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Science
10

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Dr. Barry Charington, Teacher
Saskatoon School Division
Saskatchewan Teachers' Federation

Tara Haugen, Teacher
Good Spirit School Division
Saskatchewan Teachers' Federation

Rob Kraft, Teacher
St. Paul's Roman Catholic Separate School Division
Saskatchewan Teachers' Federation

Phil Langford, President
Saskatchewan Science Teacher's Society

Kara Lengyel, Teacher
North East School Division
Saskatchewan Teachers' Federation

Patricia Lysyk, Teacher
Saskatchewan Rivers School Division
Saskatchewan Teachers' Federation

Carol Meachem, Teacher
Horizon School Division
Saskatchewan Teachers' Federation

Dr. Tim Molnar, Assistant Professor
Department of Curriculum Studies
College of Education, University of Saskatchewan

Garry Sibley, Education Outreach
Education and Training Secretariat
Federation of Saskatchewan Indian Nations

Don Spencer, Faculty
Mathematics and Science
Saskatchewan Institute of Applied Science and Technology

Dr. Warren Wessel, Associate Professor
Science Education
Faculty of Education, University of Regina

Darrell Zaba, Director
Christ the Teacher Roman Catholic Separate School Division
League of Educational Administrators, Directors and Superintendents of Saskatchewan

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Rory Bergermann
Martensville High School
Prairie Spirit School Division

David Hall
Luther College High School

Camille Hounjet
Rosetown Central High School
Sun West School Division

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Science 10

Introduction

Science is a required area of study in Saskatchewan's Core Curriculum. The purpose of this curriculum is to outline the provincial requirements for Grade 10 Science.

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

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

This curriculum provides the intended learning outcomes that Grade 10 students are expected to achieve in science by the end of the course. Indicators are included to provide the breadth and depth of what students should know and be able to do in order 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).

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;
- Grade 10 Science outcomes and indicators;
- sample assessment and evaluation criteria related to outcomes in science; and
- a glossary.

Using this Curriculum

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

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

Critical characteristics of an outcome include the following:

- focus on what students will learn rather than what teachers will teach;
- specify the skills and abilities, understandings, 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; and,
- have a developmental flow and connection to other grades where applicable.

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

Indicators are representative of what students need to know and/or be able to do in order to achieve an outcome. When teachers are planning for instruction, they must comprehend the set of indicators to understand fully the breadth and the depth of learning related to a particular outcome. Based on this understanding of the outcome, teachers may develop their own indicators that are responsive of students' interests, lives and prior learning. These teacher-developed indicators must maintain the intent of the outcome.

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 say that students should evaluate the relevance, reliability and adequacy of data collection methods, including identifying and explaining sources of error and uncertainty in measurements. This means that, although other methods can be considered, it is mandatory to identify and explain sources of error and uncertainty.
- 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 transportation, sport science or space science" as examples

of different motion-related fields. This statement provides teachers and students with possible fields to consider, while not excluding other fields.

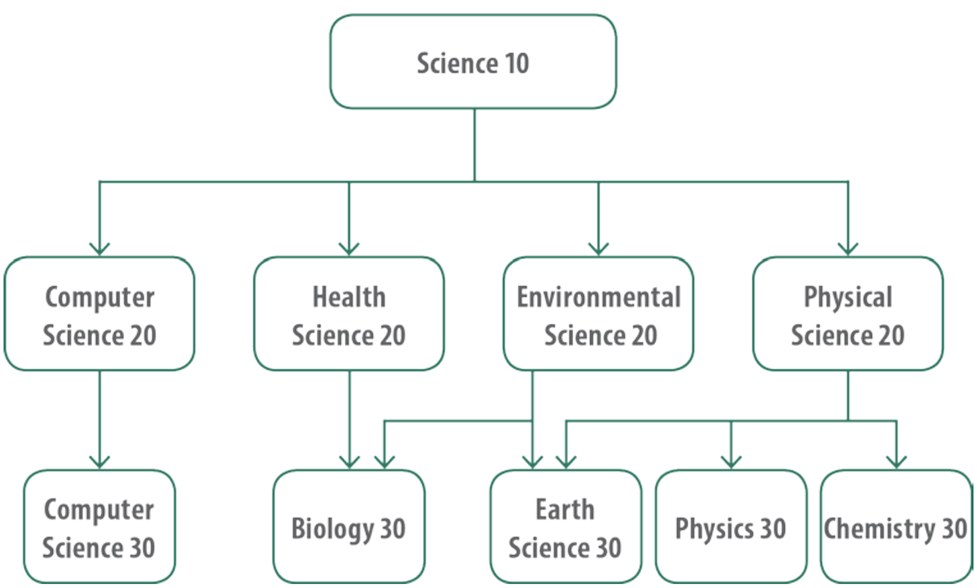
- Finally, the term "e.g.," offers specific examples of what a term, concept or strategy might look like. For example, an indicator might include the phrase "e.g., methane, propane, butane, octane, methanol, ethanol and glucose" to refer to the names of common molecular and organic compounds.

Grades 10-12 Science Framework

Saskatchewan's grades 10 to 12 science courses incorporate core ideas from the Pan-Canadian Protocol for Collaboration on School Curriculum *Common Framework of Science Learning Outcomes K to 12* (CMEC, 1997). Saskatchewan has developed science courses at Grade 11 that provide students with opportunities to learn core biology, chemistry and physics disciplinary ideas within interdisciplinary contexts. Students should select courses based on their interests and what they believe will best fit their needs after high school.

The chart below visually illustrates the courses in each pathway and their relationship to each other.

Science Pathways Framework



Each course in each pathway is to be taught and learned to the same level of rigour. No pathway or course is considered "easy science"; rather, all pathways and courses present "different sciences" for different purposes.

Students may take courses from more than one pathway for credit. The current credit requirements for graduation from Grade 12 are one 10-level credit and one 20-level credit in science.

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 various components and initiatives, Core Curriculum supports the achievement of the Goals of Education for Saskatchewan. For current information regarding Core Curriculum, please refer to the *Registrar's Handbook for School Administrators* found on the Government of Saskatchewan website. For additional information related to the various components and initiatives of Core Curriculum, please refer to the Government of Saskatchewan website for policy and foundation documents.

The Broad Areas of Learning and Cross-curricular Competencies connect the specificity of the areas of study and the day-to-day work of teachers with the broader philosophy of Core Curriculum and the Goals of Education for Saskatchewan.

