Updates
Minor revisions were made in 2014 and are described in *2014 Summary of Updates*.

SCIENCE 10
Program of Studies
2005 (Updated 2014)

PROGRAM RATIONALE AND PHILOSOPHY

Students graduating from Alberta schools require the scientific and related technological knowledge and skills that will enable them to understand and interpret their world and become productive members of society. They also need to develop attitudes that will motivate them to use their knowledge and skills in a responsible manner. Science programs provide opportunities for students to develop knowledge, skills and attitudes that they need to explore interests and prepare for further education and careers.

To become scientifically literate, students must develop a thorough knowledge of science and its relationship to technologies and society. They must also develop the broad-based skills needed to identify and analyze problems; explore and test solutions; and seek, interpret and evaluate information. To ensure that the science program is relevant to students as well as societal needs, it must present science in meaningful context—providing opportunities for students to explore the process of science, its applications and implications, and to examine related technological problems and issues. By doing so, students become aware of the role of science in responding to social and cultural change and in meeting needs for a sustainable environment, economy and society.

Program Vision

The secondary science program is guided by the vision that all students have the opportunity to develop scientific literacy. The goal of scientific literacy is to develop the science-related knowledge, skills and attitudes that students need to solve problems and make decisions, and at the same time help them become lifelong learners—maintaining their sense of wonder about the world around them.

Diverse learning experiences within the Science 10 program provide students with opportunities to explore, analyze and appreciate the interrelationships among science, technology, society and the environment, and to develop understandings that will affect their personal lives, their careers and their futures.

Goals

The following goals for Canadian science education are addressed through the Alberta science program. Science education will:

- encourage students at all grade levels to develop a critical sense of wonder and curiosity about scientific and technological endeavours
- enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and the lives of others

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- prepare students to critically address science-related societal, economic, ethical and environmental issues
- provide students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study, prepares them for science-related occupations, and engages them in science-related hobbies appropriate to their interests and abilities
- enable students, of varying aptitudes and interests, to develop a knowledge of the wide spectrum of careers related to science, technology and the environment.

Aboriginal Perspectives

Science 10 incorporates Aboriginal perspectives in order to develop, in all students, an appreciation of the cultural diversity and achievements of First Nations, Métis and Inuit (FNMI) peoples. Science 10 is designed to:

- acknowledge the contributions of Aboriginal peoples to understandings of the natural world
- support relational thinking by integrating learning from various disciplines of science
- develop the concept of our connectivity to the natural world and the importance of caring for the environment
- foster the development of positive attitudes by providing experiences that encourage all students to feel confident about their ability to succeed in science.

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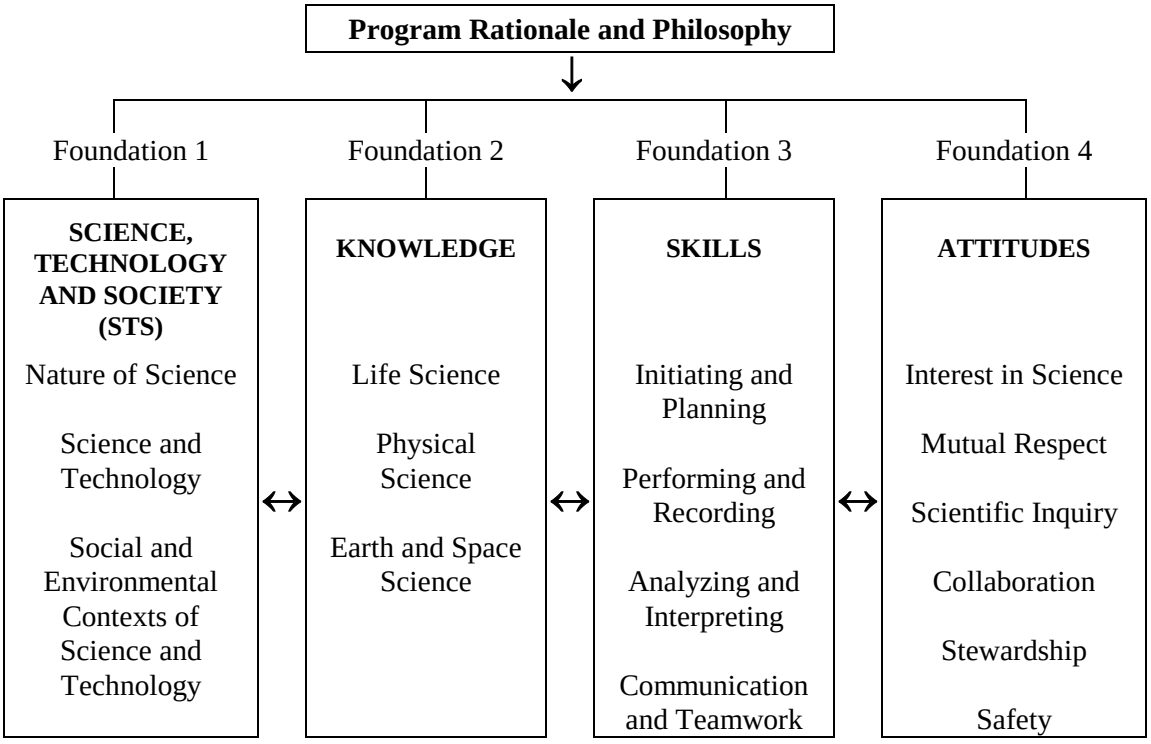
PROGRAM FOUNDATIONS

To support the development of science literacy, school programs must provide a foundation of learning experiences that address critical aspects of science and its application. These critical areas—the foundations of the program—provide general direction for the program and identify major components of its structure.



Foundation 1
Science, Technology and Society (STS)—*Students will* develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.

Foundation 2
Knowledge—*Students will* construct knowledge and understandings of concepts in life science, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge.

Foundation 3
Skills—*Students will* develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively and for making informed decisions.

Foundation 4
Attitudes—*Students will be encouraged to* develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society and the environment.

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Foundation 1: Science, Technology and Society (STS)

Foundation 1 is concerned with understanding the scope and character of science, its connections to technology, and the social context in which it is developed. The following is a brief introduction to the major ideas that underlie this component of the program.

Nature of Science

Science provides an ordered way of learning about the nature of things, based on observation and evidence. Through science, we explore our environment, gather knowledge and develop ideas that help us interpret and explain what we see. Scientific activity provides a conceptual and theoretical base that is used in predicting, interpreting and explaining natural and technological phenomena. Science is driven by a combination of specific knowledge, theory and experimentation. Science-based ideas are continually being tested, modified and improved as new knowledge and explanations supersede existing knowledge and explanations.

Science and Technology

Technology is concerned with solving practical problems that arise from human needs. 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. 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, research is often driven by societal and environmental needs and issues. As technological solutions have emerged from previous research, many of the new technologies have given rise to complex social and environmental issues. Increasingly, these issues are becoming part of the political agenda. The potential of science to inform and empower decision making by individuals, communities and society is a central role of scientific literacy in a democratic society.

Foundation 2: Knowledge

Foundation 2 focuses on the subject matter of science, including the theories, models, concepts and principles that are essential to an understanding of each science area. 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 their uniqueness, diversity, genetic continuity and changing nature. Life science includes such fields of study as ecosystems, biological diversity, the study of organisms, the study of the cell, biochemistry, genetic engineering and biotechnology.

