Ministry of Education

Saskatchewan Curriculum

Science

9

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Introduction

Science is a Required Area of Study in Saskatchewan's Core Curriculum. The provincial requirement for Grade 9 Science is 150 minutes of instruction per week (Saskatchewan Learning, 2007).

The purpose of this curriculum is to outline the provincial requirements for Grade 9 Science. This curriculum provides the intended learning outcomes that Grade 9 students are expected to achieve in science by the end of the year. Indicators are included to provide the breadth and depth of what students should know and be able to do 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).

> *Inquiry into authentic student questions generated from student experiences is the central strategy for teaching science.*
> *(National Research Council [NRC], 1996, p. 31)*

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

This curriculum includes the following information to support science instruction in Saskatchewan schools:
- connections to Core Curriculum, including the Broad Areas of Learning and Cross-curricular Competencies
- the K-12 aim and goals for science education
- characteristics of an effective science program
- Grade 9 Science outcomes and indicators
- sample assessment and evaluation criteria related to outcomes in science
- connections with other areas of study
- a glossary.

Using this Curriculum

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

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

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

Indicators are a representative list of the types of things a student 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. Indicators represent the breadth and the depth of learning related to a particular outcome. The list of indicators provided in the curriculum is not an exhaustive list. Teachers may develop additional and/or alternative indicators but those teacher-developed indicators must be reflective of and consistent with the breadth and depth that is defined by the given indicators.

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

- The term "including" prescribes content, contexts, or strategies that students must experience in their learning, without excluding other possibilities. For example, an indicator might say that students should gather evidence for the transfer of static electric charges, including charging by friction, charging by conduction, charging by induction, and electrostatic discharge. This means that, although other methods can be considered, it is mandatory to investigate the four types listed.

- 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 flannel, fur, wood, plastic, rubber, and metal" as examples of different methods of producing static electric charges. This statement provides teachers and students with possible methods to consider, while not excluding other methods.

- 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., eye colour, chin shape, ear lobes, and tongue rolling" to refer to the types of human traits that may be inherited from parents.

Although the outcomes and indicators in the science curriculum are organized by units, teachers may organize their instruction using interdisciplinary or transdisciplinary themes. There is no requirement for teachers to structure instruction into four distinct science units.

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 *Core Curriculum: Principles, Time Allocations, and Credit Policy* (Saskatchewan Learning, 2007).

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.

Developing Lifelong Learners

Students engaged in constructing and applying science knowledge naturally build a positive disposition towards learning. Throughout their study of science, students bring a natural curiosity about the natural and constructed world which

Developing lifelong learners is related to the following Goals of Education:
- *Basic Skills*
- *Lifelong Learning*
- *Self Concept Development*
- *Positive Lifestyle.*

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.

Developing a Sense of Self and Community

Developing a sense of self and community is 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.

Developing Engaged Citizens

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

As students explore connections between science, technology, society, and the environment, they experience opportunities to contribute positively to the environmental, economic, and social sustainability of local and global communities. Students reflect and act on their personal responsibility to understand and respect their place in the natural and constructed world, and make personal decisions that contribute to living in harmony with others and the natural world.

Cross-curricular Competencies

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

Developing Thinking

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

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.

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 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

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.

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

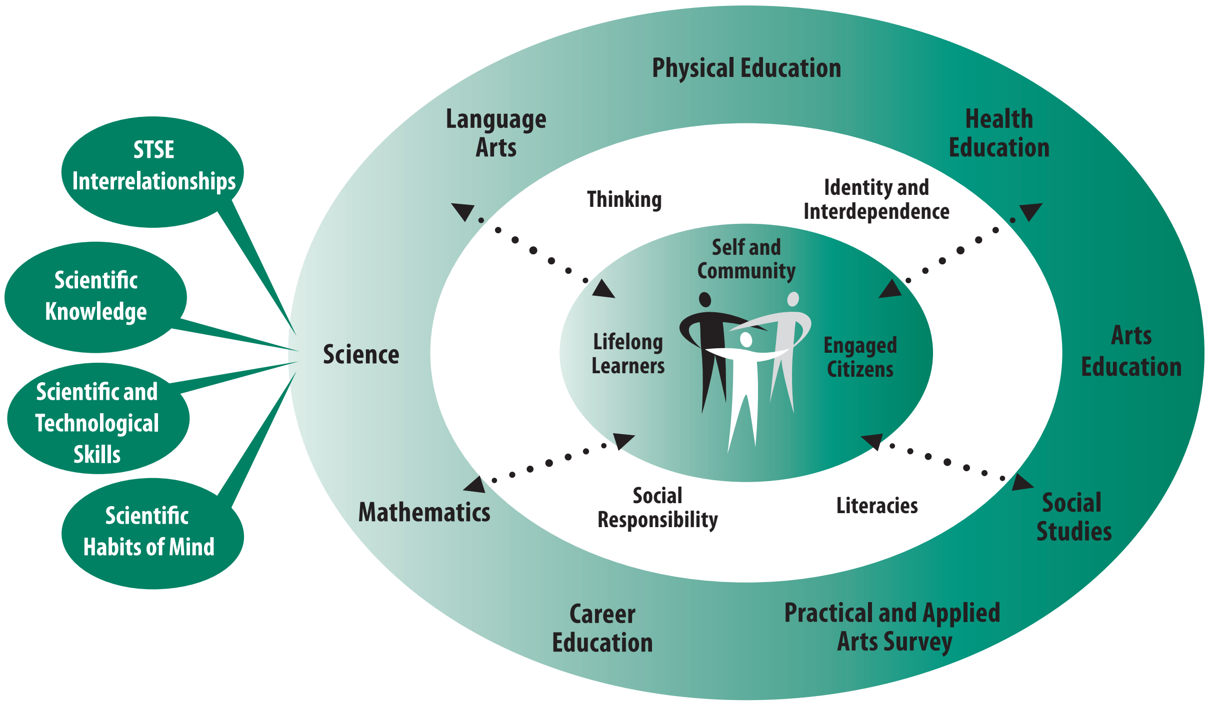
Aim and Goals

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, interdisciplinary, and transdisciplinary understanding.

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

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

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.

