SCIENCE 20–30

PROGRAM RATIONALE AND PHILOSOPHY

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

To become scientifically literate, students need to develop a knowledge of science and its relationship to technologies and society. They also need to develop the broad-based skills required to identify and analyze problems; to explore and test solutions; and to seek, interpret and evaluate information. To ensure relevance to students as well as to societal needs, a science program must present science in a 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, regardless of gender or cultural background, are given the opportunity to develop scientific literacy. The goal of scientific literacy is to develop in students the science-related knowledge, skills and attitudes that they need to solve problems and make decisions and, at the same time, to help students become lifelong learners who maintain their sense of wonder about the world around them.

Diverse learning experiences within the science 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, developed in the *Common Framework of Science Learning Outcomes K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum* (1997), 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 lives and the lives of others
- 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
- develop in students of varying aptitudes and interests a knowledge of the wide spectrum of careers related to science, technology and the environment.

Aboriginal Perspectives

Courses in the senior high school sciences incorporate 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. These courses are 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 humankind's connectivity to the natural world and foster an appreciation for 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.

Information and Communication Technology (ICT)

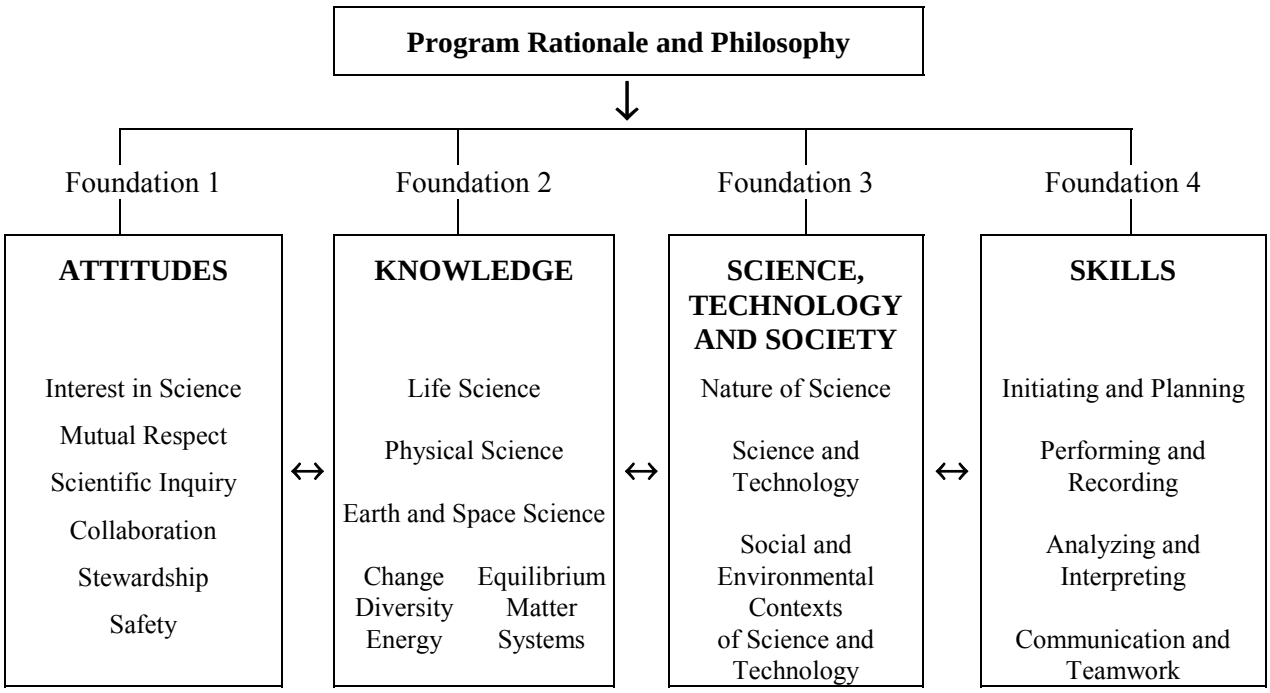
Selected curriculum outcomes from Alberta Education's Information and Communication Technology (ICT) Program of Studies are infused throughout the 20-level and 30-level sciences so that students will develop a broad perspective on the nature of technology, learn how to use and apply a variety of technologies, and consider the impact of ICT on individuals and society. The infusion of ICT outcomes supports and reinforces the understandings and abilities that students are expected to develop within Foundation 3 (Science, Technology and Society) and Foundation 4 (Skills) of these courses. Effective, efficient and ethical application of ICT outcomes contributes to the program vision.