Physical Science

Physical science, which encompasses chemistry and physics, deals with matter, energy and forces. Matter has structure, and there are interactions among its components. Energy links matter to

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gravitational, electromagnetic and nuclear forces in the universe. The conservation laws of mass and energy, and of momentum and charge, are addressed in physical science.

Earth and Space Science

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

Foundation 3: Skills

Foundation 3 is concerned with the skills that students develop in answering questions, solving problems and making decisions. While these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations. Four broad skill areas are outlined in this program of studies.

Initiating and Planning

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

Performing and Recording

These are the skills of carrying out a plan of action that involves gathering evidence by observation and, in most cases, manipulating materials and equipment.

Analyzing and Interpreting

These are the skills of examining information and evidence; processing and presenting data so that it can be interpreted; and interpreting, evaluating and applying the results.

Communication and Teamwork

In science, as in other areas, communication skills are essential at every stage where ideas are being developed, tested, interpreted, debated and agreed upon. Teamwork skills are also important, as the development and application of science ideas is a collaborative process both in society and in the classroom.

Foundation 4: Attitudes

Foundation 4 is concerned with generalized aspects of behaviour—commonly referred to as attitudes. Attitude outcomes are of a different form than outcomes for skills and knowledge; they are exhibited in a different way, and they have deeper roots in the experiences that students bring to school. Attitude development is a lifelong process that involves the home, the school, the community and society at large. Attitudes are best shown not by the events of a particular moment but by the pattern of behaviours over time. Development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and creating a readiness for responsible application of what is learned.

Interest in Science

Students will be encouraged to develop enthusiasm and continuing interest in the study of science.

Mutual Respect

Students will be encouraged to appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds.

Scientific Inquiry

Students will be encouraged to develop attitudes that support active inquiry, problem solving and decision making.

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Collaboration

Students will be encouraged to develop attitudes that support collaborative activity.

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 will be encouraged to demonstrate a concern for safety in science and technology contexts.

PROGRAM ORGANIZATION AND FORMAT

This program of studies is organized into units as outlined below.

Unit	Title	Emphasis
A	Energy and Matter in Chemical Change	Nature of Science
B	Energy Flow in Technological Systems	Science and Technology
C	Cycling of Matter in Living Systems	Nature of Science
D	Energy Flow in Global Systems	Social and Environmental Contexts

Unit Organization

In Science 10, four units of study are outlined. Each unit includes the following components.

Unit Overview

Each unit of study begins with an overview that introduces the contents of the unit and suggests an approach to its development.

Focusing Questions

These questions frame a context for introducing the unit and suggest a focus for investigative activities and application of ideas by students.

Links to Science

This section lists the science concepts and skills, relevant to the unit, that are part of the Alberta Science Grades 7–8–9 Program of Studies.

Key Concepts

Key concepts identify major ideas to be developed in each unit. Some of the key concepts may be addressed in additional units of the same course, as well as at other grade/course levels. The intended scope of treatment of these concepts is indicated by the outcomes.

Outcomes

Two levels of outcomes are provided in this program of studies.

- General Outcomes: These are the major outcomes for each unit. For Foundations 1 and 2 (STS and knowledge), the outcomes are combined and unique to each unit. For Foundation 3 (skills) and Foundation 4 (attitudes), the outcomes are common to all units.
- Specific Outcomes: These are detailed outcomes that flesh out the scope of each unit. They are shown in bulleted form.

Examples

Many of the outcomes are supported by examples. The examples **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed. Illustrative examples are written in *italics* and are separated from the outcomes by being placed in parentheses.

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Links to Mathematics

The purpose of the links to mathematics is to identify mathematical concepts and skills related to science content in the science units of study. The mathematics links identify where similar concepts and skills are developed in the mathematics programs of study to support making connections between mathematics and science learning, to build upon previous student learning, and to identify possible connections to mathematics learning that students may encounter. These links do not represent learning outcomes for science and are not considered prerequisites for Alberta science courses.

Unit Emphases

Each unit of study begins with an overview and a set of focusing questions that identify a context for study. In defining the context, one of the following areas of emphasis is identified for each unit.

- Nature of Science Emphasis: In these units, student attention is focused on the processes by which scientific knowledge is developed and tested, and on the nature of the scientific knowledge itself. The skills emphasized in these units are the skills of scientific inquiry.
- Science and Technology Emphasis: In these units, students seek solutions to practical problems by developing and testing prototypes, products and techniques to meet a given need. The skills emphasized are those of problem solving, in combination with the skills of scientific inquiry.
- Social and Environmental Contexts Emphasis: In these units, student attention is focused on issues and decisions relating to how science and technology are applied. Skill emphasis is on the use of research and inquiry skills to inform the decision-making process; students seek and analyze information and consider a variety of perspectives.

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Developing a Nature of Science Emphasis

The following concepts and skills are developed through this program emphasis.

Concepts

- The goal of science is knowledge about the natural world.
- Scientific knowledge and theories develop through hypotheses, collection of evidence through experimentation and the ability to provide explanations.
- Scientific knowledge results from peer review and replication of the research of others.
- Scientific knowledge is subject to change as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or reinforced.
- The process of scientific investigation includes:
  - identifying the theoretical basis of the investigation
  - clearly defining and delimiting research questions or ideas to be tested
  - designing the investigation
  - evaluating and selecting means to collect and record evidence
  - analyzing the evidence, and providing explanations based upon scientific theories and concepts.
- Scientific paradigms are conceptual inventions that help organize, interpret and explain findings.
  - Concepts, models and theories are often used in interpreting and explaining observations, and in predicting future observations.
  - Conventions of mathematics, nomenclature and notation provide a basis for organizing and communicating scientific theory, relationships and concepts; e.g., chemical symbols.
  - Scientific language is precise, and specific terms may be used in each field of study.
- Scientific inquiry is limited to certain questions.

Skills (focus on scientific inquiry)

Initiating and Planning; e.g.,

- identify questions to investigate
- define and delimit questions to facilitate investigation
- state a prediction and a hypothesis based on available evidence, background information or theory
- evaluate and select appropriate procedures and instruments for collecting evidence and information, including appropriate sampling procedures.

Performing and Recording; e.g.,

- carry out procedures, controlling the major variables, and adapt or extend procedures, if needed
- use appropriate instruments effectively and accurately for collecting data
- select and collect information from various print and electronic sources
- organize and integrate data, using a format that is appropriate to the task or experiment
- select and use apparatus safely, and apply Workplace Hazardous Materials Information System (WHMIS) standards to handle and dispose of materials.

Analyzing and Interpreting; e.g.,

- compile and display findings by hand or computer, using a variety of formats
- interpret patterns and trends in data, and infer and calculate linear and nonlinear relationships among the variables
- predict the value of a variable, by interpolating or extrapolating from graphical data or from a line of best fit
- identify and explain sources of error; and evaluate the relevance, reliability and adequacy of data and data collection methods
- state a conclusion, based on experimental data; and explain how evidence gathered supports or refutes a hypothesis, prediction or theory.

Communication and Teamwork; e.g.,

- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions
- evaluate individual and group processes used in planning and carrying out investigative tasks.

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Developing a Science and Technology Emphasis

The following concepts and skills are developed through this program emphasis.