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)

- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

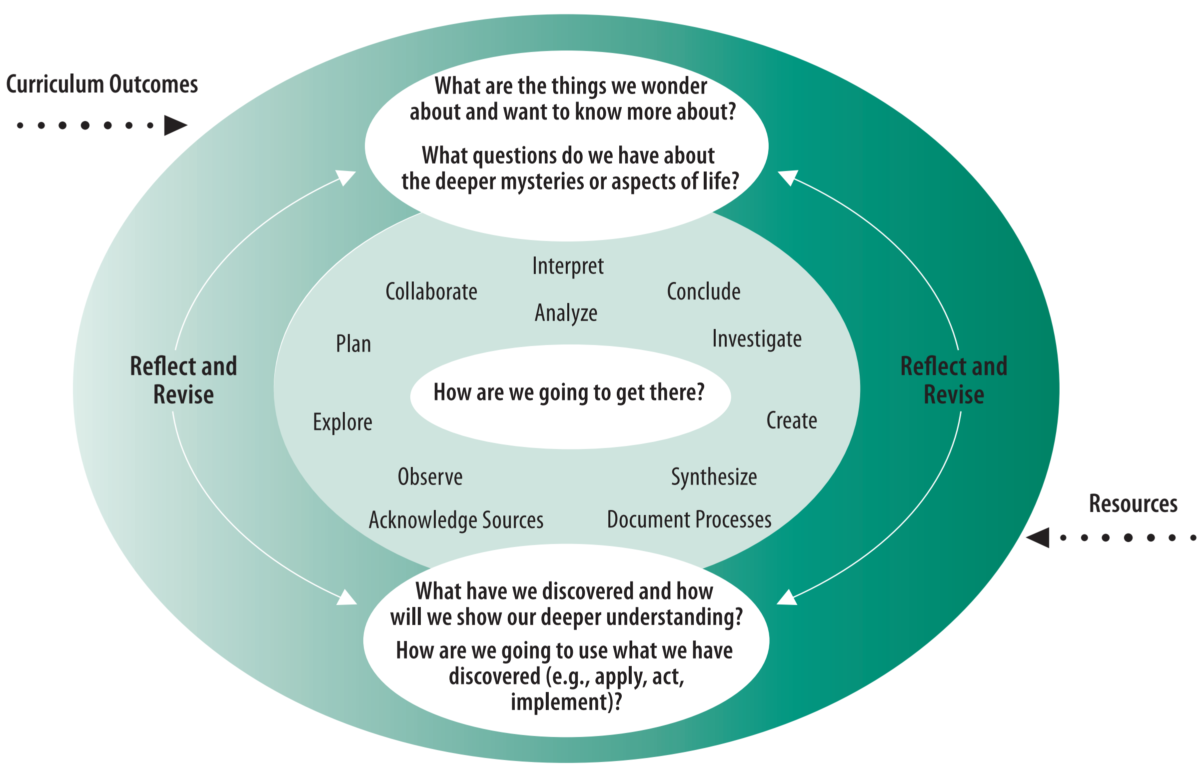
(NRC, 1996, pp. 145, 148)

> *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.

Constructing Understanding Through Inquiry



Inquiry focuses on the development of questions to initiate and guide the learning process. These questions are formulated by teachers and students 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.

Creating Questions for Inquiry in Science

In science, teachers and students can use the four learning contexts as curriculum entry points to begin their inquiry; however, the process may evolve into transdisciplinary learning opportunities, as reflective of the holistic nature of our lives and interdependent global environment.

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)

It is essential to develop questions that are evoked by student interests and have 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 transdisciplinary 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.

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

(NRC, 2000, p. 24)

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. They also invite and encourage students to pose their own questions for deeper understanding.

Students should recognize that science is often unable to answer "why" questions; in these instances, scientists rephrase their inquiries into "how" questions.

An Effective Science Education Program

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

- foundations of scientific literacy
- learning contexts
- explanations, evidence, and modelling in science
- laboratory work
- safety
- technology in science
- science challenges.

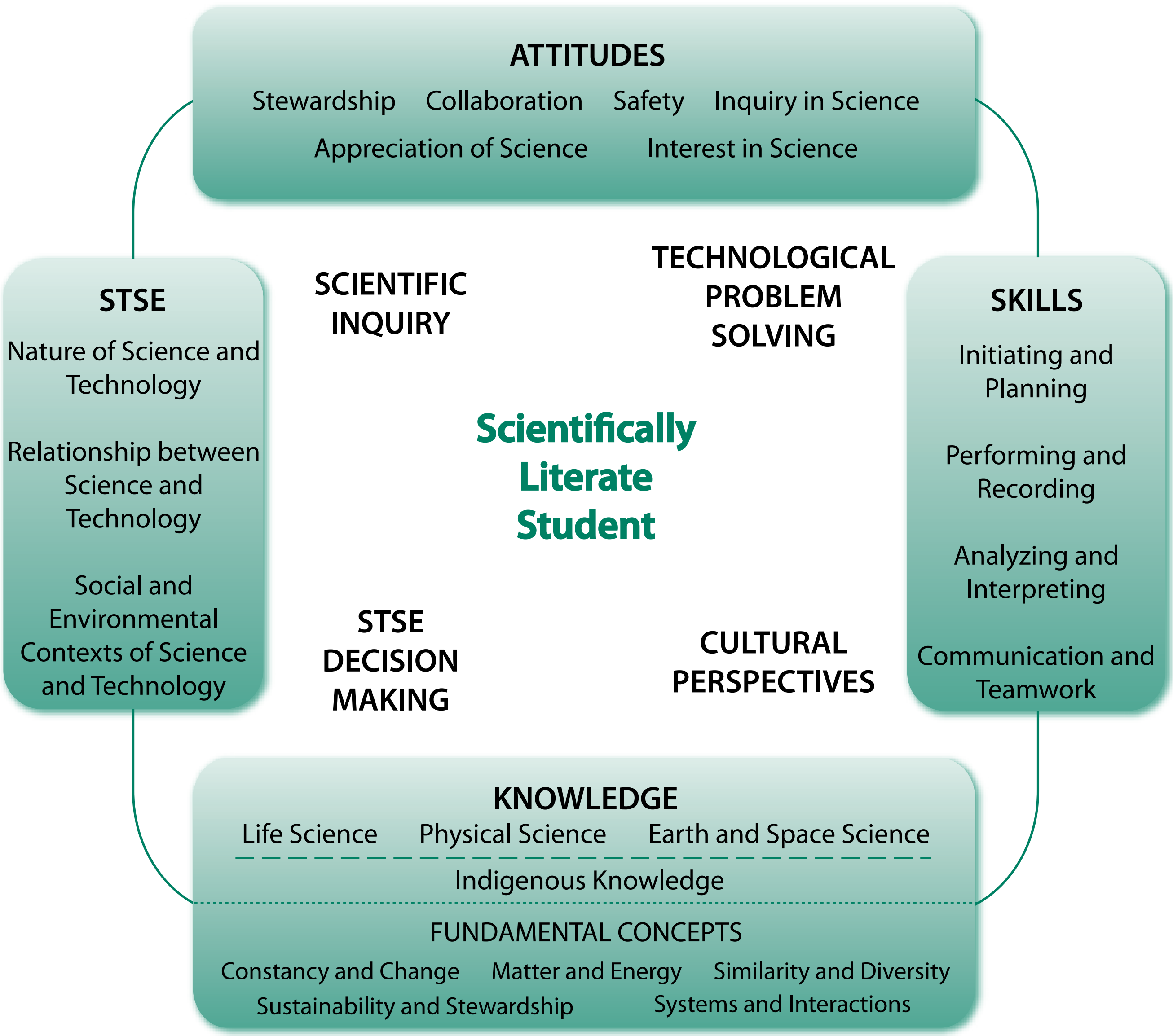
All science outcomes and indicators emphasize one or more foundations of scientific literacy; these represent the “what” of the curriculum. The learning contexts represent different processes for engaging students in achieving curricular outcomes; they are the “how” of the curriculum. The four units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

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

Technology serves to extending 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. Teachers and students may also choose to engage in science challenge activities as a means of achieving learning outcome.