Infusion of ICT outcomes provides learning opportunities for students to:

- understand the nature of technology and apply terminology appropriately
- use equipment carefully and share limited ICT resources
- use technology in an ethical manner, including respecting the ownership of information and digital resources and citing electronic sources
- use technology safely, including applying ergonomic principles and appropriate safety procedures
- use the Internet safely, including protecting personal information and avoiding contact with strangers
- use technology appropriately, including following communication etiquette and respecting the privacy of others.

PROGRAM FOUNDATIONS

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



Foundation 1
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.

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
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 4
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 1: Attitudes

Foundation 1 is concerned with the generalized aspects of behaviour that are 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 are rooted more deeply 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 student growth by interacting with students' intellectual development and by 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.

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.

Foundation 2: Knowledge

Foundation 2 focuses on the subject matter of science, including the laws, 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, organisms, cells, 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 gravitational, electromagnetic and nuclear forces in the universe. Physical science also addresses the conservation laws of mass and energy, momentum and charge.

Earth and Space Science

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

Themes are the major ideas of science and technology that transcend discipline boundaries and demonstrate unity among the natural sciences. Six themes have been identified for the senior high school sciences program.

Change
Students will develop an understanding of:

How all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled.

Diversity
Students will develop an understanding of:

The array of living and nonliving forms of matter and the procedures used to understand, classify and distinguish these forms of matter on the basis of recurring patterns.

Energy
Students will develop an understanding of:

The capacity for doing work that drives much of what takes place in the universe through its variety of interconvertible forms.

Equilibrium
Students will develop an understanding of:

The state in which opposing forces or processes balance in a static or dynamic way.

Matter
Students will develop an understanding of:

The constituent parts, and the variety of states, of the material in the physical world.

Systems
Students will develop an understanding of:

The interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

Foundation 3: Science, Technology and Society (STS)

Foundation 3 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 underlying 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, observation 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. Whereas the focus of science is on the development and verification of knowledge, the focus of technology is on the development of solutions, involving devices and systems that meet a given need within the constraints of a problem. The test of scientific 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

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 central to scientific literacy in a democratic society.

Foundation 4: Skills

Foundation 4 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 the secondary science program. Each skill area is developed at each level with increasing scope and complexity of application.

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 include gathering evidence by observation and, in most cases, manipulating materials and equipment.

Analyzing and Interpreting

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

Communication and Teamwork

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

PROGRAM ORGANIZATION

Attitude Outcomes

A listing of Attitude outcomes is included at the beginning of each of the 20-level and 30-level courses in the senior high school sciences program. These specific outcomes are to be developed throughout the particular course in conjunction with the specific outcomes for Knowledge, STS and Skills listed within each unit of study.

Units of Study

In the senior high school sciences program, four units of study are outlined for each course. Each unit in the 20-level and 30-level courses includes the following components.

Themes

Themes are the major ideas of science that transcend topics of study.

Overview

The overview introduces the contents of the unit and suggests an approach to unit development.

Links to Mathematics

This section lists topics from mathematics programs of study that are related to the science content of the unit.

Focusing Questions

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

Key Concepts

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

Outcomes

Two levels of outcomes are provided in each unit:

- General Outcomes: These are the major outcomes in the unit that students are to demonstrate over the course of their learning.
- Specific Outcomes: These are detailed outcomes that delineate the scope of each general outcome and the unit. Specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills are identified.