Broad Areas of Learning

There are three Broad Areas of Learning that 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

Related to the following Goals of Education:

- *Basic Skills*
- *Lifelong Learning*
- *Self Concept Development*
- *Positive Lifestyle.*

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

Related to the following Goals of Education:

- *Understanding & Relating to Others*
- *Self Concept Development*
- *Positive Lifestyle*
- *Spiritual Development.*

Students develop and strengthen their personal identity as they explore connections between their own understanding of the natural and constructed world and 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.

Related to the following Goals of Education:
- *Understanding & Relating to Others*
- *Positive Lifestyle*
- *Career and Consumer*
- *Decisions*
- *Membership in Society*
- *Growing with Change.*

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.

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 is already known by themselves and others. By thinking contextually, creatively and critically, students develop deeper understanding of various phenomena in the natural and constructed world.

K-12 Goals for Developing Thinking:
- *thinking and learning contextually*
- *thinking and learning creatively*
- *thinking and learning critically.*

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, of social and cultural expectations, and of 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.

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.*

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 their ideas and understanding of the natural and constructed world in multiple forms.

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.*

Developing Social Responsibility

K-12 Goals for Developing Social Responsibility:
- *using moral reasoning processes*
- *engaging in communitarian thinking and dialogue*
- *taking social action.*

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

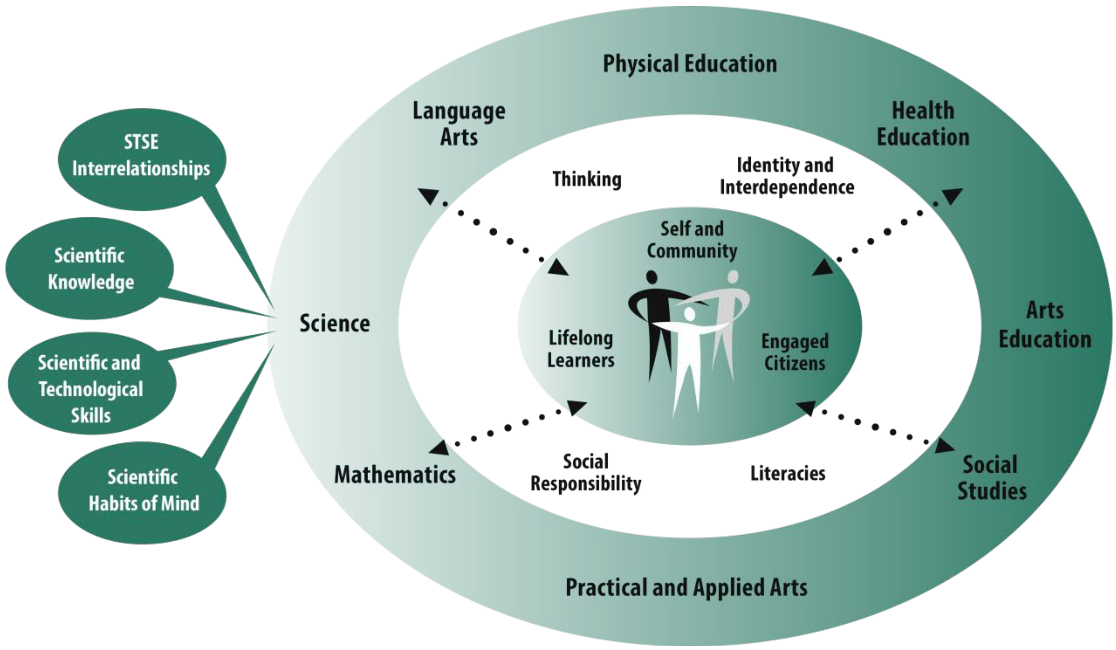
The aim of K-12 science education is to enable all Saskatchewan students to develop scientific literacy. Scientific literacy today embraces Euro-Canadian and Indigenous heritages, both of which have developed an empirical and rational knowledge of nature. A Euro-Canadian way of knowing about the natural 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, their careers and their 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, in physical science, in earth and space science and in Indigenous knowledge of nature and 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 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)

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.

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

- identify questions and concepts that guide scientific investigations.
- design and conduct scientific investigations.
- use technology and mathematics to improve investigations and communications.

- formulate and revise scientific explanations and models using logic and evidence.
- recognize and analyze alternative explanations and models.
- communicate and defend a scientific argument.

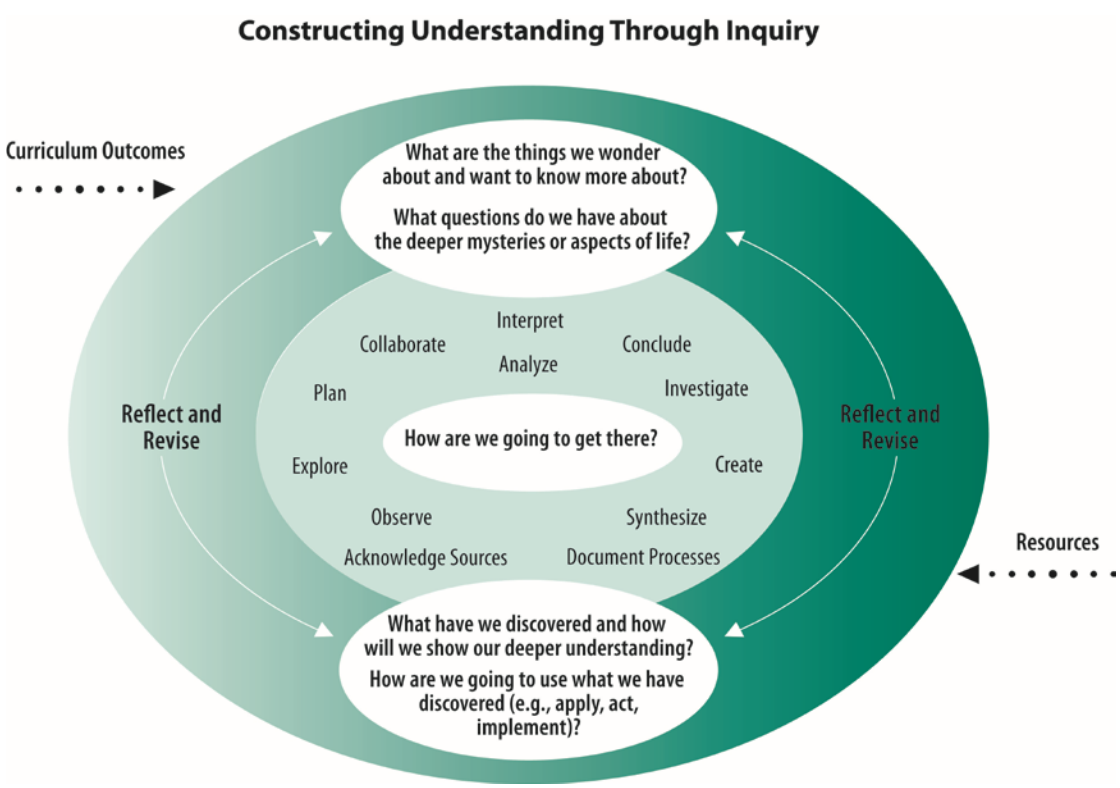
(NRC, 1996, pp. 175, 176)

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)

An important part of any inquiry process is student reflection on their learning and the documentation needed to assess the learning and make it visible. Student documentation of the inquiry process 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.



