light interacts with various objects to determine whether the objects cast shadows, allow light to pass, and/or reflect light.
- c. Classify materials and objects as opaque, transparent, or translucent based on personal observations.
- d. Design and carry out a fair test of the reflective properties of surfaces of different shapes and textures (e.g., mirrors, flat foil, crumpled foil, white paper, coloured paper, and spoons).
- e. Develop simple conclusions about the reflective properties of surfaces of different shapes and textures based on observation and experimentation.
- f. Demonstrate and describe how transparent media of different composition and shape (e.g., prisms, plastic blocks, glasses of water, and lenses) are used to change the direction of light.
- g. Investigate how light interacts with optical devices such as kaleidoscopes, reading glasses, microscopes, periscopes, telescopes, and magnifying glasses.
- h. Demonstrate the dispersion of white light into various colours using a prism, and draw simple conclusions about the composition of white light.
- i. Identify characteristics and effects of radiation that are slightly below (i.e., infrared radiation) and slightly above (i.e., ultraviolet light) the frequencies of visible light.
- j. Experiment with mixing colours of light to create colours that meet a student-specified function (e.g., mood for a dance or dramatic production).

Outcomes

LI4.3 Assess personal, societal, and environmental impacts of light-related technological innovations including optical devices.

[DM, TPS]

Indicators

- a. Evaluate the suitability of different types of light sources based on criteria such as source of energy, area illuminated, cost, and intended use.
- b. Assess positive and negative consequences of artificial sources of light (e.g., street light, automobile headlight, traffic light, emergency vehicle light, and lighted advertising sign) that have been designed to solve problems in the home, at school, and in the community.
- c. Assess the suitability of translucent, transparent, and opaque materials for specific applications (e.g., window, shower curtain, paper, light bulb, and frosted glass).
- d. Compare the types of light sources used historically and currently in Saskatchewan homes and communities.
- e. Compare the functions of optical devices (e.g., magnifying glasses, eyeglasses, contact lenses, microscopes, and telescopes) that are designed to extend our ability to observe.
- f. Evaluate the function and importance of eyeglasses and contact lenses for individuals with vision problems.
- g. Research personal, societal, and environmental impacts of light-related technological innovations (e.g., periscope, flashlight, neon lighting, camera, and laser).
- h. Design, construct, and test a prototype of an optical device (e.g., periscope, telescope, and microscope) that performs a specific student-identified function.
- i. Work with classmates to troubleshoot problems with a prototype of an optical device.
- j. Describe practices that individuals and communities can take to help protect eyes and sight.
- k. Assess methods of conserving energy through processes such as reducing the use of home lighting or using alternative types of light sources (e.g., fluorescent, compact fluorescent, and light-emitting diode).
- l. Examine how light is depicted in a variety of texts (e.g., science fiction, cartoons, movies, and poetry) and through dance and drama.
- m. Identify careers in Saskatchewan that require an understanding of light and light-related technologies (e.g., optician, photographer, astronomer, and lab technician).

Physical Science: Sound (SO)

All outcomes in this unit contribute to the development of all K-12 science goals.

Outcomes

SO4.1 Explore natural and artificial sources of sound in the environment and how those sounds are detected by humans and animals.

[CP, SI]

SO4.2 Draw conclusions about the characteristics and physical properties of sound, including pitch and loudness, based on observation.

[CP, SI]

Indicators

- a. Identify and classify, using student-developed criteria, examples of natural and artificial sounds in their environments (e.g., classroom, school, home, playground, and community).
 - b. Relate natural and artificial sources of sounds in their environment to the ways in which those sounds are produced.
 - c. Describe examples of sounds (e.g., radio, alarm clock, fire alarm, and whistling steam kettle) that people use to meet their everyday needs.
 - d. Explain how humans and other animals use sounds for various purposes such as enjoyment, warning, navigation, annoyance, ambience, and communication.
 - e. Examine connections between music of various cultures, including First Nations and Métis, and natural sounds (e.g. water moving, bird flying, and wind blowing).
 - f. Differentiate among the types of sounds produced by various stringed, woodwind, brass, and percussion instruments.
 - g. Illustrate and explain how humans create and detect sounds.
 - h. Compare the characteristics of human and animal perceptions of sound, including their sense organs to detect sound and their range of hearing.
 - i. Propose structural modifications that might improve the hearing of a specific animal.
 - j. Predict and explore how sound travels from different sources to the human ear.
-
- a. Pose questions about the characteristics of sound (e.g., Why are some sounds louder than others? Why do sounds sound different? Why are some locations noisier than other locations?).
 - b. Recognize and demonstrate that sound energy originates from vibrating objects (e.g., larynx, tuning fork, radio speaker, and musical instruments).
 - c. Compare how sound vibrations travel differently through solids, liquids, and gases such as air.