The outcomes are numbered for the purpose of referencing. This numbering is not intended to imply a fixed instructional sequence.

Examples

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

STS Emphases

The specific outcomes for Science, Technology and Society (STS) and Skills for each general outcome in a unit include one of the following emphases:

- Nature of Science
- Science and Technology
- Social and Environmental Contexts

The STS emphases provide opportunities for students to develop related concepts and skills as outlined on pages 8 to 10.

Additional Links

Links to the STS emphasis frameworks (pages 8 to 10) are shown in **boldface** and (in parentheses) after specific outcomes for STS and after specific outcomes or examples for Skills. Links to the Division 4 ICT curriculum (pages 11 to 13) are shown in **boldface** and [in brackets] after some of the specific outcomes and examples for STS and Skills. The STS and ICT links indicate that the concept or skill from the STS emphasis framework or the Division 4 ICT outcome has been addressed in the specific outcome or example.

Note: The listing of STS and ICT links is not exhaustive; other links may exist.

Framework for Developing a Nature of Science Emphasis (Grades 10–12)

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

Concepts (focus on how scientific knowledge is developed)

Students will develop an understanding that:

- the goal of science is knowledge about the natural world **(NS1)**
- scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- scientific knowledge results from peer review and replication of the research of others **(NS3)**
- scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced or rejected **(NS4)**
- the process of scientific investigation includes **(NS5)**:
  - identifying the theoretical basis of the investigation **(NS5a)**
  - defining and delimiting, clearly, research questions or ideas to be tested **(NS5b)**
  - designing the investigation **(NS5c)**
  - evaluating and selecting means to collect and record evidence **(NS5d)**
  - carrying out the investigation **(NS5e)**
  - analyzing the evidence and providing explanations based upon scientific theories and concepts **(NS5f)**
- scientific paradigms are conceptual inventions that help organize, interpret and explain findings **(NS6)**
  - Concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**
  - Conventions of mathematics, nomenclature and notation provide a basis for organizing and communicating scientific theory, relationships and concepts; e.g., chemical symbols **(NS6b)**
  - Scientific language is precise, and specific terms may be used in each field of study **(NS6c)**
- scientific inquiry is limited to certain questions **(NS7)**

Skills (focus on scientific inquiry)

Initiating and Planning **(IP–NS)**
Students will:
- identify, define and delimit questions to investigate **(IP–NS1)**
- design an experiment, identifying and controlling major variables **(IP–NS2)**
- state a prediction and a hypothesis based on available evidence or background information or on a theory **(IP–NS3)**
- evaluate and select appropriate procedures, including appropriate sampling procedures, and instruments for collecting evidence and information **(IP–NS4)**

Performing and Recording **(PR–NS)**
Students will:
- research, integrate and synthesize information from various print and electronic sources regarding a scientific question **(PR–NS1)**
- select and use appropriate instruments for collecting data effectively, safely and accurately **(PR–NS2)**
- carry out procedures, controlling the major variables, and adapt or extend procedures where required **(PR–NS3)**
- compile and organize findings and data by hand or computer, using appropriate formats such as diagrams, flowcharts, tables and graphs **(PR–NS4)**
- apply Workplace Hazardous Materials Information System (WHMIS) standards to handle and dispose of materials **(PR–NS5)**

Analyzing and Interpreting **(AI–NS)**
Students will:
- apply appropriate terminology, classification systems and nomenclature used in the sciences **(AI–NS1)**
- interpret patterns and trends in data and predict the value of a variable by interpolating or extrapolating from graphical data or from a line of best fit **(AI–NS2)**
- estimate and calculate the value of variables, compare theoretical and empirical values, and account for discrepancies **(AI–NS3)**
- identify limitations of data or measurements; explain sources of error; and evaluate the relevance, reliability and adequacy of data and data collection methods **(AI–NS4)**
- identify new questions or problems that arise from what was learned **(AI–NS5)**
- state a conclusion, based on data obtained from investigations, and explain how evidence gathered supports or refutes a hypothesis, prediction or theory **(AI–NS6)**