Concepts

- The goal of technology is to provide solutions to practical problems.
- Technological development may involve creation of prototypes and testing, as well as application of knowledge from related scientific and interdisciplinary fields.
- Technological problems often lend themselves to multiple solutions, involving different designs, materials and processes, and have intended and unintended consequences.
- Scientific knowledge may lead to the development of new technologies, and new technologies may lead to scientific discovery.
- The process for technological development includes:
  - clearly defining and delimiting the problems to be solved, and establishing criteria to assess the technological solution
  - identifying the constraints and trade-offs
  - developing designs and prototypes
  - testing and evaluating designs and prototypes on the basis of established criteria.
- The products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems.
- The appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability.

Skills (focus on problem solving)

Initiating and Planning; e.g.,

- define practical problems
- identify questions to investigate arising from practical problems
- assess and propose alternative solutions to a given practical problem, select one and develop a plan
- evaluate and select appropriate procedures and instruments for collecting data and information and for solving problems.

Performing and Recording; e.g.,

- research and synthesize information relevant to a given problem, using various print and electronic sources
- construct and test a prototype device or system, and troubleshoot problems as they arise
- select and use tools and apparatus safely.

Analyzing and Interpreting; e.g.,

- identify and troubleshoot problems, and refine the operation of prototype devices
- evaluate designs and prototypes on the basis of self-developed criteria; e.g., function, reliability, safety, efficient use of materials, impact on the environment
- identify and evaluate potential applications of findings
- identify new questions and problems that arise from what was learned.

Communication and Teamwork; e.g.,

- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- assess and recommend an approach to solving a given problem, based on findings of investigations
- evaluate individual and group processes used in planning and carrying out problem-solving tasks.

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Developing a Social and Environmental Contexts Emphasis

The following concepts and skills are developed through this program emphasis.

Concepts

- Science and technology are developed to meet societal needs and expand human capability.
- Science and technology are influenced and supported by society and have influenced, and been influenced by, historical development and societal needs.
- Science and technology have both intended and unintended consequences for humans and the environment.
- Society provides direction for scientific and technological development.
  - Canadian society supports scientific research and technological development that helps achieve a sustainable society, economy and environment.
  - Decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations.
  - Society supports scientific and technological development by recognizing accomplishments, publishing and disseminating results, and providing financial support.
- Scientific and technological activity may arise from, and give rise to, such personal and social values as accuracy, honesty, perseverance, tolerance, open-mindedness, critical-mindedness, creativity and curiosity.
- Science and technology provide opportunities for a diversity of careers based on post-secondary studies, for the pursuit of hobbies and interests, and for lifelong learning.

Skills (focus on the use of research and inquiry skills to inform the decision-making process)

Initiating and Planning; e.g.,

- identify science-related issues
- identify questions to investigate arising from science- and technology-related issues
- assess and develop appropriate procedures and instruments for collecting relevant data and information.

Performing and Recording; e.g.,

- research and synthesize information relevant to a given question, problem or issue
- identify data and information, from various print and electronic sources, that are relevant to the issue
- select and integrate information from various print and electronic sources, or from several parts of the same source.

Analyzing and Interpreting; e.g.,

- apply given criteria for evaluating evidence and sources of information
- apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments
- identify new questions and problems that arise from what was learned
- identify and evaluate potential applications of findings from a variety of scientific, technological and environmental perspectives.

Communication and Teamwork; e.g.,

- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise
- assess potential decisions; and recommend the best decision, based on findings
- make clear and logical arguments to defend a given decision on an issue, based on findings
- evaluate individual and group processes used in investigating an issue and in assessing alternative decisions.

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Unit A: Energy and Matter in Chemical Change (Nature of Science Emphasis)

Overview: Chemical changes involve energy and transformations of matter. A knowledge of the underlying structure of matter and the basic chemical species is important in understanding chemical changes. As students explore the properties of molecular and ionic compounds, including acids and bases, they begin to appreciate the need for a classification scheme and a system of nomenclature. Students classify, name compounds and write balanced chemical equations to represent chemical changes. As well, students are introduced to the law of conservation of mass and the mole concept.

Links to Science
The following science concepts are related to the content of Unit A.

Concepts	Science Course and Unit
• particle model of matter	Grade 7 Science, Unit C: Heat and Temperature
• WHMIS symbols, pure substances, mixtures and solutions	Grade 8 Science, Unit A: Mix and Flow of Matter
• reactants, products, conservation of mass, periodic table, elements, compounds, atomic theory, chemical nomenclature	Grade 9 Science, Unit B: Matter and Chemical Change
• acids and bases	Grade 9 Science, Unit C: Environmental Chemistry

Links to Mathematics: Refer to page 16.

Focusing Questions: How has knowledge of the structure of matter led to other scientific advancements? How do elements combine? Can these combinations be classified and the products be predicted and quantified? Why do scientists classify chemical change, follow guidelines for nomenclature and represent chemical change with equations?

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Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade/course levels. The intended level and scope of treatment is defined by the outcomes below.

- how chemical substances meet human needs
- Workplace Hazardous Materials Information System (WHMIS) and safe practices
- International Union of Pure and Applied Chemistry (IUPAC) nomenclature, ionic and molecular compounds, acids and bases
- evidence of chemical change
- role and need for classification of chemical change
- writing and balancing equations
- law of conservation of mass and the mole concept

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

1. Describe the basic particles that make up the underlying structure of matter, and investigate related technologies
   - identify historical examples of how humans worked with chemical substances to meet their basic needs *(e.g., how pre-contact First Nations communities used biotic and abiotic materials to meet their needs)*
   - outline the role of evidence in the development of the atomic model consisting of protons and neutrons (nucleons) and electrons; i.e., Dalton, Thomson, Rutherford, Bohr
   - identify examples of chemistry-based careers in the community *(e.g., chemical engineering, cosmetology, food processing)*

2. Explain, using the periodic table, how elements combine to form compounds, and follow IUPAC guidelines for naming ionic compounds and simple molecular compounds
   - illustrate an awareness of WHMIS guidelines, and demonstrate safe practices in the handling, storage and disposal of chemicals in the laboratory and at home
   - explain the importance of and need for the IUPAC system of naming compounds, in terms of the work that scientists do and the need to communicate clearly and precisely
   - explain, using the periodic table, how and why elements combine to form compounds in specific ratios
   - predict formulas and write names for ionic and molecular compounds and common acids *(e.g., sulfuric, hydrochloric, nitric, ethanoic)*, using a periodic table, a table of ions and IUPAC rules
   - classify ionic and molecular compounds, acids and bases on the basis of their properties; i.e., conductivity, pH, solubility, state
   - predict whether an ionic compound is relatively soluble in water, using a solubility chart
   - relate the molecular structure of simple substances to their properties *(e.g., describe how the properties of water are due to the polar nature of water molecules, and relate this property to the transfer of energy in physical and living systems)*
   - outline the issues related to personal and societal use of potentially toxic or hazardous compounds *(e.g., health hazards due to excessive consumption of alcohol and nicotine; exposure to toxic substances; environmental concerns related to the handling, storage and disposal of heavy metals, strong acids, flammable gases, volatile liquids)*

3. Identify and classify chemical changes, and write word and balanced chemical equations for significant chemical reactions, as applications of Lavoisier's law of conservation of mass