Scientific Literacy Framework



Foundations of Scientific Literacy

The K-12 goals of science education parallel the foundation statements for scientific literacy described in the *Common Framework of Science Learning Outcomes K to 12* (CMEC, 1997). 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 context in which it is developed. This foundation statement should be considered 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 ideas. 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 the processes of 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.

Traditional and Local Knowledge

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

"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).

Scientific Knowledge

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

Fundamental Ideas – Linking Scientific Disciplines

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

Constancy and Change	The ideas of constancy and change underlie understanding of the natural and constructed world. Through observations, students learn that some characteristics of materials and systems remain constant over time whereas other characteristics change. These changes vary in rate, scale, and pattern, including trends and cycles, and may be quantified using mathematics, particularly measurement.
Matter and Energy	Objects in the physical world are comprised of matter. Students examine materials to understand their properties and structures. The idea of energy provides a conceptual tool that brings together many understandings about natural phenomena, materials, and the process of change. Energy, whether transmitted or transformed, is the driving force of both movement and change.
Similarity and Diversity	The ideas of similarity and diversity provide tools for organizing our experiences with the natural and constructed world. Beginning with informal experiences, students learn to recognize attributes of materials that help to make useful distinctions between one type of material and another, and between one event and another. Over time, students adopt accepted procedures and protocols for describing and classifying objects encountered, thus enabling students to share ideas with others and to reflect on their own experiences.
Systems and Interactions	An important way to understand and interpret the world is to think about the whole in terms of its parts and alternately about its parts in terms of how they relate to one another and to the whole. A system is an organized group of related objects or components that interact with one another so that the overall effect is much greater than that of the individual parts, even when these are considered together.
Sustainability and Stewardship	Sustainability refers to the ability to meet our present needs without compromising the ability of future generations to meet their needs. Stewardship refers to the personal responsibility to take action 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 need to experience learning through each learning context at each grade; it is not necessary, nor advisable, for each student to attempt to engage in learning through each learning context in each unit. Learning within a classroom may be structured to enable individuals or groups of students to achieve the same curricular outcomes through different learning contexts.

A choice of learning approaches 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 [SI]

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

> *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.*
> *(National Research Council, 1996, p. 23)*

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
- testing and evaluating the prototype or plan.

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

> *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)*

STSE Decision Making [DM]

> *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)*

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
- reflecting back on the process of decision making.

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

Cultural Perspectives [CP]

> *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)*

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.

> *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)*

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.

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
- 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.

Explanations, Evidence, and Models 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 natural laws (e.g., the Law of Conservation of Mass).

Scientists use the terms *laws*, *theories*, and *hypotheses* to describe various types of scientific explanations about phenomena in the natural and constructed world. These meanings differ from common usage of the same terms:

- Law – A law is a generalized description, usually expressed in mathematical terms, that describes some aspect of the natural world under certain conditions.

- Theory – A theory is an explanation for a set of related observations or events that may consist of statements, equations, models, or a combination of these. Theories also predict the results of future observations. A theory becomes a theory once the explanation is verified multiple times by different groups of researchers. The procedures and processes for testing a theory are well-defined within each scientific discipline, but they vary between disciplines. No amount of evidence proves that a theory is correct. Rather, scientists accept theories until the emergence of new evidence that the theory is unable to adequately explain.

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

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, generally constructed in order to facilitate study of complex systems such as the atom, climate change, and biogeochemical cycles. Models may be physical, mental, or mathematical or contain a combination of these elements. Models are complex constructions that consist of conceptual objects and processes in which the objects participate or interact. Scientists spend considerable time and effort building and testing models to further understanding of the natural world.

When engaging in the processes of science, students 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 physical phenomena their models represent or explain. Just as importantly, students should identify which features are not represented or explained by their models. Students should determine the usefulness of their model by judging whether the model helps in understanding the underlying concepts or processes. Ultimately, students realize that different models of the same phenomena may be needed 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.

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

- initiating and planning
- performing and recording
- analyzing and interpreting
- 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.

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)

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 experiments. The narrative lab report enables students to tell the story of their process and findings in a less structured format than a typical lab report.

In a narrative lab report, students answer four questions:

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

The answers are written in an essay format rather than using the structured headings of Purpose, Procedure, Hypothesis, Data, Analysis, and Conclusion that are 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 (resources, teaching strategies, 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.

Kwan and Texley (2003) 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, 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 yourself 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 under the Hazardous Products Act govern storage and handling practices of chemicals in schools. All school divisions must comply with the provisions of the Act. Chemicals should be stored in a safe location according to chemical class, not just alphabetically. Appropriate cautionary labels must be placed on all chemical containers and all school division employees using hazardous substances should have access to appropriate Materials Safety Data Sheets. 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 Advanced Education, Employment and Labour.

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

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

Technology in Science

Technology should be used to support learning in science when:

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

(Flick & Bell, 2000)

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 (www.learner.org/north) or GLOBE (www.globe.gov).

Science Challenges

Science challenges, which may include science fairs, science leagues, Science Olympics, Olympiads, or talent searches, should be considered as instructional methods suitable for students to undertake in any unit, across units, or in conjunction with other subject areas. 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. If science challenges are undertaken as a classroom activity, teachers should consider these guidelines, adapted from the 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.

- 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 Foundation Canada (www.ysf.ca) provides further information regarding science fairs in Canada.

Outcomes and Indicators

Life Science – Reproduction and Human Development (RE)
RE9.1 Examine the process of and influences on the transfer of genetic information and the impact of that understanding on society past and present.
RE9.2 Observe and describe the significance of cellular reproductive processes, including mitosis and meiosis.
RE9.3 Describe the processes and implications of sexual and asexual reproduction in plants and animals.
RE9.4 Analyze the process of human reproduction, including the influence of reproductive and contraceptive technologies.

Physical Science – Atoms and Elements (AE)
AE9.1 Distinguish between physical and chemical properties of common substances, including those found in household, commercial, industrial, and agricultural applications.
AE9.2 Analyze historical explanations of the structure of matter up to and including: • Dalton model • Thomson model • Rutherford model • Bohr model of the atom.
AE9.3 Demonstrate an understanding of the classification of pure substances (elements and compounds), including the development and nature of the Periodic Table.

Physical Science – Characteristics of Electricity (CE)
CE9.1 Demonstrate and analyze characteristics of static electric charge and current electricity, including historical and cultural understanding.
CE9.2 Analyze the relationships that exist among voltage, current, and resistance in series and parallel circuits.
CE9.3 Assess operating principles, costs, and efficiencies of devices that produce or use electrical energy.
CE9.4 Critique impacts of past, current, and possible future methods of small and large scale electrical energy production and distribution in Saskatchewan.