Outcomes

SO4.2 continued

Indicators

- d. Differentiate between the loudness of various sounds, as measured in decibels.
- e. Compare the ability of different materials to absorb and reflect sounds of varying pitch and loudness.
- f. Compare the ability of self and others to hear sounds of various pitch and loudness.
- g. Compare the characteristics (e.g., construction and method of vibration) of string, woodwind, brass, and percussion instruments to determine how they make sound.
- h. Rephrase questions about pitch and loudness into a testable form.
- i. State and test a prediction about how the pitch and loudness of a sound can be altered.
- j. Design and construct a device such as a musical instrument which has the ability to create sounds of variable pitch and/or loudness.
- k. Suggest improvements to enhance the effectiveness of a device such as a musical instrument which has the ability to create sounds of variable pitch and/or loudness.
- l. State generalizations about the physical characteristics of sound, including pitch and loudness, learned through observation.

SO4.3 Assess personal, societal, and environmental impacts of sound-related technologies.

[DM, TPS]

- a. Explain the purpose and effect of devices (e.g., hearing aid, sonar, amplifier, microphone, oscilloscope, and ultrasound) that enhance the human ability to produce, transmit, and detect sound.
- b. Explore the use of sound in movies, television, dance, and drama.
- c. Investigate the type and loudness of sounds heard in various locations in their environment (e.g., classroom, hallway, gymnasium, music room, library, lunch room, and playground).
- d. Explore the personal and social impacts on humans who are deaf or hard of hearing, including connections to speech and the role of sign language.
- e. Explain how and why different materials are used in schools and other buildings based on their ability to absorb and/or reflect sounds.
- f. Demonstrate methods and technologies used to prevent noise pollution in their surroundings, and work with group members to evaluate the effectiveness of those methods.
- g. Explore the importance and uses of sound in different cultures, past and present.
- h. Identify positive and negative consequences, for humans and other animals, of technologies (e.g., leaf blower, stereo, car horn, motors, and fireworks) that produce sounds.

Outcomes

SO4.3 continued

Indicators

- i. Identify issues related to sound such as long-term exposure to environmental noise, portable music players, and workplace sounds, and discuss the implications of these issues on individuals, society, and the environment.
- j. Explain practices that help meet the need for protection from loud and sustained sounds to prevent short- and long-term hearing loss in humans.
- k. Research the contributions of Canadians who contributed to the development of sound-based technologies.

Earth and Space Science: Rocks, Minerals, and Erosion (RM)

All outcomes in this unit contribute to the development of all K-12 science goals.

Outcomes

RM4.1 Investigate physical properties of rocks and minerals, including those found in the local environment.

[CP, SI]

Indicators

- a. Pose questions about the properties of rocks and minerals (e.g., What is the difference between rocks and minerals? Where do we find rocks and minerals? Do rocks become minerals?).
- b. Document the locations and characteristics of rocks that exist in their local environment.
- c. Observe and record physical properties of rocks and minerals using appropriate terminology such as colour, lustre, hardness, cleavage, transparency, and crystal structure.
- d. Use appropriate tools (e.g., hand lens, safety glasses, brush, rock pick, knife, measuring tape, and gloves) safely while making observations and collecting information on the physical properties of rocks and minerals.
- e. Demonstrate respect for all components of their environment when observing and collecting rocks and minerals (e.g., do not remove rocks and minerals from private property without permission).
- f. Demonstrate processes for testing the hardness of minerals, including reference to guides such as Moh's scale of mineral hardness.
- g. Record observations of rocks and minerals using jot notes, labelled diagrams, and charts.
- h. Compare the physical properties of rocks and minerals from the local environment with those from other geological areas.