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- provide examples of household, commercial and industrial processes that use chemical reactions to produce useful substances and energy *(e.g., baking powder in baking, combustion of fuels, electrolysis of water into $H_{2(g)}$ and $O_{2(g)}$)*
- identify chemical reactions that are significant in societies *(e.g., reactions that maintain living systems, such as photosynthesis and respiration; reactions that have an impact on the environment, such as combustion reactions and decomposition of waste materials)*
- describe the evidence for chemical changes; i.e., energy change, formation of a gas or precipitate, colour or odour change, change in temperature
- differentiate between endothermic and exothermic chemical reactions *(e.g., combustion of gasoline and other natural and synthetic fuels, photosynthesis)*
- classify and identify categories of chemical reactions; i.e., formation (synthesis), decomposition, hydrocarbon combustion, single replacement, double replacement
- translate word equations to balanced chemical equations and vice versa for chemical reactions that occur in living and nonliving systems
- predict the products of formation (synthesis) and decomposition, single and double replacement, and hydrocarbon combustion chemical reactions, when given the reactants
- define the mole as the amount of an element containing 6.02×10^{23} atoms (Avogadro's number) and apply the concept to calculate quantities of substances made of other chemical species (*e.g., determine the quantity of water that contains 6.02×10^{23} molecules of H_2O*)
- interpret balanced chemical equations in terms of moles of chemical species, and relate the mole concept to the law of conservation of mass

Skill Outcomes (focus on scientific inquiry)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- define and delimit problems to facilitate investigation
- design an experiment, identifying and controlling major variables *(e.g., design an experiment to differentiate between categories of matter, such as acids, bases and neutral solutions, and identify manipulated and responding variables)*
- state a prediction and a hypothesis based on available evidence and background information *(e.g., state a hypothesis about what happens to baking soda during baking)*
- evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring and decision making *(e.g., list appropriate technology for classifying compounds, such as litmus paper or conductivity tester)*

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Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures *(e.g., when performing an experiment to illustrate conservation of mass, demonstrate an understanding of closed and open systems and control for loss or gain of matter during a chemical change)*
- use library and electronic research tools to collect information on a given topic *(e.g., information on compounds we use and their toxicity, using standard references, such as the Merck Index, as well as Internet searches)*
- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., collect information on research into subatomic matter, research how pre-contact First Nations communities used available materials such as brain tissue for tanning hides)*
- demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for the handling and disposal of laboratory materials *(e.g., recognize and use Material Safety Data Sheets [MSDS] information)*
- select and use apparatus, technology and materials safely *(e.g., use equipment, such as Bunsen burners, electronic balances, laboratory glassware, electronic probes and calculators correctly and safely)*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- describe and apply classification systems and nomenclature used in the sciences *(e.g., investigate periodicity in the periodic table, classify matter, and name elements and compounds based on IUPAC guidelines)*
- apply and assess alternative theoretical models for interpreting knowledge in a given field *(e.g., compare models for the structure of the atom)*
- compare theoretical and empirical values and account for discrepancies *(e.g., measure the mass of a chemical reaction system before and after a change, and account for any discrepancies)*
- identify and explain sources of error and uncertainty in measurement, and express results in a form that acknowledges the degree of uncertainty *(e.g., measure and record the mass of a material, use significant digits appropriately)*
- identify new questions or problems that arise from what was learned *(e.g., how did ancient peoples discover how to separate metals from their ores?; evaluate the traditional Aboriginal method for determining alkaline properties of substances)*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others *(e.g., use appropriate communication technology to elicit feedback from others)*

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- represent large and small numbers using appropriate scientific notation
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., use appropriate* Système international *(SI) units, and IUPAC nomenclature)*

Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., apply concepts learned in the classroom to the everyday use of chemicals; show interest in a broad scope of chemistry-related careers)*

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., recognize the contributions of Canadians to contemporary knowledge of the structure of matter; show awareness of and respect for traditional Aboriginal knowledge about the use of biotic and abiotic materials)*

Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., evaluate inferences and conclusions based on particles of matter that cannot be observed directly)*

Collaboration

Students will be encouraged to:

Work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., contribute to group work willingly, assume a variety of roles and accept responsibility for any problems that arise)*

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment *(e.g., recognize that environmental consequences may arise from the development, use and disposal of chemical materials)*

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities *(e.g., acknowledge the need for regulations to govern the storage, handling and disposal of potentially hazardous materials in the school laboratory and at home or in the workplace)*

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Links to Mathematics
The following mathematics outcomes are related to the content of Unit A but are not considered prerequisites.

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10C, Measurement, Specific Outcome 2; Mathematics 10-3, Measurement, Specific Outcome 1; Mathematics 20-3, Algebra, Specific Outcome 3; Mathematics 30-3, Measurement, Specific Outcome 1
Ratio and Proportions	Grade 8 Mathematics, Number, Specific Outcomes 3, 4 and 5
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1
Powers	Mathematics10C, Algebra and Number, Specific Outcome 3

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Unit B: Energy Flow in Technological Systems (Science and Technology Emphasis)

Overview: The first and second laws (conservation and conversion) of thermodynamics have been useful in the development of modern and efficient energy conversion devices. Students investigating mechanical energy conversions and transfers in systems will recognize that while energy is conserved, useful energy diminishes with each conversion. Students learn that energy can be observed only when it is being transferred, and that mechanical energy can be quantified. Energy conservation and conversion concepts are applied by students to explain energy conversions in natural and technological systems, and to investigate the design and function of energy conversion technologies.

Links to Science
The following science concepts are related to the content of Unit B.

Concepts	Science Course and Unit
• heat energy needs and technologies, thermal energy, heat transfer, energy conservation	Grade 7 Science, Unit C: Heat and Temperature
• forces on and within structures, direction of forces	Grade 7 Science, Unit D: Structures and Forces
• transmission of force and motion, simple machines, measurement of work in joules	Grade 8 Science, Unit D: Mechanical Systems
• forms of energy, energy transformation, renewable and nonrenewable energy	Grade 9 Science, Unit D: Electrical Principles and Technologies

Links to Mathematics: Refer to page 22.

Focusing Questions: Which came first, science or technology, and is it possible for technological development to take place without help from pure science? How did efforts to improve the efficiency of heat engines result in the formulation of the first and second laws of thermodynamics? How can the analysis of moving objects help in the understanding of changes in kinetic energy, force and work? Why are efficiency and sustainability important considerations in designing energy conversion technologies?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade/course levels. The intended level and scope of treatment is defined by the outcomes below.