Earth and Space Science – Exploring our Universe (EU)
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe.
EU9.2 Analyze scientific explanations of the formation and evolution of our solar system and the universe.
EU9.3 Examine how various cultures, past and present, including First Nations and Métis, understand and represent astronomical phenomenon.
EU9.4 Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration.

Life Science: Reproduction and Human Development (RE)

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

Outcomes	Indicators
RE9.1 Examine the process of and influences on the transfer of genetic information and the impact of that understanding on society past and present. ***[CP, DM]***	a. Identify questions to investigate related to genetics. b. Provide examples of genetic conditions whose causes and cures are not understood according to current scientific and technological knowledge (e.g., some causes of male infertility, cystic fibrosis, Down's syndrome, and muscular dystrophy). c. Recognize that the nucleus of a cell contains genetic information and identify the relationship among chromosomes, genes, and DNA in transmitting genetic information. d. Identify examples of dominant and recessive traits in humans and other living things. e. Observe, collect, and analyze class and/or family data of human traits that may be inherited from parents (e.g., eye colour, chin shape, ear lobes, and tongue rolling). f. Discuss environmental factors and personal choices that may lead to changes in a cell's genetic information (e.g., toxins, carcinogens, pesticides, smoking, overexposure to sunlight, and alcohol abuse). g. Provide examples of Saskatchewan and Canadian contributions to the science and technology of genetics and reproductive biology in plants and animals. h. Select and synthesize information from various sources to illustrate how developments in genetics, including gene therapy and genetic engineering, have had an impact on global and local food production, populations, the spread of disease, and the environment. i. Describe careers in Saskatchewan or Canada that require an understanding of genetics or reproductive biology.
RE9.2 Observe and describe the significance of cellular reproductive processes, including mitosis and meiosis. ***[CP, SI]***	a. Observe and describe cell division (e.g., binary fission, mitosis, and meiosis) using microscopes, prepared slides, and/or videos. b. Construct a visual, dramatic, or other representation of the basic process of cell division as part of the cell cycle, including what happens to the cell membrane and the contents of the nucleus.

Outcomes	Indicators
RE9.2 continued	c. Recognize that the nucleus of a cell determines cellular processes. d. Identify major shifts in scientific understanding of cell growth and division, including the role of microscopes and related technologies. e. Explain how the cell theory accounts for cell division. f. Compare binary fission, mitosis, and meiosis, and distinguish between cell division processes during meiosis and mitosis including the creation of diploid and haploid cells. g. Relate cancer to cellular processes.
RE9.3 Describe the processes and implications of sexual and asexual reproduction in plants and animals. ***[SI]***	a. Identify questions to investigate about sexual and asexual reproduction in plants. b. Compare advantages and disadvantages of sexual and asexual reproduction for individual plants and animals, and for populations. c. Describe various methods of asexual reproduction in plant species (e.g., budding, grafting, binary fission, spore production, fragmentation, and vegetative reproduction) and list specific examples. d. Describe various methods of asexual reproduction in animal species (e.g., budding, parthenogenesis) and list specific examples (e.g., hydra, aphids, and hammerhead shark). e. Investigate and describe applications of asexual reproduction knowledge and techniques in the Saskatchewan agricultural and/or forestry sector. f. Describe the process of sexual reproduction in seed plant species, including methods of pollination. g. Describe examples of sexual reproduction in animal species, including hermaphroditic species (e.g., Clownfish, wrasses, snails, and earthworms).

Outcomes	Indicators
RE9.4 Analyze the process of human reproduction, including the influence of reproductive and contraceptive technologies. ***[SI, DM]***	a. Pose questions about the process of human reproduction. b. Compare the structure and function of the male and female human reproductive systems, including the role of hormones. c. Describe the major stages of human development from conception to birth, including reference to signs of pregnancy, X and Y chromosomes, zygote, embryo, and fetus. d. Acknowledge differing cultural perspectives, including First Nations and Métis perspectives, regarding the sacredness, interconnectedness, and beginning of human life. e. Provide examples of scientific knowledge that has resulted in the development of reproductive technologies (e.g., in vitro fertilization, artificial insemination, and embryo transfer) and contraceptive technologies (e.g., condoms, oral contraceptive pill, diaphragm, intra-uterine devices, sterilization, and the morning after pill). f. Examine social and cultural issues related to the use of reproductive and/or contraceptive technologies in humans and defend a given position on an issue related to the use of reproductive and/or contraceptive technologies in humans.

Physical Science: Atoms and Elements (AE)

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

Outcomes	Indicators
AE9.1 Distinguish between physical and chemical properties of common substances, including those found in household, commercial, industrial, and agricultural applications. ***[SI]***	a. Demonstrate knowledge of Workplace Hazardous Materials Information System (WHMIS) standards by identifying WHMIS symbols that represent each category, examples of substances that belong within each category, and the risks and cautions associated with each category. b. Explore local knowledge of properties of matter and traditional uses of substances, including medicines. c. Share personal understandings about physical and chemical properties of matter. d. Investigate common materials and describe them in terms of their physical properties such as smell, colour, melting point, boiling point, density, solubility, ductility, crystal shape, conductivity, hardness, lustre, texture, and malleability. e. Classify substances found in household, commercial, industrial, and agricultural applications based on their physical and/or chemical properties.

Outcomes	Indicators
AE9.1 continued	f. Provide examples of how society's needs for new products can lead to scientific research and technological developments based on understanding of physical and chemical properties of matter. g. Investigate changes in the properties of materials and identify those that are indicators of chemical changes (e.g., change in colour, change in odour, formation of a gas or precipitate, or the release or absorption of thermal energy). h. Use equipment, tools, and materials appropriately and safely when conducting investigations into physical and chemical properties of substances. i. State a conclusion, based on experimental data, which supports or refutes an initial idea related to personal understanding of physical and chemical properties of matter. j. Differentiate between physical and chemical properties of matter and physical and chemical changes in matter, based on observable evidence. k. Provide examples to illustrate that scientific and technological activity related to chemistry takes place in a variety of individual and group settings within Saskatchewan.
AE9.2 Analyze historical explanations of the structure of matter up to and including: o ***Dalton model*** o ***Thomson model*** o ***Rutherford model*** o ***Bohr model of the atom.*** ***[SI]***	a. Propose personal explanations for the structure and/or composition of matter. b. Use appropriate scientific terminology when describing atoms and elements (e.g., mass, charge, electron, proton, neutron, nucleus, atom, molecule, element, compound, neutral, positive, negative, ion, isotope, and periodic table). c. Describe First Nations and Métis views on the nature and structure of matter. d. Identify major shifts in understanding matter that have enabled more detailed explanations of the structure and composition of the atom up to and including the Bohr model of the atom. e. Construct models to illustrate the structure and components of matter, including the major historical atomic models (e.g., Dalton, Thomson, Rutherford, and Bohr), using information selected and synthesized from various sources. f. Evaluate individual and group processes used in planning and completing a task related to constructing models of atoms and molecules. g. Discuss strengths and limitations of models in science using historical and contemporary examples of atomic models.