Creating Questions for Inquiry in Science

Inquiry focuses on the development of questions to initiate and guide the learning process. Students and 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 section of this document 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 has 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, and help students connect what they are learning to their experiences and life beyond school.

Questions give students some 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.

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)

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; and,*
- *lead to gathering and using data to develop explanations for natural phenomena.*

(NRC, 2000, p. 24)

Science Challenges

Science challenges, which may include science fairs, science leagues, science olympics, olympiads or talent searches, are instructional methods suitable for students to undertake to achieve curricular outcomes. Teachers may incorporate science challenge activities as an integral component of the science program or treat them similar to other extracurricular activities such as school sports and clubs. Teachers undertaking science challenges as a classroom activity should consider these guidelines, adapted from the National Science Teachers Association (NSTA) position statement *Science Competitions* (1999):

- Student and staff participation should be voluntary and open to all students.
- Emphasis should be placed on the learning experience rather than the competition.
- Science competitions should supplement and enhance other learning and support student achievement of curriculum outcomes.
- Projects and presentations should be the work of the student, with proper credit given to others for their contributions.
- Science competitions should foster partnerships among students, the school and the science community.

Science challenge activities may be conducted solely at the school level, or with the intent of preparing students for competition in one of the regional science fairs, perhaps as a step towards the Canada-Wide Science Fair. Although students may be motivated by prizes, awards and the possibility of scholarships, teachers should emphasize that the importance of doing a science fair project includes attaining new experiences and skills that go beyond science, technology or engineering. Students learn to present their ideas to an authentic public that may consist of parents, teachers and the top scientists in a given field.

Science fair projects typically consist of:

- an experiment, which is an original scientific experiment with a specific, original hypothesis. Students should control all important variables and demonstrate appropriate data collection and analysis techniques;
- a study, which involves the collection of data to reveal a pattern or correlation. Studies can include cause and effect relationships and theoretical investigations of the data. Studies are often carried out using surveys given to human subjects; or,
- an innovation, which deals with the creation and development of a new device, model, or technique in a technological field. These innovations may have commercial applications or be of benefit to humans.

Youth Science Canada provides further information regarding science fairs in Canada.

An Effective Science Education Program

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

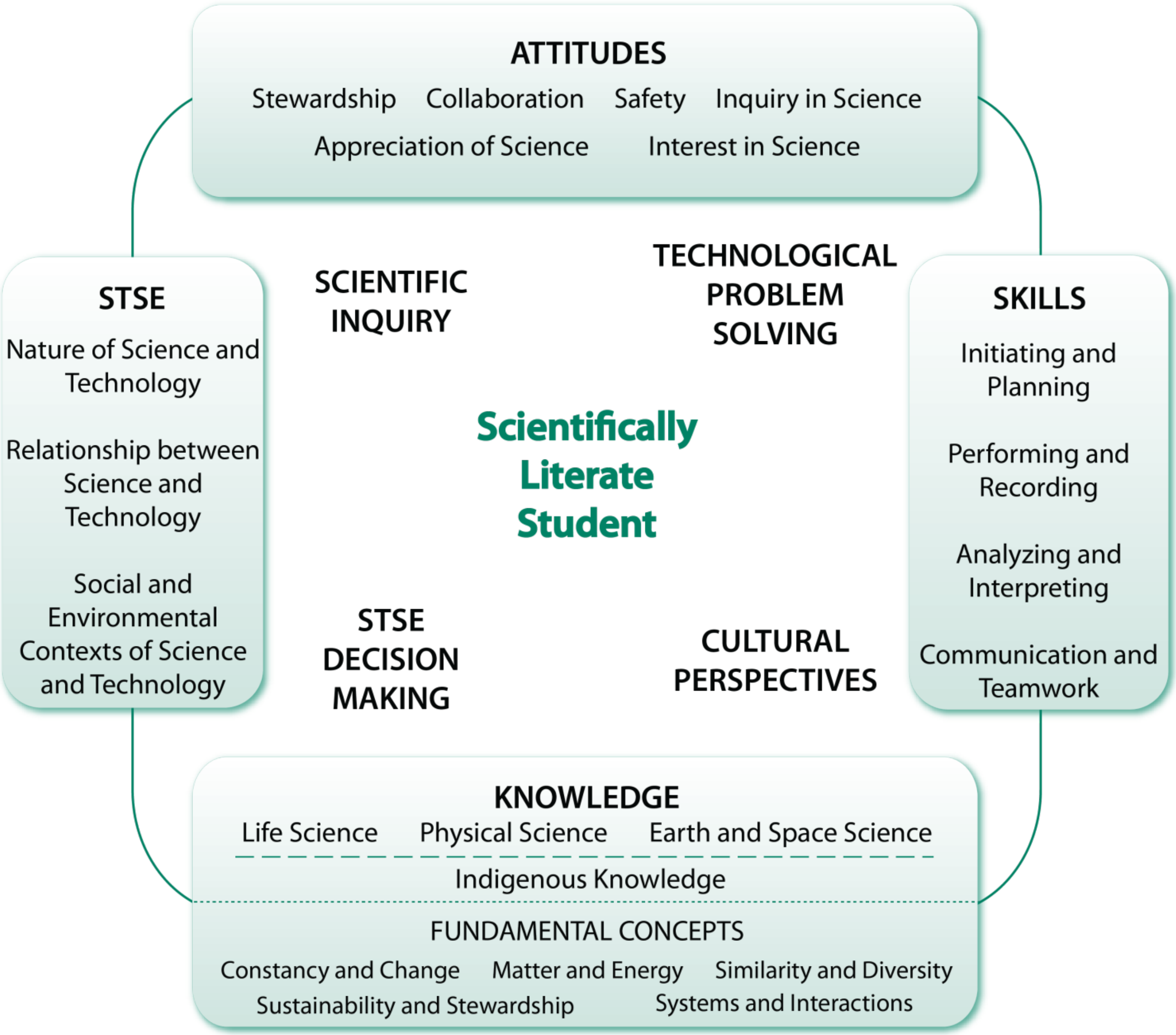
- incorporating all foundations of scientific literacy;
- using the learning contexts as entry points into student inquiry;
- understanding and effectively using the language of science;
- engaging in laboratory and field work;
- practicing safety; and
- choosing and using technology in science appropriately.