- forms and interconversions of energy
- technological innovations of engines that led to the development of the concept of energy
- one-dimensional motion
- mechanical energy conversions and work
- design and function of technological systems and devices involving potential and kinetic energy and thermal energy conversions
- efficient use of energy, and the environmental impact of inefficient use of energy

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

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1. Analyze and illustrate how technologies based on thermodynamic principles were developed before the laws of thermodynamics were formulated
   - illustrate, by use of examples from natural and technological systems, that energy exists in a variety of forms *(e.g., mechanical, chemical, thermal, nuclear, solar)*
   - describe, qualitatively, current and past technologies used to transform energy from one form to another, and that energy transfer technologies produce measurable changes in motion, shape or temperature *(e.g., hydroelectric and coal-burning generators, solar heating panels, windmills, fuel cells; describe examples of Aboriginal applications of thermodynamics in tool making, design of structures and heating)*
   - identify the processes of trial and error that led to the invention of the engine, and relate the principles of thermodynamics to the development of more efficient engine designs (*e.g., the work of James Watt; improved valve designs in car engines*)
   - analyze and illustrate how the concept of energy developed from observation of heat and mechanical devices *(e.g., the investigations of Rumford and Joule; the development of pre-contact First Nations and Inuit technologies based on an understanding of thermal energy and transfer)*

2. Explain and apply concepts used in theoretical and practical measures of energy in mechanical systems
   - describe evidence for the presence of energy; i.e., observable physical and chemical changes, and changes in motion, shape or temperature
   - define kinetic energy as energy due to motion, and define potential energy as energy due to relative position or condition
   - describe chemical energy as a form of potential energy *(e.g., energy stored in glucose, adenosine triphosphate [ATP], gasoline)*
   - define, compare and contrast scalar and vector quantities
   - describe displacement and velocity quantitatively
   - define acceleration, quantitatively, as a change in velocity during a time interval: $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$
   - explain that, in the absence of resistive forces, motion at constant speed requires no energy input
   - recall, from previous studies, the operational definition for force as a push or a pull, and for work as energy expended when the speed of an object is increased, or when an object is moved against the influence of an opposing force
   - define gravitational potential energy as the work against gravity
   - relate gravitational potential energy to work done using $E_p = mgh$ and $W = Fd$ and show that a change in energy is equal to work done on a system: $\Delta E = W$
   - quantify kinetic energy using $E_k = 1/2\ mv^2$ and relate this concept to energy conservation in transformations *(e.g., for an object falling a distance "h" from rest: $mgh = Fd = 1/2\ mv^2$)*
   - derive the SI unit of energy and work, the joule, from fundamental units
   - investigate and analyze one-dimensional scalar motion and work done on an object or system, using algebraic and graphical techniques *(e.g., the relationships among distance, time and velocity; determining the area under the line in a force–distance graph)*

3. Apply the principles of energy conservation and thermodynamics to investigate, describe and predict efficiency of energy transformation in technological systems
   - describe, qualitatively and in terms of thermodynamic laws, the energy transformations occurring in devices and systems (*e.g., automobile, bicycle coming to a stop, thermal power plant, food chain, refrigerator, heat pump, permafrost storage pits for food*)

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- describe how the first and second laws of thermodynamics have changed our understanding of energy conversions (*e.g., why heat engines are not 100% efficient*)
- define, operationally, "useful" energy from a technological perspective, and analyze the stages of "useful" energy transformations in technological systems (*e.g., hydroelectric dam*)
- recognize that there are limits to the amount of "useful" energy that can be derived from the conversion of potential energy to other forms in a technological device (*e.g., when the potential energy of gasoline is converted to kinetic energy in an automobile engine, some is also converted to heat; when electrical energy is converted to light energy in a light bulb, some is also converted to heat*)
- explain, quantitatively, efficiency as a measure of the "useful" work compared to the total energy put into an energy conversion process or device
- apply concepts related to efficiency of thermal energy conversion to analyze the design of a thermal device (*e.g., heat pump, high efficiency furnace, automobile engine*)
- compare the energy content of fuels used in thermal power plants in Alberta, in terms of costs, benefits, efficiency and sustainability
- explain the need for efficient energy conversions to protect our environment and to make judicious use of natural resources (*e.g., advancement in energy efficiency; Aboriginal perspectives on taking care of natural resources*)

Skill Outcomes (focus on problem solving)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- design an experiment, identifying and controlling major variables *(e.g., design an experiment involving a combustion reaction to demonstrate the conversion of chemical potential energy to thermal energy)*
- formulate operational definitions of major variables *(e.g., predict or hypothesize the conversion of energy from potential form to kinetic form, in an experiment using a pendulum or free fall)*

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures *(e.g., perform an experiment to demonstrate the equivalency of work done on an object and the resulting kinetic energy; design a device that converts mechanical energy into thermal energy)*
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., use a computer-based laboratory to compile and organize data from an experiment to demonstrate the equivalency of work done on an object and the resulting kinetic energy)*
- use library and electronic research tools to collect information on a given topic *(e.g., compile information on the energy content of fuels used in Alberta power plants; trace the flow of energy from the Sun to the lighting system in the school, identifying what changes are taking place at each stage of the process)*

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- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., create electronic documents, containing multiple links, on using alternative energy sources, such as wind or solar, to generate electricity in Alberta; relate the importance of the development of effective and efficient engines to the time of the Industrial Revolution and to present-day first-world economics)*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display evidence and information, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., plot distance–time, velocity–time and force–distance graphs; manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets)*
- identify limitations of data or measurement *(e.g., recognize that the measure of the local value of gravity varies globally; use significant digits appropriately)*
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables *(e.g., interpret a graph of changing kinetic and potential energy from a pendulum during one-half of a period of oscillation; calculate the slope of the line in a distance–time graph; analyze a simple velocity–time graph to describe acceleration; calculate the area under the line in a force–distance graph)*
- compare theoretical and empirical values and account for discrepancies *(e.g., determine the efficiency of thermal energy conversion systems)*
- state a conclusion based on experimental data, and explain how evidence gathered supports or refutes the initial hypothesis *(e.g., explain the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system)*
- construct and test a prototype of a device or system, and troubleshoot problems as they arise *(e.g., design and build an energy conversion device)*
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each and select one as the basis for a plan *(e.g., assess whether coal or natural gas should be used to fuel thermal power plants in Alberta)*
- evaluate a personally designed and constructed device on the basis of self-developed criteria *(e.g., evaluate an energy conversion device based on a modern or traditional design)*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- represent large and small numbers using appropriate scientific notation
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., use appropriate Système international (SI) units , fundamental and derived units; use advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics)* work cooperatively with team members to develop and carry out a plan and to troubleshoot problems as they arise *(e.g., develop a plan to build an energy conversion device, seek feedback, test and review the plan, make revisions, and implement the plan)*

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Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and pursue personal interests and career possibilities within science-related fields *(e.g., apply concepts learned in the classroom to everyday phenomena related to energy; show interest in a broad scope of science-related fields in which energy plays a significant role)*

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., appreciate Aboriginal technologies of the past and present that use locally-available materials and apply scientific principles; recognize that science and technology develop in response to global concerns, as well as to local needs)*

Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., assess problem using a variety of criteria; respect alternative solutions; honestly evaluate limitations of their designs; be persistent in finding the best possible answer or solution to a question or problem)*

Collaboration

Students will be encouraged to:

Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., select a variety of strategies, such as group brainstorming, active listening, paraphrasing and questioning, to find the best possible solution to a problem; work as a team member when assigning and performing tasks; accept responsibility for problems that arise)*

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment *(e.g., recognize that their choices and actions, and the choices and actions that technologists make, can have an impact on others and on the environment)*

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities *(e.g., demonstrate concern for self and others in planning and carrying out experimental activities and the design of devices; select safe methods for collecting evidence and solving problems)*

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Links to Mathematics
The following mathematics outcomes are related to the content of Unit B but are not considered prerequisites.