Outcomes

RM4.1 continued

Indicators

- i. Develop a classification scheme to organize their understanding of rocks and minerals.
- j. Account for any variation between their classification schemes of rocks and minerals and those of classmates, Elders, traditional knowledge keepers, geologists, or other resources.
- k. Differentiate between rocks and minerals.
- l. Develop simple generalizations about the physical characteristics of rocks and minerals based on observation and research.

RM4.2 Assess how human uses of rocks and minerals impact self, society, and the environment.

[DM]

- a. Discuss ways in which people of different cultures value, respect, and use rocks and minerals, including First Nations and Métis connections to Mother Earth.
- b. Identify objects in their local environment that are made from rocks and minerals (e.g., nickel, table salt, pottery, cement, carvings, brick, jewellery, bicycle, nutrients, battery, copper wiring, soda can, plumbing pipe, and sidewalk).
- c. Research historical (e.g., flint arrowhead, gold jewellery, paint pigment, and coal heating) and contemporary (e.g., fertilizer, building products, ceramics, glass, salt, silver fillings, and electronics) uses for rocks and minerals in Saskatchewan.
- d. Suggest alternative materials that could be used to create everyday objects or propose new uses for rocks and minerals.
- e. Relate uses for rocks and minerals to characteristics such as functionality, mineral shape, cost, availability, and aesthetics.
- f. Identify locations where minerals, including potash, sodium sulphate, salt, kaolin, uranium, copper, coal, diamond, and gold, are extracted in Saskatchewan.
- g. Discuss the economic benefits associated with mineral extraction and refining, including related careers, in Saskatchewan.
- h. Analyze issues related to the extraction and use of minerals from the perspectives of various stakeholders (e.g., company owner, employee, scientist, Elder, environmental group, and end user).
- i. Research ways in which products made from rocks or minerals can be recycled and reused.
- j. Suggest methods of reclaiming resource extraction sites (e.g., quarry, strip mine, open pit mine, and hard rock mine) to reduce short- and long-term impacts on communities and the environment.
- k. Assess their own and their family's impact on natural resources based on their current lifestyle.

Outcomes

RM4.3 Analyze how weathering, erosion, and fossils provide evidence to support human understanding of the formation of landforms on Earth.

[CP, SI, TPS]

Indicators

- a. Construct a visual representation of the diversity of landscapes and landforms throughout Saskatchewan, including those that have significance for First Nations and Métis people.
- b. Examine the effects of natural phenomena (e.g., tidal wave, flash flood, hurricane, tornado, earthquake, mud slide, forest fire, avalanche, and meteor impact) that cause rapid and significant changes to the landscape.
- c. Explain how rocks can be classified as igneous, sedimentary, or metamorphic based on the processes by which they form.
- d. Discuss practices and techniques (e.g., mulching, crop rotation, strip farming, windbreaks, terracing, and sediment basins) for minimizing and controlling erosion locally and in communities around the world.
- e. Design and construct a prototype of a system for minimizing and controlling gravitational, water, shoreline, ice, or wind erosion in a given situation.
- f. Evaluate both a prototype of a personally constructed system for minimizing and controlling erosion and the use of prototypes in science for modelling natural phenomena.
- g. Describe possible short- and long-term effects of wind, water, and ice on local, national, and global landscapes (e.g., sandy beaches, coastline erosion, rounded rock formations, sand dunes, river deltas, glacial deposits, and cracks in rocks).
- h. Predict the effects of weathering on various landforms (e.g., butte, cliff, cave, valley, river, waterfall, and beach) in Saskatchewan.
- i. Suggest explanations of how soils form from rocks, including the roles of wind, water, and biological processes (e.g., decomposition of plant and animal matter, and growth of plant roots play) over time.
- j. Create models of different types (e.g., amber, imprint, cast, and mould) of plant and animal fossils.
- k. Discuss how fossils and the fossil record provide evidence of Earth's history, including the formation of various landforms.
- l. Predict the types of plant or animal fossils that would be found in Saskatchewan landforms in the past, present, and future.
- m. Explain how scientists develop explanations of natural phenomena based on observations and data.
- n. Pose new questions about Saskatchewan landforms based on what was learned.