Outcomes	Indicators
AE9.2 continued	h. Provide examples of technologies that have enhanced, promoted, or made possible scientific research about the structure of the atom (e.g., microscope, cathode ray tube, and mass spectrometer). i. Pose new questions and problems that arise from what was learned about atomic structure (e.g., "Why do different molecules containing the same elements behave differently?" "How do atoms stick together in a molecule?" "Are there smaller particles than electrons, protons, and neutrons?").
AE9.3 Demonstrate an understanding of the classification of pure substances (elements and compounds), including the development and nature of the Periodic Table. ***[SI]***	a. Differentiate between elements, compounds, and mixtures (mechanical mixtures and solutions), with reference to the terms homogenous and heterogeneous. b. Classify pure substances as elements or compounds. c. Construct a graphic representation of one or more elements that symbolizes each element in a meaningful way and contains relevant information such as name, atomic number, possible uses, and historical background. d. Identify examples of common elements (e.g., first 18 elements and K, Ca, Fe, Ni, Cu, Zn, I, Ag, Sn, Au, W, Hg, Pb, and U), and compare their atomic structure and physical and chemical properties. e. Identify the eight elements that occur in nature as diatomic molecules (e.g., H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2, and At_2). f. Identify and evaluate potential applications of understanding of the characteristics of elements (e.g., identify fertilizers as a possible application of elements, and evaluate the potential use of given elements when choosing a fertilizer). g. Write and interpret chemical symbols or formulae of common elements and compounds and identify the elements and number of atoms of each in a given compound (e.g., He, Na, C, H_2O, H_2O_2, CO, CO_2, $CaCO_3$, SO_2, FeO, NO_2, O_3, CH_4, C_3H_8, NH_3, $NaHCO_3$, KCl, HCl, H_2SO_4, ZnO, and NaCl). h. Construct Bohr model representations of the first 18 elements. i. Trace the historical development of the modern periodic table and compare alternative arrangements that convey information about the classification of elements.

Outcomes	Indicators
AE9.3 continued	j. Apply the concept of systems as a tool by interpreting the organizational structure and patterns inherent within the periodic table, including periods, groups (families), atomic mass (mass number), atomic number, metals, non-metals, and metalloids. k. Predict the physical and chemical properties of an element or family of elements (e.g., alkali metals, alkaline-earth metals, hydrogen, halogens, noble gases, and transition metals) based on its position within the periodic table. l. Determine the number of protons and electrons in an atom given the atomic number of an element. m. Determine the number of electrons, protons, and neutrons of an isotope of an element given the atomic number and mass number of an element. n. Discuss the difference between the use of the terms "law" and "theory" in science with reference to the periodic law and the atomic theory of matter.

Physical Science: Characteristics of Electricity (CE)

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

Outcomes	Indicators
CE9.1 Demonstrate and analyze characteristics of static electric charge and current electricity, including historical and cultural understanding. ***[CP, SI, TPS]***	a. Pose questions to investigate related to static electric charge and current electricity. b. Gather evidence for the transfer of static electric charges, including charging by friction, charging by conduction, charging by induction, and electrostatic discharge and create written, visual, and/or dramatic representations of those processes. c. State the properties of static electrical charges. d. Examine how the importance of lightning in First Nations and Métis culture is conveyed through stories and legends.

Outcomes	Indicators
CE9.1 continued	e. Use a technological problem-solving process to design, construct, and evaluate the reliability of a device to detect static electrical charges, such as an electroscope. f. Explain, with reference to electron transfer, the production of static electrical charges in some common materials such as flannel, fur, wood, plastic, rubber, and metal. g. Describe the operation of technologies that have been developed based on scientific understanding of static electric charge and discharge (e.g., air filters, fabric softeners, lightning rods, automotive painting, plastic wrap, grounding straps, Van de Graaff generator, and photocopiers). h. Outline the contributions of people from various cultures to modern understanding of static electric charge and current electricity (e.g., Thales, Robert Boyle, Benjamin Franklin, Michael Faraday, Nikola Tesla, Georg Ohm, Alessandro Volta, André-Marie Ampère, James Wimshurst, and Robert Van de Graaff), and past and present careers that require an understanding of static electric charge and current electricity. i. Identify dangers to the human body associated with static electric charge and discharge, and current electricity, and discuss how technologies such as grounding straps, lightning rods, grounded plugs, fuses, and circuit breakers are designed to minimize such dangers. j. Design and safely conduct an investigation to determine the resistance of various materials such as copper wire, Nichrome wire, graphite, rubber tubing, wood, glass, distilled water, and ionic solutions to electric current. k. Differentiate between conductors, insulators, and superconductors in electric circuits. l. Differentiate between a complete circuit, a closed circuit, an open circuit, and a short circuit. m. Describe the flow of charge in an electrical circuit based on the particle theory of matter and electron transfer.
CE9.2 Analyze the relationships that exist among voltage, current, and resistance in series and parallel circuits. ***[SI]***	a. Demonstrate the importance of using precise language in science and technology by formulating operational definitions for voltage, resistance, and current. b. Demonstrate the role of switches and variable resistors in series and parallel circuits, and identify practical examples of switches and variable resistors in daily life. c. Model the characteristics of series and parallel circuits using analogies or visual and/or physical representations.

Outcomes	Indicators
CE9.2 continued	d. Use an ammeter, voltmeter, and/or multimeter safely and accurately to measure current and voltage of a variety of student-constructed series and parallel circuits, and identify potential sources of error in instrument readings. e. Display data from the investigation of voltage, current, and resistance in series and parallel circuits in tabular form and graphically. f. Calculate values of unknown quantities in electric circuits using Ohm's Law (I = V/R). g. Model, using appropriate standard circuit diagram symbols, series and parallel circuits that include an energy source, one or more switches, and various loads designed to accomplish specific tasks (e.g., household lighting, flashlight, electric fan, blender, coffee maker, toy vehicle, and automotive lighting). h. Rephrase questions related to electric circuits in a testable form (e.g., rephrase a question such as "Why do we use parallel circuits in household wiring?" to "How do the voltage and current in a series circuit compare with those in a parallel circuit?").
CE9.3 Assess operating principles, costs, and efficiencies of devices that produce or use electrical energy. ***[SI, TPS]***	a. Explain the energy transformations involved in devices that use or produce light, heat, sound, motion, and magnetic effects (e.g., toaster, light bulb, thermocouple, oven, refrigerator, television, hair dryer, kettle, fan, electric blanket, and remote-controlled toy vehicle). b. Use a technological problem-solving process to collaboratively design, construct, and evaluate a prototype of an electric motor that meets student-identified criteria or solves a student-identified problem. c. Calculate the efficiency of common energy-converting devices and suggest reasons why the efficiency is always less than 100%. d. Interpret the energy efficiency rating of household electrical appliances and calculate their costs of operation in Saskatchewan over a given time by identifying the power rating and using the formula Cost = Power x time x rate. e. Evaluate the design of a household electrical appliance on the basis of criteria such as function, cost, and impact on daily life and the environment, and suggest alternative designs that are more sustainable. f. Identify, and suggest explanations for, discrepancies in variations in the monthly costs of electrical energy for a household or business.