All science outcomes and indicators emphasize one or more foundations of scientific literacy; these represent 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.

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

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

To achieve the vision of scientific literacy outlined in this curriculum, students must increasingly 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, to initiate investigations, to communicate findings and to complete projects that demonstrate learning.



- All science outcomes and indicators emphasize one or more of the foundations of scientific literacy (STSE, Knowledge, Skills and Attitudes); these represent the "what" of the curriculum. All outcomes are mandatory.
- The four learning contexts (Scientific Inquiry, Technological Problem Solving, Cultural Perspectives and STSE Decision Making) represent different processes for engaging students in achieving curricular outcomes; they represent the "how" of the curriculum.

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). 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 are continually being tested, modified and improved as new ideas supersede existing ones. Technology, like science, is a creative human activity, but is concerned with solving practical problems that arise from human/social needs, particularly the need to adapt to the environment and to fuel a nation's economy. New products and processes are produced by research and development through inquiry and design.

Relationships between Science and Technology

Historically, the development of technology has been strongly linked to the development of science, with each making contributions to the other. While there are important relationships and interdependencies, there are also important differences. 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 us explain, interpret and predict; the test of technology is that it works – it enables 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 can be used to show that cultural and intellectual traditions have influenced the focus and methodologies of science, and that science, in turn, has influenced the wider world of ideas. Today, societal and environmental needs and issues often drive research agendas. As technological solutions have emerged from previous research, many of the new technologies have given rise to complex social and environmental issues which are increasingly 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. The conservation laws of mass and energy, momentum and charge are addressed in physical science.

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 such fields of study as geology, hydrology, meteorology and astronomy.

Sources of Knowledge about Nature

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 better 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	Scientific 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).	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 Concepts – Linking Scientific Disciplines

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

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 are also 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 can contribute to the development of scientific literacy.

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.

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 to be aware of the limits of science and technology as well as 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 that facilitate prediction.
- The **technological problem solving** learning context reflects an emphasis on designing and building to solve practical human problems similar to the way an engineer would.
- The **STSE decision making** learning context reflects the need to engage citizens in thinking about human and world issues through a scientific lens in order to inform and empower decision making by individuals, communities and society.
- The **cultural perspectives** learning context reflects a humanistic perspective that views teaching and learning as cultural transmission and acquisition (Aikenhead, 2006).

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

These learning contexts are not mutually exclusive; thus, well-designed instruction may incorporate more than one learning context. Students should 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 of study. 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 can also 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.
- 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 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)

Scientific Inquiry [SI]

Inquiry is a defining feature of the scientific way of knowing nature. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Scientific inquiry is a multifaceted 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; and,
- 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 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)

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 is typically 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; and,
- testing, evaluating and refining 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 the relationships among science, technology, society and the environment. Students must also consider values or ethics, however, 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; and,
- 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.

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)

Cultural Perspectives [CP]

Students should recognize and respect that all cultures develop knowledge systems to describe and explain nature. Two knowledge systems which are 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 are, in part, conveyed through the other three learning contexts and when addressing the nature of science. Cultural perspectives on science can also be taught in activities that explicitly explore Indigenous knowledge or knowledge from other cultures.

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)

Addressing cultural perspectives in science involves:

- recognizing and respecting knowledge systems that various cultures have developed to understand the natural world and technologies they have created to solve human problems;
- recognizing that science, as one of those knowledge systems, evolved within Euro-Canadian cultures;
- valuing place-based knowledge to solve practical problems; and,
- 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 to Indigenous knowledge.

The Language of Science

The terms "law", "theory" and "hypothesis" have special meaning in 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 laws (e.g., the law of conservation of mass and Newton's laws of motion).

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. An explanation is verified multiple times by different groups of researchers before it becomes a theory. 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 adequately explain. At this point, the theory is discarded or modified to explain the new evidence. Note that theories never become laws; theories explain laws.

- 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, constructed in order to facilitate study of complex systems such as the atom, climate change and biogeochemical cycles. Models may be physical, mental, 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 are constantly building and testing their own models of understanding of 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 natural 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 in order to investigate or understand different aspects of the phenomena.

Laboratory Work

Laboratory work is often at the centre of scientific research; as such, it should also 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, the classroom or the 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 authentically participate in and benefit from those experiences.

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)

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

- initiating and planning;
- performing and recording;
- analyzing and interpreting; and,
- communication and teamwork.

Laboratory investigations also help students understand the nature of science; specifically that theories and laws 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 experiences for students. Most importantly, the laboratory experience needs to go beyond conducting confirmatory "cook-book" experiments. Similarly, computer simulations and teacher demonstrations are valuable but should not serve as substitutions for hands-on student laboratory activities.

Assessment and evaluation of student performance must reflect the nature of the laboratory experience by addressing scientific and technological skills. As such, the results of student investigations and experiments do not always need to be written up using formal laboratory reports. Teachers may consider alternative formats such as narrative lab reports for some investigations. 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 to these questions may be written in an essay format or point form rather than using the structured headings of Purpose, Procedure, Hypothesis, Data, Analysis and Conclusion typically associated with a formal lab report. For some investigations, teachers may decide it is sufficient for students to write a paragraph describing the significance of their findings.

Safety

Safety in the classroom is of paramount importance. Other components of education (e.g., resources, teaching strategies and facilities) attain their maximum utility only in a safe classroom. To create a safe classroom requires that a teacher be informed, aware and proactive and that the students listen, think and respond appropriately.

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

Safe practice in the laboratory is the joint responsibility of the teacher and students. The teacher's responsibility is to provide a safe environment and to ensure the 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.

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

Teachers should be aware of *Safety in the K-12 Science Classroom* (Worksafe Saskatchewan, 2013). This resource supports planning and safe learning by providing information on safety legislation and standards. It provides examples of common chemical, physical and biological hazards and shows how to protect against, minimize and eliminate these hazards.

The Chemical Hazard Information Table in Safety in the K-12 Science Classroom (Worksafe Saskatchewan, 2013) provides detailed information including appropriateness for school use, hazard ratings, WHMIS class, storage class and disposal methods for hundreds of chemicals.