Assessment and Evaluation of Student Learning

Assessment and evaluation require thoughtful planning and implementation to support the learning process and inform teaching. All assessment and evaluation of student achievement must be based on the outcomes in the provincial curriculum.

Assessment involves the systematic collection of information about student learning with respect to:

- achievement of provincial curriculum outcomes
- effectiveness of teaching strategies employed
- student self-reflection on learning.

Evaluation compares assessment information against criteria based on curriculum outcomes for the purpose of communicating to students, teachers, parents/caregivers, and others about student progress, and making informed decisions about the teaching and learning process.

Reporting of student achievement must be in relation to curriculum outcomes. Assessment information unrelated to outcomes (e.g., attendance, behaviour, general attitude, completion of homework, and effort) can be gathered and reported to complement the reported achievement related to curricular outcomes.

We assess students for three interrelated purposes. Each type of assessment, systematically implemented, contributes to an overall picture of an individual student's achievement.

Assessment for learning involves the use of information about student progress to support and improve student learning, inform instructional practices, and:

- is teacher-driven for student, teacher, and parent use
- occurs throughout the teaching and learning process using a variety of tools
- engages teachers in providing differentiated instruction, feedback to students to enhance learning, and information to parents in support of learning.

Assessment as learning actively involves student reflection on learning, monitoring her/his own progress, and:

- engages students in critically analyzing learning related to curricular outcomes (metacognition)
- is student-driven with teacher guidance for personal use
- occurs throughout the learning process.

Assessment of learning involves teachers' use of evidence of student learning to make judgements about student achievement and:

- provides the opportunity to report evidence of achievement related to curricular outcomes
- occurs at the end of a learning cycle using a variety of tools
- provides the foundation for discussions on placement or promotion.

Connections with Other Areas of Study

Although some learning outcomes or subject-area knowledge may be achieved through discipline-specific instruction, deeper understanding may be attained through the integration of the disciplines. Some outcomes for each area of study complement each other and offer opportunities for subject-area integration. Integrating science with another area of study can help students develop in a holistic manner by addressing physical, emotional, mental, and spiritual dimensions.

By identifying a particular context to use as an organizer, the outcomes from more than one subject area can be achieved, and students can make connections across areas of study. Integrated, interdisciplinary instruction, however, must be more than just a series of activities. An integrated approach must facilitate students' learning of the related disciplines and understanding of the conceptual connections. The learning situations must achieve each individual subject area's outcomes and ensure that in-depth learning occurs. If deep understanding is to occur, the experiences cannot be based on superficial or arbitrarily connected activities (Brophy & Alleman, 1991, p. 66). The outcomes and activities of one area of study must not be obscured by the outcomes or activities of another area of study (Education Review Office, 1996, p. 13).

Many possibilities for the integration of science and other subject areas exist. In doing this integration, however, teachers must be cautious not to lose the integrity of any of the subjects. Integration gives students experience with transfer of knowledge and provides rich contexts in which the students are able to make sense of their learning. A few of the ways in which science can be integrated into other subject areas (and other subject areas into science) at grade four follow.

Arts Education

The conceptual focus for Grade 4 Arts Education is "Saskatchewan Voices". This focus includes investigations of works of art that express ideas about Saskatchewan. Connections between arts education and science may include:

- Conducting a simulation, role play, dance composition, or dramatic representation to demonstrate how plants, animals, and landscapes interact with each other in the local community.
- Gathering observations of local habitats, communities, and landscapes using sketches, drawings, photographs, and/or video recordings.
- Investigating how artists use light, colour, and sound to provide a mood or context for artistic expressions.

-
- Listening to, interpreting, and creating sounds of varying characteristics which come from natural sources or musical instruments.