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10C, Measurement, Specific Outcomes 1 and 2; Mathematics 10-3, Measurement, Specific Outcome 1; Mathematics 20-3, Algebra, Specific Outcome 3; Mathematics 30-3, Measurement, Specific Outcome 1
Rate and Proportions	Grade 8 Mathematics, Number, Specific Outcomes 3 and 4; Mathematics 20-2, Measurement, Specific Outcome 1
Graph Analysis	Grade 9 Mathematics, Patterns and Relations (Patterns), Specific Outcome 2; Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1
Solving Equations	Grade 9 Mathematics, Patterns and Relations (Variables and Equations), Specific Outcome 3; Grade 9 Mathematics, Number, Specific Outcome 6;
Slope	Mathematics10C, Relations and Functions, Specific Outcome 3 and 5; Mathematics 20-3, Algebra, Specific Outcome 2
Powers	Mathematics10C, Algebra and Number, Specific Outcome 3
Scale Diagrams	Mathematics 20-2, Measurement, Specific Outcome 2; Mathematics 20-3, Geometry, Specific Outcome 2

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Unit C: Cycling of Matter in Living Systems (Nature of Science Emphasis)

Overview: The fundamental unit of life, the cell, is an example of an efficient open system comprised of a cell membrane and organelles that carry out the basic functions of all living organisms. Students will learn that technological advancements in microscopy have enhanced the study of cells and cellular processes. The understanding of life processes at the cellular level can also be applied to multicellular organisms.

Links to Science
The following science concepts are related to the content of Unit C.

Concepts	Science Course and Unit
• life processes, and structure of plants	Grade 7 Science, Unit B: Plants for Food and Fibre
• organisms, cells, system organs, tissues	Grade 8 Science, Unit B: Cells and Systems

Links to Mathematics: Refer to page 28.

Focusing Questions: How did the cell theory replace the concept of "spontaneous generation" and revolutionize the study of life sciences? How do single-celled organisms carry out life functions? How do plants use specialized cells and processes to accomplish the same functions as a single cell, but on a larger scale? How does imaging technology further our understanding of the structure and function of cells?

Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade/course levels. The intended level and scope of treatment is defined by the outcomes below.

- microscopy and the emergence of cell theory
- cellular structures and functions, and technological applications
- active and passive transport of matter
- relationship between cell size and shape, and surface area to volume ratio
- use of explanatory and visual models in science
- cell specialization in multicellular organisms; i.e., plants
- mechanisms of transport, gas exchange, and environmental response in multicellular organisms; i.e., plants

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Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

1. Explain the relationship between developments in imaging technology and the current understanding of the cell
   - trace the development of the cell theory: all living things are made up of one or more cells and the materials produced by these, cells are functional units of life, and all cells come from pre-existing cells *(e.g., from Aristotle to Hooke, Pasteur, Brown, and Schwann and Schleiden; recognize that there are sub-cellular particles, such as viruses and prions, which have some characteristics of living cells)*
   - describe how advancements in knowledge of cell structure and function have been enhanced and are increasing as a direct result of developments in microscope technology and staining techniques *(e.g., electron microscope, confocal laser scanning microscope [CLSM])*
   - identify areas of cell research at the molecular level *(e.g., DNA and gene mapping, transport across cell membranes)*

2. Describe the function of cell organelles and structures in a cell, in terms of life processes, and use models to explain these processes and their applications
   - compare passive transport of matter by diffusion and osmosis with active transport in terms of the particle model of matter, concentration gradients, equilibrium and protein carrier molecules *(e.g., particle model of matter and fluid-mosaic model)*
   - use models to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes
   - describe the cell as a functioning open system that acquires nutrients, excretes waste, and exchanges matter and energy
   - identify the structure and describe, in general terms, the function of the cell membrane, nucleus, lysosome, vacuole, mitochondrion, endoplasmic reticulum, Golgi apparatus, ribosomes, chloroplast and cell wall, where present, of plant and animal cells
   - compare the structure, chemical composition and function of plant and animal cells, and describe the complementary nature of the structure and function of plant and animal cells
   - describe the role of the cell membrane in maintaining equilibrium while exchanging matter
   - describe how knowledge about semi-permeable membranes, diffusion and osmosis is applied in various contexts *(e.g., attachment of HIV drugs to cells and liposomes, diffusion of protein hormones into cells, staining of cells, desalination of sea water, peritoneal or mechanical dialysis, separation of bacteria from viruses, purification of water, cheese making, use of honey as an antibacterial agent and berries as a preservative agent by traditional First Nations communities)*
   - describe cell size and shape as they relate to surface area to volume ratio, and explain how that ratio limits cell size *(e.g., compare nerve cells and blood cells in animals, or plant root hair cells and chloroplast-containing cells on the surface of leaves)*

3. Analyze plants as an example of a multicellular organism with specialized structures at the cellular, tissue and system levels
   - explain why, when a single-celled organism or colony of single-celled organisms reaches a certain size, it requires a multicellular level of organization, and relate this to the specialization of cells, tissues and systems in plants
   - describe how the cells of the leaf system have a variety of specialized structures and functions; i.e., epidermis including guard cells, palisade tissue cells, spongy tissue cells, and phloem and xylem vascular tissue cells to support the process of photosynthesis

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- explain and investigate the transport system in plants; i.e., xylem and phloem tissues and the processes of transpiration, including the cohesion and adhesion properties of water, turgor pressure and osmosis; diffusion, active transport and root pressure in root hairs
- explain and investigate the gas exchange system in plants; i.e., lenticels, guard cells, stomata and the process of diffusion
- explain and investigate phototropism and gravitropism as examples of control systems in plants
- trace the development of theories of phototropism and gravitropism *(e.g., from Darwin and Boysen-Jensen to Went)*

Skill Outcomes (focus on scientific inquiry)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- define and delimit problems to facilitate investigation *(e.g., how do plants adjust to accommodate different environmental conditions such as varying levels of light and fertilizer)*
- design an experiment, identifying and controlling major variables *(e.g., design an investigation to determine the effect of $CO_{2(g)}$ concentration on the number of chloroplasts found in an aquatic plant cell)*
- state a prediction and a hypothesis based on available evidence and background information *(e.g., hypothesize how biochemical interconversions of starch and glucose might regulate the turgor pressure of cells; hypothesize the direction of root and plant growth of a bean plant growing on a rotating turntable, and predict the effects of varying RPMs on the angle of growth)*
- identify the theoretical basis of an investigation, and develop a prediction and a hypothesis that are consistent with the theoretical basis *(e.g., use the particle theory to hypothesize how the rate of diffusion is affected by varying particle size, and then predict the rates of diffusion of a sucrose solution and a starch solution when placed into dialysis tubing in a beaker of water)*
- formulate operational definitions of major variables *(e.g., define concentration gradient, equilibrium)*

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures *(e.g., perform an experiment to determine the effect of tonicity on plasmolysis and deplasmolysis in plant cells, such as staminal hairs or aquatic leaf cells, identify variables that do affect plasmolysis, such as the amount of light and heat, and control these variables)*
- use instruments effectively and accurately for collecting data *(e.g., use a microscope to observe movement of water in plants; prepare wet mounts of tissue from flowering plants, and observe cellular structures specific to plant and animal cells; stain cells to make them visible)*
- estimate quantities *(e.g., compare sizes of various types of cells under the microscope; calculate magnification, field of view and scale)*