Texley, Kwan, and Summers (2004) suggest that teachers, as professionals, consider 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 your personal safety knowledge and certifications.
  - Be aware of national, provincial, school 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, visitors and you 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. It is important that students practise ethical, responsible behaviours when caring for and experimenting with live animals. For 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 (WHMIS 1998 and WHMIS 2015) under the *Hazardous Products Act* and the *Hazardous Product Regulations* govern storage and handling practices of chemicals in schools. All school divisions must comply with the provisions of these regulations. 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 *Materials Safety Data Sheets* (WHMIS 1998) or *Safety Data Sheets* (WHMIS 2015). 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 Health Canada and the Saskatchewan Ministry of Labour Relations and Workplace Safety.

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 which 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 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.
    - Databases and spreadsheets can facilitate the analysis and display of student-collected data or data obtained from scientists.
- **Visualization and Imaging**
    - 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.
    - 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.
- **Communication and Collaboration**
    - 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 or GLOBE.

Technology should be used to support learning in science when it:

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

(Flick & Bell, 2000)

Outcomes at a Glance

Career Investigation
SCI10-CI1 Investigate career paths related to various branches and sub-branches of science.

Climate and Ecosystem Dynamics
SCI10-CD1 Assess the implications of human actions on the local and global climate and the sustainability of ecosystems.
SCI10-CD2 Investigate factors that influence Earth's climate system, including the role of the natural greenhouse effect.
SCI10-CD3 Examine biodiversity through the analysis of interactions among populations within communities.
SCI10-CD4 Investigate the role of feedback mechanisms in biogeochemical cycles and in maintaining stability in ecosystems.

Chemical Reactions
SCI10-CR1 Explore the properties of chemical reactions, including the role of energy changes, and applications of acids and bases.
SCI10-CR2 Name and write formulas for common ionic and molecular chemical compounds, including acids and bases.
SCI10-CR3 Represent chemical reactions and conservation of mass symbolically using models, word and skeleton equations and balanced chemical equations.
SCI10-CR4 Investigate the rates of chemical reactions, including factors that affect the rate.

Force and Motion in Our World
SCI10-FM1 Explore the development of motion-related technologies and their impacts on self and society.
SCI10-FM2 Investigate and represent the motion of objects that travel at a constant speed in a straight line.
SCI10-FM3 Investigate and represent the motion of objects that undergo acceleration.
SCI10-FM4 Explore the relationship between force and motion for objects moving in one and two dimensions.

Legend

SCI10-CD1a	
SCI10	Course name
CD	Unit of study
1	Outcome number
a	Indicator
[CP, DM, SI, TPS]	Learning context(s) that best support this outcome
(A, K, S, STSE)	Foundation(s) of Scientific Literacy that apply to this indicator

Outcomes and Indicators

Career Investigation	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
SCI10-CI1 Investigate career paths related to various branches and sub-branches of science. [DM]	a. Create a representation that demonstrates interrelationships between various branches and sub-branches of science. (STSE, S, A) b. Explore the breadth of science-related work roles and who is engaged in those work roles in the community. (STSE, S, A) c. Develop a profile of a specific individual involved in a science career, addressing factors such as their educational and personal background, what drew them to their career, the focus of their work and their advice for others who wish to pursue a similar career. (STSE, S, A) d. Research the range of science-related programs offered by post-secondary institutions in Saskatchewan and across the country. (STSE, S, A) e. Identify the ways in which professional societies and organizations provide support to those engaged in science-related careers in Saskatchewan. (STSE, S, A) f. Research the educational qualifications of people engaged in science-related careers. (STSE, S, A) g. Attend a science-related career fair and analyze career choices based on information gathered. (STSE, S, A) h. Identify how personal activities and interests relate to topics in secondary science curricula. (STSE, S, A) i. Represent the range of career options available related to a specific branch or sub-branch of science. (STSE, S, A)

Climate and Ecosystem Dynamics	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
SCI10-CD1 Assess the implications of human actions on the local and global climate and the sustainability of ecosystems. [CP, DM]	a. Pose questions or problems relating to the effects of human actions on global climate change and the sustainability of ecosystems that arise from personal research. (A, S, STSE) b. Reflect upon your personal view of humanity's relationship with the environment. (STSE, A) c. Research how people from Aboriginal and other cultures view relationships between living organisms and their ecosystems, and the role of humans in those relationships. (STSE) d. Examine the positions of First Nations and government agencies responsible for the stewardship and management of resources, including the duty to consult. (STSE, A)

	e. Evaluate changes in the scientific worldview of sustainability and human's responsibility to protect ecosystems, considering key milestones and publications such as *Our Common Future*, *Rio Declaration on Environment and Development*, *Agenda 21*, *Convention on Biological Diversity* and the *Bonn Declaration*. (STSE, A) f. Discuss why it is important to consider economic, social justice and environmental perspectives when examining sustainability. (STSE, A) g. Select, integrate and analyze the validity of information from various human, print and electronic sources (e.g., government publications, community resources and personally collected data), with respect to sustainability, sustainable development and education for sustainable development. (S) h. Provide examples of human actions that have contributed to the anthropogenic greenhouse effect. (K, STSE) i. Research how scientists examine changes to the key indicators of climate change (e.g., CO_2 concentration, global surface temperature, Arctic sea ice area, land ice mass and sea level) to support the scientific understanding of climate change. (K, STSE, A) j. Reflect upon individual and societal behavioural and lifestyle choices that can help to minimize anthropogenic sources of global climate change. (K, STSE) k. Develop, present and defend a position or course of action based on personal research related to mitigating the effects of global or local climate change or to enhancing the sustainability of an ecosystem, taking into account human and environmental needs. (S, A, STSE) l. Assess the current and potential future effects of ongoing changes to Earth's climate systems on the people and the environment in Saskatchewan and Canada's Arctic region. (K, STSE)
SCI10-CD2 Investigate factors that influence Earth's climate system, including the role of the natural greenhouse effect. [DM, SI]	a. Differentiate between weather and climate, and the impacts of each on daily life. (K, STSE) b. Understand that Earth's climate system results from the exchange of thermal energy and moisture between the sun, ice sheets, oceans, solid earth and the biosphere over a range of timescales. (K, A) c. Investigate how Earth's axial tilt, rotation and revolution around the sun cause uneven heating of Earth's surface, resulting in global convection currents, the Coriolis effect, jet streams, thermohaline circulation of the oceans and climate zones. (S, K) d. Hypothesize how energy transfer, weather and climate might be different if Earth had a different axial tilt, diameter, period of rotation and/or period of revolution. (S, STSE, A)