English Language Arts (ELA)

As students gather and evaluate information, construct and refine knowledge, and share what they know with a variety of audiences, they use and develop their language skills. The environment/technology context in English language arts can provide students with an opportunity to learn and apply science knowledge. Some specific examples of connections between ELA and science at grade four include:

- Throughout the science curriculum, students should view, listen to, read, comprehend, and respond to a variety of texts, including fiction, non-fiction, videos, websites, and summarize the main ideas and supporting details of those texts.
- Students should understand that the structure of science textbooks differs from the structure of other types of texts. By gaining an understanding of that structure, students will be able to read those texts efficiently and effectively for a variety of purposes, including gathering information, following directions, understanding information, and enjoyment.
- Students should present the results of their science inquiries using a variety of text forms, including expository, informational, and procedural texts (e.g., document the procedure for determining changes in characteristics of shadows), descriptive texts (e.g., listen to and describe sounds in their environment), and persuasive texts (e.g., propose actions to maintain or restore natural habitats).
- Students should reflect on and critique their choices of grade-appropriate strategies for communicating their science learning.

Health Education

Connections often can be found between the topics in health education and science, even though students may conduct their inquiries into these topics from different disciplinary “worlds”. Examples of the connection between these areas of study at grade four include:

- Discussing and reviewing the need for safety rules and practices when investigating plants and animals in various habitats.
- Comparing how healthy and unhealthy eating practices influence humans and animals.

Mathematics

A key connection between mathematics and science is the search for patterns and relationships in the natural and constructed world.

Inquiries in science require students to collect, analyze, and display data, which require the application of a variety of mathematical skills and processes, including measuring, counting, and data analysis skills. When students construct mathematical and physical models in science to represent and explain natural phenomena, they apply mathematical skills related to number. Some specific examples of these connections in grade four include:

- Measuring, in cm^2 or m^2 , the area of regular and irregular shaped plant and animal habitats.
- Identifying repeating patterns when investigating the location, shape, and relative size of shadows.
- Examining the shape and symmetry of rock and mineral samples.

Physical Education

Both science and physical education involve understanding of the human body, albeit within different disciplinary “worlds”. Understanding scientific principles related to movement can serve to enhance skillful movement of the human body; in contrast, the analysis of human movement can contribute to a deeper understanding of the underlying scientific principles. An example of this connection in grade four is:

- Examining how the structural features of humans related to the circulatory, respiratory, and muscular body systems enable them to meet their basic needs, (e.g., food, water, air, movement, nutrients, reproduction, and light) within their habitats.

Social Studies

The content of social studies and science often can be used to connect the two areas of study, particularly with respect to connections between the environment and all living things, including humans. This connection is emphasized through the STSE (Science-Technology-Society-Environment) foundation of scientific literacy and the STSE Decision Making learning context. Some specific examples of these connections in grade four include:

- Identifying characteristics of Saskatchewan landscapes which influence and have influenced migration patterns of animals and settlement patterns of humans.
- Examining the impact of traditional and contemporary lifestyles on plant and animal habitats and communities in Saskatchewan.
- Investigating relationships between increased agricultural knowledge and current and traditional farming and farm stewardship practices.

Glossary

Adaptations are physical characteristics or behaviours that help living things survive in different environments.

Brass instruments produce sound when the vibration of the player's lips causes a column of air in a tube to vibrate.

Carnivores are animals that feed on other animals or animal parts.

A **classification system** is a way of grouping things based on similarities.

A **community** is a collection of populations of different species interacting with each other in the same place.

Consumers are living things, including all animals, which rely on other living things for food.

Cultural perspectives is the learning context that reflects a humanistic perspective which views teaching and learning as cultural transmission and acquisition.

Decomposers are living things that break down dead or decaying organisms.

Erosion is the process by which particles of rock and soil are loosened and moved elsewhere by wind, water, ice, or gravity.

A **food chain** is a model that shows the pathway of energy from one living thing to another in an ecosystem.

A **food web** is a model that shows several interconnected food chains within an ecosystem.

Fossils are the preserved traces, remains, or imprints of plants, animals, and other organisms that lived long ago.

Frequency is a measure of how fast something is vibrating.

A **habitat** is an environmental area that is inhabited by a particular species of animal, plant, or other organism.

Herbivores are animals that feed on plants.

A **hypothesis** is a testable, proposed explanation of observable phenomena.

Igneous rock is formed by the cooling and solidification of molten or partially molten magma.

Interdependence means being mutually and physically responsible to others.