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- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., organize data obtained from measuring daily temperature and bloom dates of plant species, such as aspen, poplar, common purple lilac and crocus to determine a relationship between the two variables)*
- use library and electronic research tools to collect information on a given topic *(e.g., upload and download text, image, audio and video files on emerging technologies for studying cells)*
- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., create electronic documents containing multiple links, or summarize articles based on the scientific principles and/or technological developments)*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display, by hand or computer, evidence and information in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., collect data on the number of stomata per unit area on various plant leaves that grow in areas of differing humidity, and compile this data in a spreadsheet and graph it to determine whether there is a relationship between the variables)*
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables *(e.g., compare the surface area to volume ratio of various cells, and relate the findings to the function of each cell; trace ingredients in modern medicines to their traditional counterparts)*
- state a conclusion based on experimental data, and explain how evidence gathered supports or refutes the initial hypothesis *(e.g., observe and record macroscopic and microscopic changes in a growing plant for evidence of differentiation)*
- explain how data support or refute a hypothesis or prediction
- construct and test a prototype of a device or system, and troubleshoot problems as they arise *(e.g., create a model of a cell to illustrate a certain function, for example, use a balloon and tape to represent a guard cell)*
- identify new questions or problems that arise from what was learned *(e.g., determine the purpose of cellular structures from observations of fresh and prepared materials, using dissecting and compound microscopes, or micrographs)*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions; and receive, interpret, understand, support and respond to the ideas of others *(e.g., describe cytoplasmic streaming in a single-celled organism, and communicate an inference about similar movement in the cells of a multicellular organism)*
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., draw analogies between division of labour in cells and in communities; record and explain the movement of water in plants)*

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Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., apply concepts learned in the classroom to everyday phenomena related to cells and multicellular organisms; investigate careers in fields, such as botany, forestry, horticulture, cytology, genetics and health care)*

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., value the roles and contributions of men and women from many cultures in using science and technology to further our understanding of the cell and of living systems, recognize and appreciate the contributions of the traditional knowledge of Aboriginal peoples to science and technology)*

Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., recognize that traditional Aboriginal cultures employed the principles of scientific inquiry through observation and experimentation to solve a variety of unique challenges)*

Collaboration

Students will be encouraged to:

Work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *(e.g., assume responsibility for their share of the work in preparing for investigations, gathering and recording data; consider alternative approaches suggested by group members)*

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment *(e.g., show care and respect for all forms of life; evaluate the impact on the environment of personal choices, as well as the choices scientists make when carrying out an investigation)*

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities *(e.g., demonstrate concern for self and others in planning and carrying out experimental activities; select safe methods of collecting evidence and solving problems)*

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Links to Mathematics
The following mathematics outcomes are related to the content of Unit C but are not considered prerequisites.

Concept	Mathematics Course, Strand and Specific Outcome
Data Analysis and Collection	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10C, Measurement, Specific Outcomes 1, 2 and 3; Mathematics 10-3, Measurement, Specific Outcome 1; Mathematics 20-3, Algebra, Specific Outcome 3; Mathematics 30-3, Measurement, Specific Outcome 1
Rate, Ratio and Proportion	Grade 8 Mathematics, Number, Specific Outcomes 4 and 5
Graph Analysis	Grade 9 Mathematics, Patterns and Relations (Patterns), Specific Outcome 2; Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1
Solving Equations	Mathematics 20-3, Algebra, Specific Outcome 1
Scale Diagrams	Grade 9 Mathematics, Shape and Space (Transformations), Specific Outcome 4; Mathematics 20-2, Measurement, Specific Outcomes 2 and 3; Mathematics 20-3, Geometry , Specific Outcome 2

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Unit D: Energy Flow in Global Systems (Social and Environmental Contexts Emphasis)

Overview: Solar energy sustains life and drives the global climate systems on Earth. Without solar energy there would be no heat or precipitation and, therefore, no life on Earth. Students will gain an understanding that the absorption and transfer of thermal energy at and near Earth's surface results in a variety of climate zones with characteristic weather patterns and biomes. Climatic factors largely determine the flora and fauna found in each of the world's major biomes. The *United Nations Intergovernmental Panel on Climate Change* has stated that the balance of evidence suggests a human influence on global climate. Scientists from various fields are studying this relationship to determine the potential impact on biomes.

Links to Science
The following science concepts are related to the content of Unit D.

Concepts	Science Course and Unit
• environmental monitoring, environmental impacts, energy flow, environmental management	Grade 7 Science, Unit A: Interactions and Ecosystems
• thermal energy, change of state, heat transfer	Grade 7 Science, Unit C: Heat and Temperature
• climate, glaciers and icecaps	Grade 8 Science, Unit E: Freshwater and Saltwater Systems
• biological diversity, habitat diversity	Grade 9 Science, Unit A: Biological Diversity

Links to Mathematics: Refer to page 35.

Focusing Questions: Are there relationships between solar energy, global energy transfer processes, climate and biomes? What evidence suggests our climate may be changing more rapidly than living species can adapt? Is human activity causing climate change? How can we reduce our impact on the biosphere and on global climate, while still meeting human needs?

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Key Concepts

The following concepts are developed in this unit and may also be addressed in other units at other grade/course levels. The intended level and scope of treatment is defined by the outcomes below.

- social and environmental contexts for investigating climate change
- solar radiation budget
- climate zones, transfer of thermal energy by the hydrosphere and the atmosphere
- hydrologic cycle and phase change
- relationship between biomes, solar energy and climate
- human activity and climate change

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

1. Describe how the relationships among input solar energy, output terrestrial energy and energy flow within the biosphere affect the lives of humans and other species
   - explain how climate affects the lives of people and other species, and explain the need to investigate climate change *(e.g., describe the responses of human and other species to extreme climatic conditions; describe housing designs, animal habitats, clothing and fur in conditions of extreme heat, cold, dryness or humidity, wind)*
   - identify the Sun as the source of all energy on Earth
   - analyze, in general terms, the net radiation budget, using per cent; i.e., solar energy input, terrestrial energy output, net radiant energy
   - describe the major characteristics of the atmosphere, the hydrosphere and the lithosphere, and explain their relationship to Earth's biosphere
   - describe and explain the greenhouse effect, and the role of various gases—including methane, carbon dioxide and water vapour—in determining the scope of the greenhouse effect

2. Analyze the relationships among net solar energy, global energy transfer processes—primarily radiation, convection and hydrologic cycle—and climate.
   - describe, in general terms, how thermal energy is transferred through the atmosphere (i.e., global wind patterns, jet stream, Coriolis effect, weather systems) and through the hydrosphere (i.e., ocean currents, large bodies of water) from latitudes of net radiation surplus to latitudes of net radiation deficit, resulting in a variety of climatic zones *(e.g., analyze static and animated satellite images)*
   - investigate and describe, in general terms, the relationships among solar energy reaching Earth's surface and time of year, angle of inclination, length of daylight, cloud cover, albedo effect and aerosol or particulate distribution
   - explain how thermal energy transfer through the atmosphere and hydrosphere affects climate
   - investigate and interpret how variations in thermal properties of materials can lead to uneven heating and cooling
   - investigate and explain how evaporation, condensation, freezing and melting transfer thermal energy; i.e., use simple calculations of heat of fusion $H_{fus} = \frac{Q}{n}$ and vaporization $H_{vap} = \frac{Q}{n}$, and $Q = mc\Delta t$ to convey amounts of thermal energy involved, and link these processes to the hydrologic cycle