	e. Explain how greenhouse gases (e.g., water vapour, carbon dioxide, methane, nitrous oxide, sulphur dioxide and ozone), particles, clouds and surface albedo affect the amount of solar energy absorbed and re-radiated at various locations on Earth. (K) f. Explain the role of natural sources (e.g., volcanoes, fire, evaporation and living organisms) of the primary greenhouse gases in Earth's atmosphere and how they contribute to the natural greenhouse effect. (K, A) g. Design, construct and evaluate the effectiveness of a model used to illustrate the natural greenhouse effect, the reflectivity of Earth's surface or the relationship between Earth's axial tilt and the seasons. (S, STSE, A) h. Investigate, through laboratory activities or simulations, heat transfer in air and water, including heat involved in phase changes. (S, A) i. Examine how interactions between heat, pressure and the Coriolis Effect result in global wind patterns, ocean currents, jet streams and severe weather (e.g., hurricanes, tornadoes, blizzards and thunderstorms). (S, STSE) j. Analyze weather and atmospheric data to identify patterns in temperature and atmospheric pressure, and changes in those patterns locally, regionally and globally. (S) k. Provide examples of positive and negative feedback mechanisms in Earth's climate system. (K, STSE) l. Provide examples to show how scientific understanding may be refined in light of new evidence. (STSE)
SCI10-CD3 Examine biodiversity through the analysis of interactions among populations within communities. [DM, SI]	a. Discuss the importance of biodiversity and maintaining biodiversity. (S, K) b. Understand that scientists describe biomes as resulting from the interaction of biotic and abiotic factors such as temperature, precipitation, insolation, latitude, altitude and geography. (A, K) c. Compare the biodiversity and climatic characteristics of several of Earth's major biomes. (S, K) d. Estimate the abundance of organisms in a local ecosystem using random (e.g., quadrat), systematic (e.g., line transect and belt transect) and/or stratified sampling techniques. (S) e. Determine the population density, percentage frequency and/or percentage cover of one or more organisms in an ecosystem using primary or secondary population data. (S) f. Discuss ethical and cultural perspectives related to studying biotic components of ecosystems, including the potential benefits and consequences of technologies (e.g., radio collar) and techniques (e.g., mark and recapture) used to collect data. (K, STSE, A)

	g. Examine ways in which scientists collaborate with Elders, knowledge keepers and other community members to gather and interpret data related to biotic components of ecosystems. (STSE, A) h. Construct and/or interpret graphs of population dynamics of humans and other species to determine population trends within an ecosystem. (S, A) i. Investigate various ways in which natural populations attempt to maintain equilibrium, and relate this equilibrium to the resource limits of an ecosystem with reference to concepts such as carrying capacity, natality, mortality, immigration and emigration. (S, K) j. Examine the relationship between the biodiversity of an ecosystem, its primary productivity and ecological resilience. (K, S) k. Examine how factors such as invasive species, habitat loss and climate change affect biodiversity within an ecosystem, and can result in species becoming at-risk (i.e., vulnerable, threatened and extirpated). (K, STSE) l. Analyze how the bioaccumulation and biomagnification of human-made substances can affect the viability and biodiversity of organisms and populations in an ecosystem. (K, STSE)
SCI10-CD4 Investigate the role of feedback mechanisms in biogeochemical cycles and in maintaining stability in ecosystems. [CP, DM, SI]	a. Explain systems in terms of their type (e.g., open, closed and isolated), equilibrium (e.g., dynamic, static, stable and unstable) and their associated feedbacks (e.g., positive and negative). (K) b. Create a representation of a feedback mechanism that is relevant to a specific biogeochemical (e.g., carbon, nitrogen, phosphorus and water) cycle. (S) c. Explore Indigenous ways of understanding the role of matter and energy in the environment. (STSE, K) d. Describe how human actions can affect the cycling of matter and flow of energy through ecosystems. (K, A, STSE) e. Examine the role of photosynthesis, respiration and sinks in the cycling of carbon through the environment. (K, A) f. Design and carry out an investigation to determine the effect of carbon dioxide levels on photosynthesis and/or to determine the effect of nitrogenous-based fertilizer on plant or algal growth. (S, A) g. Compare the processes of nitrification and denitrification in terrestrial and aquatic ecosystems. (K) h. Research the short-term and long-term effects of small-scale and large-scale agricultural practices on the cycling of phosphorus, nitrogen and other nutrients in an ecosystem. (K, A, STSE) i. Analyze the interdependence between the water cycle and other biogeochemical cycles. (K, S)

Chemical Reactions	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
SCI10-CR1 Explore the properties of chemical reactions, including the role of energy changes, and applications of acids and bases. [CP, SI]	a. Create a representation about the prevalence of chemistry in our lives. (A, S) b. Research the ways in which people, including First Nations and Métis, from various times and cultures have applied their understanding of the transformation of materials to produce new substances. (STSE) c. Observe and describe a variety of chemical reactions, including synthesis, decomposition, combustion, single replacement and double replacement. (S, K) d. Demonstrate knowledge of Workplace Hazardous Materials Information System (WHMIS 1998 and WHMIS 2015) standards by selecting and applying proper techniques for handling and disposing of lab materials and interpreting *Materials Safety Data Sheets* (MSDS) and *Safety Data Sheets* (SDS). (K, STSE, A) e. Explain why it can be difficult to classify changes as physical or chemical, including reference to the reversibility of the reaction. (K, A) f. Differentiate between reactants and products in chemical reactions. (K) g. Investigate the properties of endothermic and exothermic chemical reactions, including identifying where or how energy is absorbed or released in the reaction and identifying potential benefits and consequences of the reaction. (K, S) h. Research practical examples of chemical reactions involving acids and bases, including neutralization reactions such as those involved in chemical spills, soda-acid fire extinguishers and antacids. (S, STSE) i. Provide examples of the importance of pH measurements in areas such as biology, chemistry, food science, environmental science and water treatment. (K, STSE) j. Research the operation of technologies designed to monitor and manage pH in various applications such as swimming pools, consumer products, agriculture and horticulture. (K, S, STSE)
SCI10-CR2 Name and write formulas for common ionic and molecular chemical compounds, including acids and bases. [SI]	a. Examine the relationship between an element's position on the periodic table, the number of its valence electrons and its chemical properties. (K, A) b. Discuss the importance of valence electrons, and whether they are shared or transferred, in determining bond type in chemical compounds. (K) c. Name and write formulas for common ionic compounds, including compounds involving polyatomic ions, using the periodic table and a list of common ions. (S)