A **landform** is a physical feature in an environment that is defined by its surface form and location in the landscape.

A **landscape** is all of the natural and constructed visible features of an area.

Loudness, measured in decibels (dB), is the physical strength or amplitude of a sound.

Metamorphic rock is formed by the transformation of existing sedimentary, igneous, or other metamorphic rock due to extreme heat and pressure in Earth's interior.

Minerals are naturally occurring solids formed through geological processes that have definite chemical compositions and crystalline structures.

Omnivores are animals that feed on both animals and plants.

Opaque materials prevent light from passing through them.

Percussion instruments produce sound when struck with an implement or when shaken and cause the object to vibrate.

Physical properties are aspects of a material that can be measured or observed without changing the identity of the material (e.g., smell, colour, texture, transparency, viscosity, absorbency, hardness, lustre, and cleavage).

Pitch, measured in hertz (Hz), is the frequency of a sound.

A **population** is the collection of all individuals of the same species living in a certain place at the same time.

A **predator** is a living thing that hunts and kills other organisms for food.

Prey are living things that are hunted by predators.

Producers are living things capable of making their own food, including all green plants.

Reflection of light or sound is the change in direction of light or sound when it strikes a surface, such as from air onto a mirror and back into the air.

Rocks are naturally occurring solid aggregates of minerals and mineral particles.

Scavengers are living things that consume dead organisms or dead plant biomass.

Scientific inquiry is the learning context that reflects an emphasis on understanding the natural and constructed world using systematic empirical processes that lead to the formation of theories that explain observed events and that facilitate prediction.

Scientific literacy is an evolving combination of the knowledge of nature, skills, processes, and attitudes that students need to develop inquiry, problem solving, and decision making abilities to become lifelong learners, and to maintain a sense of wonder about and responsibility towards the natural and constructed world.

Sedimentary rock is formed by the building up of layers of solid fragments or the precipitation of minerals from solution.

A **shadow** is an area where direct light from a source is blocked by an object.

Soil is the naturally occurring mixture of mineral and organic matter that forms the loose covering on Earth's surface.

Stringed instruments produce sound by vibrating the strings.

STSE, or Science-Technology-Society-Environment, is the foundation of scientific literacy that is concerned with understanding the scope and character of science, its connections to technology, and the social context in which it is developed.

STSE decision making is the learning context that reflects the need to engage citizens in thinking about human and world issues through a scientific lens to inform and empower decision making by individuals, communities, and society.

Technological problem solving is the learning context that emphasizes on designing and building to solve practical human problems.

Translucent materials allow light to pass through them diffusely.

Transparent materials allow light to pass through freely.

A **vibration** is something moving back and forth very quickly.

Weathering is the breaking down of rocks and minerals through mechanical, chemical, and biological processes.

WHMIS is the Workplace Hazardous Materials Information System, which provides standardized information about hazardous materials.

Woodwind instruments produce sound when the player blows air against a sharp edge or through a reed.

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Suggested Reading

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Feedback Form

The Ministry of Education welcomes your response to this curriculum and invites you to complete and return this feedback form.

Grade 4 Science Curriculum:

1. Please indicate your role in the learning community:

- ☐ parent
- ☐ teacher
- ☐ resource teacher
- ☐ guidance counsellor
- ☐ school administrator
- ☐ school board trustee
- ☐ teacher librarian
- ☐ school community council member
- ☐ other _____

What was your purpose for looking at or using this curriculum?

2. a) Please indicate which format(s) of the curriculum you used:

- ☐ print
- ☐ online

b) Please indicate which format(s) of the curriculum you prefer:

- ☐ print
- ☐ online

3. Please respond to each of the following statements by circling the applicable number.

The curriculum content is:	Strongly Agree	Agree	Disagree	Strongly Disagree
appropriate for its intended purpose	1	2	3	4
suitable for your use	1	2	3	4
clear and well organized	1	2	3	4
visually appealing	1	2	3	4
informative	1	2	3	4

4. Explain which aspects you found to be:

Most useful:

Least useful:

5. Additional comments:

6. Optional:

Name: _____

School: _____

Phone: _____ Fax: _____

Thank you for taking the time to provide this valuable feedback.

Please return the completed feedback form to:

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