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3. Relate climate to the characteristics of the world's major biomes, and compare biomes in different regions of the world
   - describe a biome as an open system in terms of input and output of energy and matter and exchanges at its boundaries (*e.g., compare and contrast cells and biomes as open systems*)
   - relate the characteristics of two major biomes (i.e., grassland, desert, tundra, taiga, deciduous and rain forest) to net radiant energy, climatic factors (temperature, moisture, sunlight and wind) and topography (mountain ranges, large bodies of water)
   - analyze the climatographs of two major biomes (i.e., grasslands, desert, tundra, taiga, deciduous and rain forest) and explain why biomes with similar characteristics can exist in different geographical locations, latitudes and altitudes
   - identify the potential effects of climate change on environmentally sensitive biomes *(e.g., impact of a reduction in the Arctic ice pack on local species and on Aboriginal societies that rely on traditional lifestyles)*

4. Investigate and interpret the role of environmental factors on global energy transfer and climate change
   - investigate and identify human actions affecting biomes that have a potential to change climate *(e.g., emission of greenhouse gases, draining of wetlands, forest fires, deforestation)* and critically examine the evidence that these factors play a role in climate change *(e.g., global warming, rising sea level(s))*
   - identify evidence to investigate past changes in Earth's climate *(e.g., ice core samples, tree ring analysis)*
   - describe and evaluate the role of science in furthering the understanding of climate and climate change through international programs *(e.g., World Meteorological Organization, World Weather Watch, Global Atmosphere Watch, Surface Heat Budget of the Arctic Ocean (SHEBA) project, The Intergovernmental Panel on Climate Change (IPCC); the study of paleoclimates and models of future climate scenarios)*
   - describe the role of technology in measuring, modelling and interpreting climate and climate change *(e.g., computer models, devices to take measurements of greenhouse gases, satellite imaging technology)*
   - describe the limitations of scientific knowledge and technology in making predictions related to climate and weather *(e.g., predicting the direct and indirect impacts on Canada's agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns)*
   - assess, from a variety of perspectives, the risks and benefits of human activity, and its impact on the biosphere and the climate *(e.g., compare the Gaia hypothesis with traditional Aboriginal perspectives on the natural world; identify and analyze various perspectives on reducing the impact of human activity on the global climate)*

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Skill Outcomes (focus on the use of research and inquiry skills to inform the decision-making process)

Initiating and Planning

Students will:

Ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from practical problems and issues *(e.g., develop questions related to climate change, such as "How will global warming affect Canada's northern biomes?"; "How will a species be affected by an increase or decrease in average temperature?"*
- design an experiment, and identify specific variables *(e.g., investigate the heating effect of solar energy, using variables, such as temperature, efficiency and materials used)*
- formulate operational definitions of major variables *(e.g., define heat of fusion or vaporization as the quantity of energy to change the state of one mole of matter at its melting or boiling point in the absence of temperature change)*

Performing and Recording

Students will:

Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information

- carry out procedures, controlling the major variables and adapting or extending procedures where required *(e.g., perform an experiment to determine the ability of various materials to absorb or reflect solar energy)*
- use instruments, effectively and accurately, to collect data *(e.g., use a barometer, rain gauge, thermometer, anemometer)*
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data *(e.g., organize data to prepare climatographs for comparing biomes)*
- use library and electronic research tools to collect information on a given topic *(e.g., research sources of greenhouse gases; research protocols to control human sources of greenhouse gases)*
- select and integrate information from various print and electronic sources or from several parts of the same source *(e.g., collect weather and climate data, both historic and current, from the Internet)*

Analyzing and Interpreting

Students will:

Analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compile and display, by hand or computer, evidence and information in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots *(e.g., construct climate graphs to compare any two of the following biomes: grassland, desert, tundra, taiga, deciduous forest, rain forest)*
- identify and apply criteria for evaluating evidence and sources of information, including identifying bias *(e.g., investigate the issue of global climate change)*
- interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables *(e.g., analyze a graph of mean monthly temperatures for cities that are at similar latitudes but have different climates)*

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- identify limitations of data, evidence or measurement *(e.g., list the limitations of data and evidence of past climate changes, evaluate the validity of interpolations and extrapolations, use significant digits appropriately)*
- state a conclusion based on experimental data, and explain how evidence gathered supports or refutes the initial hypothesis *(e.g., summarize an analysis of the relationship between human activity and changing biomes)*
- explain how data support or refute a hypothesis or a prediction *(e.g., provide evidence for or against the hypothesis that human activity is responsible for climate change)*
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan *(e.g., design a home for a specific climate; analyze traditional Aboriginal home designs for their suitability in particular climates)*

Communication and Teamwork

Students will:

Work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- represent large and small numbers using appropriate scientific notation
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results *(e.g., use appropriate Système international (SI) units, fundamental and derived units, significant digits)*
- synthesize information from multiple sources or from complex and lengthy texts, and make inferences based on this information *(e.g., use integrated software effectively and efficiently to produce work that incorporates data, graphics and text)*
- identify multiple perspectives that influence a science-related decision or issue *(e.g., consult a wide variety of electronic sources that reflect varied viewpoints and economic, social, scientific and other perspectives on global warming and climate change)*
- develop, present and defend a position or course of action, based on findings *(e.g., a strategy to reduce greenhouse gas emissions caused by the transportation of people and goods)*

Attitude Outcomes

Interest in Science

Students will be encouraged to:

Show interest in science-related questions and issues, and confidently pursue personal interests and career possibilities within science-related fields *(e.g., expand their inquiries beyond the classroom and into their everyday lives; show interest in careers related to climate and the environment)*

Mutual Respect

Students will be encouraged to:

Appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds *(e.g., appreciate Aboriginal clothing and home designs of the past and present that use locally-available materials to adapt to climate; recognize that science and technology develop in response to global concerns, as well as to local needs; consider more than one factor or perspective when making decisions on Science, Technology and Society [STS] issues)*

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Scientific Inquiry

Students will be encouraged to:

Seek and apply evidence when evaluating alternative approaches to investigations, problems and issues *(e.g., view a situation from different perspectives, propose options and compare them when making decisions or taking action; evaluate inferences and conclusions with a critical mind and without bias, being cognizant of the many factors involved in experimentation)*

Collaboration

Students will be encouraged to:

Work collaboratively in carrying out investigations and in generating and evaluating ideas *(e.g., choose a variety of strategies, such as active listening, paraphrasing and questioning, in order to understand other points of view; consider a variety of perspectives and seek consensus before making decisions)*

Stewardship

Students will be encouraged to:

Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment *(e.g., recognize that human actions today may affect the sustainability of biomes for future generations; identify, without bias, potential conflicts between responding to human wants and needs and protecting the environment)*

Safety

Students will be encouraged to:

Show concern for safety in planning, carrying out and reviewing activities *(e.g., demonstrate concern for self and others in planning and carrying out experimental activities involving the heating of materials; select safe methods for collecting evidence and solving problems)*

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Links to Mathematics
The following mathematics outcomes are related to the content of Unit D but are not considered prerequisites.

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcomes 1 and 3
Rate, Ratio and Proportion	Grade 8 Mathematics, Number, Specific Outcomes 3, 4 and 5
Graph Analysis	Grade 8 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 1; Grade 9 Mathematics, Patterns and Relations (Patterns), Specific Outcome 2; Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1
Solving Equations	Grade 9 Mathematics, Patterns and Relations (Variables and Equations), Specific Outcome 3

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