	d. Analyze the relationship between the structure of ionic compounds, their chemical formulas and their common names. (K) e. Classify substances as ionic or molecular, based on their properties and the results of student conducted tests (e.g., melting/boiling point, electrical conductivity and solubility). (S) f. Relate the properties (e.g., solubility, conductivity in solution or gaseous form, high melting point and brittleness) of ionic compounds to their uses. (STSE, K) g. Name and write formulas for common molecular and organic compounds (e.g., methane, propane, butane, octane, methanol, ethanol and glucose), using the periodic table and a list of numerical Greek prefixes. (S) h. Design and carry out investigations to determine the properties of acids and bases, including selecting and using appropriate instruments for safely collecting evidence. (S, A) i. Classify substances as acids, bases or salts, based on observable properties, name and chemical formula. (S) j. Investigate how certain substances, including those traditional to First Nations and Métis cultures, can serve as acid-base indicators. (K, STSE, A) k. Describe how the pH scale is used to classify substances as acidic, basic or neutral. (S, STSE, A) l. Name and write formulas for common acids and bases, using the periodic table, a list of ions and rules for naming acids and bases. (S) m. Explain the importance of scientific nomenclature systems such as the International Union of Pure and Applied Chemistry (IUPAC) naming conventions in communicating information about chemical compounds. (STSE, A)
SCI10-CR3 Represent chemical reactions and conservation of mass symbolically using models, word and skeleton equations and balanced chemical equations. [SI, DM]	a. Design and safely carry out an experiment to confirm the law of conservation of mass, identifying and controlling major variables. (A, S) b. Explain the importance of the concept of conservation of mass in understanding, interpreting and predicting results of chemical reactions. (K, S) c. Represent chemical reactions, organic compounds and conservation of mass using models and word equations. (S, K, A) d. Represent chemical reactions and conservation of mass using skeleton equations and balanced equations. (S, K, A) e. Translate word equations to balanced chemical equations and balanced chemical equations to word equations. (S, K) f. Differentiate between the use of subscripts and coefficients in representing the numbers of atoms and molecules present in chemical reactions. (S)

	g. Categorize chemical reactions as synthesis, decomposition, combustion, single replacement and double replacement, including acid base neutralization. (S, K, A) h. Verify whether a chemical equation is correctly balanced, and correct any errors. (S) i. Discuss the value of representing chemical reactions using models, word and skeleton equations and balanced chemical equations. (STSE)
SCI10-CR4 Investigate the rates of chemical reactions, including factors that affect the rate. [SI]	a. Provide examples of chemical reactions that occur over a range of time scales. (K) b. Predict how factors such as temperature of the reactant(s), concentration of the reactant(s), surface area of the reactant(s) and the presence or absence of catalysts or inhibitors might affect the rate of a chemical reaction. (S, A) c. Formulate scientific questions about the rates of chemical reactions and the factors that affect rates of chemical reactions. (S, STSE) d. Design and perform an experiment to determine how various factors affect chemical reaction rates, including identifying and controlling major variables. (S, STSE, A) e. Compile and organize data, using appropriate formats and data treatments to facilitate interpretation of data related to rates of chemical reactions. (S, A) f. Interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables related to chemical reaction rates. (S, A) g. Reflect upon data collection and analysis procedures, and suggest improvements to increase precision and accuracy. (S, A, STSE) h. Use the collision model to explain differences in chemical reaction rates. (K, STSE) i. Value the processes for drawing conclusions in science. (A, STSE) j. Research how the rates of chemical reactions are controlled in everyday situations as well as in agricultural and industrial applications. (STSE) k. Work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise when investigating rates of reactions. (S, A)

Force and Motion in Our World	
All outcomes contribute to the development of all K-12 science goals.	
Outcomes	**Indicators**
SCI10-FM1 Explore the development of motion-related technologies and their impacts on self and society. [DM, TPS]	a. Create a representation of different types of motion and motion-related technologies from various cultures, including First Nations and Métis. (S, STSE) b. Describe how motion that may appear imperceptible to humans (e.g., continental drift, subatomic particles, light, blood circulating and galaxies) can be measured using appropriate technologies. (K, STSE) c. Evaluate the historical development of a motion-related technology, including the role of continued testing in the development and improvement of the technology. (STSE) d. Design, construct and evaluate a prototype of an object that meets a student-identified need related to motion. (STSE, S, A) e. Evaluate the design and function of a motion-related technology using student-identified criteria such as safety, cost, availability and impact on everyday life and the environment. (STSE) f. Describe examples of Canadian contributions to science and technology in motion-related fields such as transportation, sport science or space science. (STSE)
SCI10-FM2 Investigate and represent the motion of objects that travel at a constant speed in a straight line. [SI]	a. Provide examples of objects that exhibit, or appear to exhibit, uniform motion. (K) b. Discuss the concept of 'frame of reference' in determining whether an object is in motion and in constructing representations of an object's motion. (S, K, A) c. Construct scale diagrams of displacement vectors (i.e., collinear, non-collinear [perpendicular], and non-collinear [non-perpendicular]) to represent changes in an object's position. (S, A) d. Design and carry out experiments to determine the properties of uniform motion, using technologies such as photogates, motion detectors, ticker timers and stopwatches to collect distance and time data effectively and accurately. (S, STSE, A) e. Discuss the importance of distinguishing between scalar (e.g., distance, speed and time) and vector (e.g., position, displacement, velocity and acceleration) quantities when studying motion. (K) f. Construct and analyze graphs (i.e., distance-time, position-time, speed-time and velocity-time) using student-collected data obtained from objects undergoing uniform motion or through computer simulations. (S, A) g. Describe quantitatively the relationship among distance, time and speed for everyday objects that undergo uniform motion. (K)