Outcomes	Indicators
CE9.3 continued	g. Make informed decisions about personal use of devices that use electrical energy, taking into account environmental and social advantages and disadvantages. h. Propose a course of action to reduce the consumption of electrical energy in Saskatchewan, taking into account personal, societal, and environmental needs.
CE9.4 Critique impacts of past, current, and possible future methods of small and large scale electrical energy production and distribution in Saskatchewan. ***[DM, TK]***	a. Provide examples of how technological developments related to the production and distribution of electrical energy have affected and continue to affect self and community, including electricity use on reserves, traditional lands, and traditional life in Saskatchewan. b. Compare the operating principles, efficiency, lifespan, and safety, of past and current technologies developed to produce and store electrical energy, (e.g., electrochemical cells, wet cells, dry cells, and batteries) in the home, business, and industry. c. Discuss the merits of primary and secondary cells and explain why secondary cells are not always appropriate to meet certain needs for electrical energy. d. Illustrate and describe the transfer and conversion of energy from a typical generating station to a home in Saskatchewan, including the role of transformers. e. Assess the efficiency and impact of large scale versus small scale electrical energy distribution systems for home, business, agricultural, and industrial applications. f. Describe scientific, technological, societal, and environmental perspectives related to past, current, and proposed large-scale methods of electrical energy generation in Saskatchewan (e.g., hydroelectric dams, coal and natural gas-fired plants, wind turbines, solar energy, geothermal, biomass, and nuclear plants). g. Evaluate evidence and sources of information created by different stakeholders related to various methods of electrical energy production in Saskatchewan, including alternative energy sources such as geothermal, biomass, clean coal, and co-generation.

Earth and Space Science: Exploring our Universe (EU)

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

Outcomes	Indicators
EU9.1 Inquire into the motion and characteristics of astronomical bodies in our solar system and the universe. ***[SI]***	a. Pose questions about the characteristics of and relationships between astronomical bodies. b. Observe and identify movement patterns of the major visible bodies in the night sky. c. Compare historical and modern explanations for the real and apparent motion, including real and apparent retrograde motion, of celestial bodies (e.g., sun, moon, planets, comets, and asteroids) and artificial satellites. d. Create a physical and/or visual representation of the apparent motion of astronomical bodies, including retrograde motion, as seen from various locations within our solar system. e. Compare the efficacy of various historical and contemporary models of planetary motion, including geocentric and heliocentric models, for explaining observed astronomical phenomena. f. Describe and explain the role of experimentation, collecting evidence, finding relationships, proposing explanations, and imagination in the development of scientific knowledge of the solar system and universe (e.g., explain how data provided by astronomy, radio astronomy, satellite-based astronomy, and satellite exploration of the sun, planets, moons, and asteroids contribute to our knowledge of the solar system). g. Conduct an experiment, simulation, or demonstration to investigate the motion and/or characteristics of one or more astronomical bodies. h. Compare the composition and physical characteristics of astronomical bodies within the solar system, including the planets, comets, asteroids, and meteors, using appropriate scientific terminology and units (e.g., light years, astronomical units). i. Describe the effects of solar phenomena, including sunspots, solar flares, and solar radiation, on Earth. j. Classify the major components of the universe, including stars, quasars, black holes, nebulae, and galaxies, according to their distinguishing physical characteristics.

Outcomes	Indicators
EU9.1 continued	k. Organize data about the characteristics of the major components of the solar system or universe using tables, spreadsheets, charts, and/or diagrams and draw conclusions about those characteristics specifically and the solar system and universe generally. l. State a prediction and a hypothesis about astronomical phenomenon based on background information or an observed pattern of events (e.g., predict the next visit of a comet based on past observations, predict the location of Venus or Mars over a period of days).
EU9.2 Analyze scientific explanations of the formation and evolution of our solar system and the universe. ***[SI]***	a. Describe scientific theories on the formation of the solar system, including planets, moons, asteroids, and comets. b. Describe scientific theories and models of the origin and evolution of the universe and the observational evidence that supports those theories (e.g., red shift of galaxies, cosmic microwave background radiation, and abundance of light elements). c. Construct and critique a visual representation of the life cycle of stars using appropriate scientific terminology and identify strengths and weaknesses of the representation. d. Explain the need for new evidence in order to continually test existing theories in science (e.g., explain the need for new evidence obtained from space-based telescopes and close-up observations by satellites, which can reinforce, adjust, or reject existing inferences based on observations from Earth). e. Identify new questions and problems that arise from what was learned about the origins of the universe (e.g., "What are the limits of space travel?", "How old is the Universe?", and "Is Earth the only suitable home for humans?").
EU9.3 Examine how various cultures, past and present, including First Nations and Métis, understand and represent astronomical phenomenon. ***[CP]***	a. Describe First Nations and Métis perspectives on the origin of the solar system and the universe. b. Identify how worldviews related to astronomical phenomenon are expressed through First Nations and Métis stories and oral traditions. c. Explain the importance many individuals and cultures place or have placed on the summer and winter solstices and vernal and autumnal equinoxes. d. Identify common characteristics of stories, past and present, describing the origin of the world from various cultures and those in fantasy literature.

Outcomes	Indicators
EU9.4 Analyze human capabilities for exploring and understanding the universe, including technologies and programs that support such exploration. ***[DM, TPS]***	a. Identify the major advances of the Canadian, North American, and other space programs that have enabled space probes and human spaceflight exploration of the solar system and universe. b. Use a technological problem-solving process to design and evaluate a prototype of a habitable space vehicle that could support human exploration beyond our solar system to a student-selected destination. c. Identify potential physical and psychological barriers to exploring and/or living in the universe beyond the inner solar system. d. Calculate theoretical values of the time for light or spacecraft at a given speed to travel to a distant star or other astronomical object. e. Conduct appropriate research and defend a given position on the economic and societal benefits of space exploration. f. Describe particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems related to exploring and understanding the universe (e.g., quadrant, astrolabe, cross-staff, optical telescope, star chart, radio telescope, satellite, space-based telescope, unmanned probe, and robotics). g. Describe and apply techniques for determining the position of objects in space using the horizontal (e.g., azimuth and altitude) and equatorial coordinate systems (e.g., declination and right ascension). h. Provide examples of how Canadian research projects in space science and technology are supported by governments, universities, and private agencies. i. Research space science careers in Canada (e.g., astronauts, astrophysicists, materials technologists, pilots, and computer programmers). j. Describe possible positive and negative effects of a particular scientific or technological development related to space exploration, and explain why a practical solution requires a compromise between competing priorities (e.g., describe effects such as the spinoffs from space technologies to everyday usage and the potential military use of space exploration, and recognize the need to evaluate these effects).