	h. Derive the relationship between speed, distance and time (i.e., $v = \frac{\Delta d}{\Delta t}$) and between velocity, displacement and time (i.e., $\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$) using student-collected data from objects undergoing uniform motion. i. Solve problems related to the motion of objects that travel at a constant speed in a straight line. (S)
SCI10-FM3 Investigate and represent the motion of objects that undergo acceleration. [SI]	a. Develop and carry out experiments to determine the properties of accelerated motion, including identifying variables to be tested, developing appropriate sampling procedures for data collection, collecting and recording data and analyzing data to generate conclusions. (S, STSE) b. Evaluate the relevance, reliability and adequacy of data and data collection methods, including identifying and explaining sources of error and uncertainty in measurements. (STSE, S) c. Apply the concept of 'rate of change' to operationally define speed, velocity and acceleration. (K) d. Demonstrate the importance of converting measurements to the same units when solving motion problems. (K) e. Differentiate between the concepts of instantaneous and average as they relate to speed and velocity. (K) f. Construct and analyze graphs (i.e., distance-time, position-time, speed-time and velocity-time) that represent the motion of objects that undergo acceleration. (S) g. Solve problems related to acceleration using the equations of motion (e.g., $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$, $\Delta \vec{d} = \vec{v_i} t + \frac{1}{2} \vec{a} \Delta t^2$). (S) h. Value the role and contribution of science and technology in understanding phenomena that are directly observable and those that are not. (A)
SCI10-FM4 Explore the relationship between force and motion for objects moving in one and two dimensions. [SI, TPS]	a. Pose and refine scientific questions about the ways in which forces cause objects to move or change their motion. (A, S) b. Investigate the effects of applying constant forces to objects at rest and to objects moving at a constant velocity in a straight line. (S, A) c. Add force vectors in one and two dimensions (i.e., collinear, non-collinear [perpendicular] and non-collinear [non-perpendicular]) using vector diagrams to determine the net force acting on an object. (S) d. Demonstrate the role of friction in changing the position and/or motion of an object. (K, S) e. Provide examples of technologies that have been developed to increase or decrease frictional forces between two or more surfaces. (STSE) f. Analyze student-collected data to verify the relationship between the acceleration of an object and the net force acting on it. (S) g. Describe and provide examples of Newton's three laws of motion in practical situations such as sports, flight and transportation. (K, A)

Assessment and Evaluation of Student Learning

Assessment and evaluation require thoughtful planning and implementation to support the learning process and to 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; and,
- 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 to make informed decisions about the teaching and learning process.

There are three interrelated purposes of assessment. 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; and,
- engages teachers in providing differentiated instruction, feedback to students to enhance their learning and information to parents in support of learning.

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

- supports students in critically analyzing learning related to curricular outcomes;
- is student-driven with teacher guidance; and,
- occurs throughout the learning process.

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

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

Glossary

Acids are substances that produce hydrogen ions [H^+] when dissolved in water. They are sour-tasting, good conductors of electricity, turn blue litmus paper red and react with bases to form salts and water.

An **acid-base indicator** is a substance that changes colour at specific pH levels.

Albedo is a measure of the ability of a surface to reflect light.

Anthropogenic means to be caused or influenced by humans.

Average speed (or velocity) refers to a calculation of change in distance (or position) over a time interval for a moving object.

Bases are substances that produced hydroxide ions [OH^-] when dissolved in water. They are bitter tasting, good conductors of electricity, feel slippery, turn red litmus paper blue and react with acids to form salts and water.

Bioaccumulation is the increase in concentration of a pollutant from the environment to the first organism in a food chain.

Biodiversity is a measure of the number and variety of species in an ecosystem.

A **biogeochemical cycle**, or nutrient cycle, is the path of a nutrient through an ecosystem.

Biomagnification is the tendency of pollutants to become concentrated in successive trophic levels.

Biomes are the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment.

A **catalyst** is a substance that changes the rate of a chemical reaction but is not changed in the reaction.

A **chemical reaction** is a process that involves the formation of new substances with new properties.

Climate is the weather conditions of an area averaged over many years.

Climate change is a change in the "average weather" that a given region experiences. This includes all features associated with the weather such as temperature, wind patterns and precipitation.

The **Coriolis Effect** is the apparent change in direction of a moving object in a rotating system. In weather systems, this refers to the curvature of the prevailing wind systems (westerlies and trade winds) due to Earth's rotation.

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

An **ecosystem** includes the living and non-living components of a biological community and their interrelationships through nutrient cycles and the flow of energy.

An **endothermic** reaction absorbs energy from the surroundings.

An **exothermic** reaction releases energy to the surroundings.

A **frame of reference** is an arbitrary coordinate system from which quantities are measured.

Feedback mechanisms either change a system to a new state or return it to its original state.

The **Greenhouse effect** is a natural process by which a planet's atmosphere traps thermal energy from the sun, causing the temperature of the atmosphere to increase.

Greenhouse gases such as water vapour, carbon dioxide, methane, ozone, nitrous oxides and chlorofluorocarbons absorb and re-emit infrared radiation in the atmosphere.

An **inhibitor** is a substance that prevents or decreases the rate of a chemical reaction.

Instantaneous speed (or velocity) refers to the actual speed (or velocity) of an object at a particular instant in time.

Insolation is the total amount of solar radiation energy received on a given surface area during a given time.

An **ionic compound** is a neutral compound that consists of positive and negative ions held together by an ionic bond.

The **jet stream** refers to high-speed winds in the upper troposphere.

A **molecular compound** is a neutral compound composed of two or more non-metallic elements held together by covalent bonds.

Neutralization is the reaction between an acid and a base that produces a salt and water.

Nomenclature is a system of names or terms; in chemistry this is the system for naming chemical compounds.

An **organic compound** is a molecular compound that contains carbon, excluding carbides, carbonates, cyanides and oxides.

Random sampling is a sampling technique in which each member of the total population has an equal chance of being selected.

Rate of change is a measure of how fast a quantity changes per unit time.

A **scalar quantity** is fully described by a magnitude.

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 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.

Stratified sampling is a sampling technique which is used when the parent population is made up of sub-sets of a known size.

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 in order to inform and empower decision making by individuals, communities and society.

STSE, which stands for science, technology, society and the 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.

Sustainability refers to the ability to meet our present needs without compromising the ability of future generations.

A **system** is an assemblage of parts, working together, forming a functioning whole.

Systematic sampling is a sampling technique in which samples are chose in a regular way, such as equal distances or times.

A **vector quantity** is fully described by both a magnitude and a direction.

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

Thermohaline circulation is the large-scale ocean circulation that is driven by global density gradients driven by surface heat and freshwater fluxes.

Uniform motion is motion at a constant speed in a straight line.

Weather is the day-to-day environmental conditions in a location.

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Suggested Readings

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

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1. Please indicate your role in the learning community

☐ parent

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☐ other ____

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

2. How does this curriculum address the needs of your learning community organization?

Please explain.

The curriculum content is:	Strongly Agree	Agree	Disagree	Strongly Disagree
appropriate for its intended purpose	1	2	3	4
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clear and well organized	1	2	3	4
visually appealing	1	2	3	4
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3. Explain which aspects you found to be :

Most useful:

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4. Additional comments:

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