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
- 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. Reporting of student achievement must be in relation to curriculum outcomes.

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
- 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
- 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
- provides the foundation for discussions on placement or promotion.

Connections with Other Areas of Study

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

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

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

Arts Education

The conceptual focus for Grade 9 Arts Education is "Taking Action". This focus engages students in expressing perspectives and raising awareness about topics of concern to youth. Topics of concern may be drawn from the study of science. Connections between arts education and science may include:

- Create a drama involving a genetic experiment, crisis, or legal situation including a conflict such as the use or misuse of DNA information.
- Create dances that investigate how DNA and chromosomes store and transfer genetic material.
- Create a 2-D drawing, mixed media collage, or 3-D sculpture using the structure of matter as inspiration for the work.

- Research examples and have students create interactive sculptures incorporating electricity (e.g., parts of the sculpture may move or recordings may be activated by movements from the viewer).
- Create dances that interpret the motion and characteristics of astronomical bodies in the solar system and universe.
- Analyze the music of composers whose work was inspired by the stars and planets (e.g., Gustav Holst's *The Planets*). Compare the music elements and characteristics of two selections (e.g., Mars, The Bringer of War vs. Venus, the Bringer of Peace). How does the composer represent each planet?
- Create a drama that explores the consequences of discovering new evidence or proposing conflicting theories about the evolution of the solar system and universe.

Career Education

Areas of study such as science can provide the context for student experiences of connections between personal knowledge and skills to career pathways and their connections to community. Two specific examples of these connections between science and career education at grade nine include:

- Investigate science and technology-related careers and workplaces that require an understanding of plant and animal reproduction, the structure of material, production and distribution of electricity, and the universe.
- Use the results of their investigations into science to support the initial construction of a personal life and work plan in career education.

English Language Arts (ELA)

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

- Throughout the science curriculum, students should view, listen to, read, comprehend, and respond to a variety of texts, including fiction, non-fiction, videos, websites, and summarize the main ideas and supporting details of those texts.
- Students should understand that the structure of science textbooks differs from the structure of other types of texts. By gaining an understanding of that structure, students

are able to read those texts efficiently and effectively for a variety of purposes, including gathering information, following directions, understanding information, and for enjoyment.
- Students should present the results of their science inquiries using a variety of text forms, including expository, informational, and procedural texts (e.g., document the development of a prototype of an electric motor), descriptive texts (e.g., state the importance many individuals and cultures place or have placed on the summer and winter solstices, and vernal and autumnal equinoxes), and persuasive texts (e.g., explain positive and negative impacts of various sources of electrical energy).
- Students should reflect on and critique their choices of grade-appropriate strategies for communicating their science learning.

Health Education

Connections can often be found between the topics in health education and science, although students may conduct their inquiries into these topics from different disciplinary "worlds". Some specific examples of the connection between these areas of study at grade nine is:
- Understanding the process of human reproduction, including the influence of reproductive and contraceptive technologies will complement the development of personal insight, motivation, and skills necessary to enhance and promote sexual health and avoid health-compromising sexual attitudes and behaviours.
- Knowing the role of DNA, genes, and chromosomes in storing and transferring genetic material supports students' understanding of the causes and transmission of genetic disorders and particular chronic illnesses.

Mathematics

A key connection between mathematics and science is the search for patterns and relationships in the natural and constructed world. Inquiries in science require students to collect, analyze, and display data, which require the application of a variety of mathematical skills, understandings, and processes, including measuring, counting, and data analysis skills. When students construct mathematical and physical models in science to represent and explain natural phenomena, they apply mathematical skills related to number and probability. Some specific examples of these connections in grade nine include:

- Apply their understanding of powers with integral exponents to their calculations of travel time to astronomical objects within our universe.
- Consider the role of probability in society through their analysis of class or individual data with respect to specific physical traits related to human reproduction.
- Create, interpolate, and extrapolate information from graphs and tables in their exploration of various sets of data related to atoms and elements.

Physical Education

Both science and physical education involve understanding of the human body, albeit within different disciplinary "worlds". Understanding scientific principles related to movement can serve to enhance skillful movement of the human body; by contrast, the analysis of human movement can contribute to a deeper understanding of the underlying scientific principles. Two specific examples of connections between these areas of study at grade nine include:

- Student investigations of human adaptations to their environments in the long term can contribute to an understanding of the effects of inactivity on body composition among humans today.
- When students investigate how the forces of thrust, drag, lift, and gravity act on living things and constructed devices that fly through the air in science, they can apply their understanding of these forces by demonstrating skill-related components of fitness such as power, speed, and balance, by examining the forces that act on balls and objects that fly through the air, and by explaining the effects of different forces on skill performance.

Social Studies

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

- Students explore the impact and significance of technology in daily life, and how technology has shaped and influenced our society and societies of the past.
- Explore current and historical interpretations of astronomical phenomena, and how those interpretations are (were) used in societies around the world.

Glossary

Altitude is a measure of the height of a celestial body above the observer's horizon.

An **ammeter** is an instrument used to measure electric current in a circuit.

Asexual reproduction (e.g., budding, grafting, binary fission, spore production, fragmentation, vegetative reproduction) is reproduction without the fusion of sex cells, resulting in identical offspring and parent.

Astronomical bodies include all physical entities, associations, or structures that exist in outer space.

An **astronomical unit** (AU) is a measure of the distance used to describe the position of planets relative to the sun and is equal to the approximate mean distance between Earth and the sun.

An **atom** is the smallest part of an element that is representative of that element.

The **atomic mass** (mass number) is equal to the number of neutrons and protons in the atomic nucleus of an element.

The **atomic number** of an element is equal to the number of protons which define the element.

Azimuth is the angle between the most northerly point of the horizon and the point directly below a celestial body.

A **battery** is a combination of two or more electrochemical cells.

Binary fission is a type of asexual reproduction in which a parent cell divides exactly into two identical cells.

Celestial bodies are all astronomical bodies excluding Earth.

The **cell cycle** is the series of events involving growth, replication, and division of a cell.

Cell division is the splitting of a single cell into two similar cells, and involves the division of the nucleus (mitosis) and the cytoplasm.

Cell membrane is a semi-permeable barrier that surrounds the cytoplasm of a cell and allows certain materials to pass into or out of the cell.

Charging by conduction occurs when two charged materials come into physical contact with each other.

Charging by friction occurs when two differently charged materials are rubbed together.

Charging by induction occurs when a charged material is brought close to, but does not touch, a neutral material.

A **chemical change** is a change that results when two or more substances react to form a different substance or substances that have different properties from the original ones.

A **chemical property** is a property of a material that becomes evident during a chemical change.

Chromosomes are structures in the nucleus of a cell that are made up of strands of DNA.

A **compound** is a chemical combination of two or more elements in a specific ratio.

Contraceptive techniques (condoms, oral contraceptive pill, intra-uterine devices, sterilization, morning after pill) are methods of preventing pregnancy.

A **conductor** is a material that allows electric charge to flow through easily.

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

Current electricity is the steady flow of charged particles.

Current is the rate at which charged particles flow past a point and is measured in Amperes (A).

A **dependent variable** is something that can be measured and whose value may change as a result of an experiment.

DNA (deoxyribonucleic acid) is the genetic material found mainly in the nuclei of living things.

Dominant trait is the outward form observed when two opposite-acting alleles are inherited.

A **dry cell** is an electrochemical cell that has its electrolyte in the form of a paste.

The **ecliptic** is the apparent path of the Sun and planets through the stars during the year, as viewed from Earth.

Efficiency is the ratio of useful energy output to the total energy input in a device or system.

Electrical energy is the energy carried by charged particles.

An **electrochemical cell** is a device used for generating voltage from chemical reactions.

An **electron** is the negatively charged particle that orbits the nucleus of an atom.

An **electroscope** is an instrument used to detect the presence and magnitude of static electric charge.

Electrostatic discharge occurs when excess static electric charge is neutralized by a flow of charge to or from the surroundings.

An **element** is a pure substance that is made up of only one type of atom and cannot be broken down into other substances.

An **embryo** is an undeveloped organism in its beginning stages; in humans, this stage lasts for eight weeks after conception.

The **energy efficiency rating** provides an indication of how much electric energy a device consumes in operation.

An **equinox** (vernal, autumnal) is either of two times a year when the Sun crosses the equator and the length of day and night is equal.

A **fair test** is an experiment that has been planned and controlled so that only one variable is changed at a time.

A **fetus** is a developing organism in a post-embryonic stage; after the eighth week following conception in humans.

Genes are segments of DNA, located at one particular place on a chromosome, which determines a specific characteristic of an organism.

Genetic information is heritable information carried in DNA in almost all cells of the organism and passed on from parent to offspring.

Genetics is the study of how heritable characteristics are transmitted through generations of organisms.

Geocentric means earth-centered.

A **group**, or family, is a vertical column of elements in the periodic table, such as the alkali metals, alkaline-earth metals, hydrogen, halogens, noble gases, and transition metals.

Heliocentric means sun-centered.

Hermaphrodite is an organism that has both male and female sex organs, as is commonly exhibited in plants and some animals, such as earthworms; may also occur in organisms that typically only have one set of sex organs.

Heterogeneous means different throughout.

Homogeneous means the same throughout.

An **independent variable** is something that can be changed by an experimenter to cause an effect.

The **inner solar system** includes the terrestrial planets (Mercury, Venus, Earth, and Mars) and the asteroid belt.

Insulators are materials that strongly resist the flow of current, such as wood, rubber, and air.

Isotopes are atoms of the same element with different numbers of neutrons.

Meiosis is the division of chromosomes that results in reproductive cells (sperm and eggs) or spores with one chromosome from each chromosomal pair.

Metalloids are the elements B, Si, Ge, As, Sb, Te, and Po that form a staircase separating the metals from non-metals on the periodic table.

Metals include elements found below the staircase of metalloids in the periodic table of the elements.

Mitosis is the process of cellular division which results in two cells, each with the same number of chromosomes and genetic material as the parent cell.

A **molecule** is an electrically neutral group of atoms held together in a definite arrangement by covalent bonds.

A **multimeter** is used to measure voltage, current, and resistance.

A **neutron** is the sub-atomic particle found in the nucleus of an atom that has no net electric charge and a mass slightly larger than that of a proton.

Non-metals include elements found above the staircase of metalloids in the periodic table of the elements and hydrogen.

The **nucleus** of an atom is the dense region in the center consisting of protons and neutrons.

Nucleus is the structure in a cell that contains the genetic material (chromosomes) and is enclosed by a nuclear membrane.

Ohms' Law states that the current through a conductor is directly proportional to the voltage across the conductor and inversely proportional to the resistance of the conductor ($I = V/R$).

An **operational definition** of a variable explains how to measure the variable.

A **period** is a horizontal row in the periodic table of the elements.

A **physical change** is the change in appearance or state of a substance that does not change its composition.

Physical properties are aspects of a material that can be measured or perceived without changing the identity of the material (smell, colour, melting point, boiling point, density, solubility, ductility, crystal shape, conductivity, hardness, lustre, texture, and malleability).

Power is the rate at which a device converts energy, and is measured in watts (W).

Pregnancy is the state of carrying a fetus or embryo in the female body.

A **primary cell** is a cell in which the electrochemical reaction is not reversible.

A **proton** is the sub-atomic particle found in the nucleus of an atom that has a positive electric charge.

Recessive trait is the characteristic that is masked when two opposite-acting alleles are inherited.

Reproductive technologies (in vitro fertilization, artificial insemination, embryo transfer) are techniques that are used in human and animal reproduction, normally to increase fertility or to facilitate pregnancy.

Resistance is a measure of a material's opposition to the steady flow of charged particles.

Retrograde motion is movement of a planetary body in a direction opposite to the other bodies within its system.

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.

A **secondary cell** is an electrochemical cell that is rechargeable.

Sexual reproduction involves the union of reproductive cells (eggs and sperm), usually from two different parents, to form a zygote which will be genetically unique from both parents.

Static electric charge is a charge on an object creating by rubbing objects or materials together.

A **short circuit** is an accidental low-resistance connection between two points in a circuit, often allowing excess current to flow.

A **solstice** is either of two times in the year (winter, summer) when the sun reaches its highest or lowest in the sky (at noon) for the year.

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.

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.

A **superconductor** is a material that offers no resistance to the flow of electric charge.

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

Voltage is a measure of how much electrical energy each charged particle carries and is measured in Volts (V).

A **voltmeter** is used to measure voltage in electric circuits.

A **wet cell** is an electrochemical cell that has a liquid electrolyte.

WHMIS is an acronym that stands for Workplace Hazardous Materials Information System.

X chromosome is a sex chromosome present in cells of both males and females. Females have two, males have one.

Y chromosome is a sex chromosome that is present only in cells of males, along with a single X chromosome.

Zygote is the cell that results from the union of two reproductive cells (sperm and egg) during sexual reproduction.

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Feedback Form

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

Document Title: **Grade 9 Science Curriculum**

1. Please indicate your role in the learning community

☐ parent ☐ teacher ☐ resource teacher

☐ guidance counsellor ☐ school administrator ☐ school board trustee

☐ teacher librarian ☐ school community council member

☐ other ____

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

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

☐ print

☐ online

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

☐ print

☐ online

3. How does this curriculum address the needs of your learning community or organization? Please explain.

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

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

5. Explain which aspects you found to be:

   Most useful:

   Least useful:

7. Additional comments:

7. Optional:

   Name: ____________________

   School: ____________________

   Phone: ____________________ Fax: ____________________

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

Please return the completed feedback form to:

Executive Director
Curriculum and E-Learning Branch
Ministry of Education
2220 College Avenue
Regina SK S4P 4V9
Fax: 306-787-2223