Communication and Teamwork **(CT–NS)**
Students will:
- work collaboratively to develop and carry out investigations **(CT–NS1)**
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**
- evaluate individual and group processes used in planning and carrying out investigative tasks **(CT–NS3)**

Framework for Developing a Science and Technology Emphasis (Grades 10–12)

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

Concepts (focus on the interrelationship of science and technology)

Students will develop an understanding that:

- the goal of technology is to provide solutions to practical problems **(ST1)**
- technological development may involve the creation of prototypes, the testing of prototypes and the application of knowledge from related scientific and interdisciplinary fields **(ST2)**
- technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3)**
- scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4)**
- the process for technological development includes **(ST5)**:
  - defining and delimiting, clearly, the problems to be solved and establishing criteria to assess the technological solution **(ST5a)**
  - identifying the constraints, the benefits and the drawbacks **(ST5b)**
  - developing designs and prototypes **(ST5c)**
  - testing and evaluating designs and prototypes on the basis of established criteria **(ST5d)**
- the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6)**
- the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7)**

Skills (focus on problem solving)

Initiating and Planning **(IP–ST)**
Students will:

- identify questions to investigate arising from practical problems **(IP–ST1)**
- propose and assess alternative solutions to a given practical problem, select one and develop a plan **(IP–ST2)**
- evaluate and select appropriate procedures and instruments for collecting data and information and for solving problems **(IP–ST3)**

Performing and Recording **(PR–ST)**
Students will:

- research, integrate and synthesize information from various print and electronic sources relevant to a practical problem **(PR–ST1)**
- construct and test a prototype device or system and troubleshoot problems as they arise **(PR–ST2)**
- select and use tools, apparatus and materials safely **(PR–ST3)**

Analyzing and Interpreting **(AI–ST)**
Students will:

- evaluate designs and prototypes on the basis of self-developed criteria; e.g., function, reliability, cost, safety, efficient use of materials, impact on the environment **(AI–ST1)**
- analyze alternative solutions to a given problem, identify potential strengths and weaknesses of each and recommend an approach to solving the problem, based on findings **(AI–ST2)**
- solve problems by selecting appropriate technology to perform manipulations and calculations **(AI–ST3)**
- identify new questions and problems that arise from what was learned and evaluate potential applications of findings **(AI–ST4)**

Communication and Teamwork **(CT–ST)**
Students will:

- work collaboratively to test a prototype device or system and troubleshoot problems as they arise **(CT–ST1)**
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions **(CT–ST2)**
- evaluate individual and group processes used in planning and carrying out problem-solving tasks **(CT–ST3)**

Framework for Developing a Social and Environmental Contexts Emphasis (Grades 10–12)

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

Concepts (focus on issues related to the application of science and technology)

Students will develop an understanding that:

- science and technology are developed to meet societal needs and expand human capability **(SEC1)**
- science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2)**
- science and technology have both intended and unintended consequences for humans and the environment **(SEC3)**
- society provides direction for scientific and technological development **(SEC4)**
  - Canadian society supports scientific research and technological development to facilitate a sustainable society, economy and environment **(SEC4a)**
  - Decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations **(SEC4b)**
  - Society supports scientific and technological development by recognizing accomplishments, publishing and disseminating results and providing financial support **(SEC4c)**
- 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 **(SEC5)**
- 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 **(SEC6)**

Skills (focus on applying science to inform decision-making processes)

Initiating and Planning **(IP–SEC)**
Students will:

- identify questions to investigate that arise from issues related to the application of science and technology **(IP–SEC1)**
- plan complex searches for information, using a wide variety of electronic and print sources **(IP–SEC2)**
- assess and develop appropriate processes for collecting relevant data and information about science-and-technology-related issues **(IP–SEC3)**

Performing and Recording **(PR–SEC)**
Students will:

- research, integrate and synthesize information from various print and electronic sources relevant to a given question, problem or issue **(PR–SEC1)**
- select information and gather evidence from appropriate sources and evaluate search strategies **(PR–SEC2)**

Analyzing and Interpreting **(AI–SEC)**
Students will:

- apply given criteria for evaluating evidence and assess the authority, reliability, scientific accuracy and validity of sources of information **(AI–SEC1)**
- apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments **(AI–SEC2)**
- assess potential decisions and recommend the best one, based on findings **(AI–SEC3)**
- identify new questions that arise and evaluate, from a variety of perspectives, potential implications of findings **(AI–SEC4)**

Communication and Teamwork **(CT–SEC)**
Students will:

- work collaboratively to investigate a science-and-technology-related issue **(CT–SEC1)**
- communicate in a persuasive and an engaging manner, using appropriate multimedia forms, to further understand a complex science-and-technology-related issue **(CT–SEC2)**
- make clear and logical arguments to defend a given decision on an issue, based on findings **(CT–SEC3)**
- evaluate individual and group processes used in investigating an issue and in evaluating alternative decisions **(CT–SEC4)**

Division 4 ICT Outcomes

Category: Communicating, Inquiring, Decision Making and Problem Solving

General Outcomes	Specific Outcomes
C1 **Students will access, use and communicate information from a variety of technologies.**	**C1** 4.1 plan and perform complex searches, using more than one electronic source 4.2 select information from appropriate sources, including primary and secondary sources 4.3 evaluate and explain the advantages and disadvantages of various search strategies 4.4 communicate in a persuasive and engaging manner, through appropriate forms, such as speeches, letters, reports and multimedia presentations, applying information technologies for context, audience and purpose that extend and communicate understanding of complex issues
C2 **Students will seek alternative viewpoints, using information technologies.**	**C2** 4.1 consult a wide variety of sources that reflect varied viewpoints on particular topics 4.2 evaluate the validity of gathered viewpoints against other sources
C3 **Students will critically assess information accessed through the use of a variety of technologies.**	**C3** 4.1 assess the authority, reliability and validity of electronically accessed information 4.2 demonstrate discriminatory selection of electronically accessed information that is relevant to a particular topic
C4 **Students will use organizational processes and tools to manage inquiry.**	**C4** 4.1 use calendars, time management or project management software to assist in conducting an inquiry
C5 **Students will use technology to aid collaboration during inquiry.**	**C5** 4.1 use telecommunications to pose critical questions to experts 4.2 participate in a variety of electronic group formats
C6 **Students will use technology to investigate and/or solve problems.**	**C6** 4.1 investigate and solve problems of prediction, calculation and inference 4.2 investigate and solve problems of organization and manipulation of information 4.3 manipulate data by using charting and graphing technologies in order to test inferences and probabilities 4.4 generate new understandings of problematic situations by using some form of technology to facilitate the process 4.5 evaluate the appropriateness of the technology used to investigate or solve a problem
C7 **Students will use electronic research techniques to construct personal knowledge and meaning.**	**C7** 4.1 use appropriate strategies to locate information to meet personal needs 4.2 analyze and synthesize information to determine patterns and links among ideas 4.3 use appropriate presentation software to demonstrate personal understandings

Division 4 ICT Outcomes (continued)

Category: Foundational Operations, Knowledge and Concepts

General Outcomes	Specific Outcomes
F1 **Students will demonstrate an understanding of the nature of technology.**	**F1** 4.1 assess the strengths and weaknesses of computer simulations in relation to real-world problems 4.2 solve mathematical and scientific problems by selecting appropriate technology to perform calculations and experiments 4.3 apply terminology appropriate to technology in all forms of communication 4.4 demonstrate an understanding of the general concepts of computer programming and the algorithms that enable technological devices to perform operations and solve problems
F2 **Students will understand the role of technology as it applies to self, work and society.**	**F2** 4.1 use technology outside formal classroom settings 4.2 analyze how technological innovations and creativity affect the economy 4.3 demonstrate an understanding of new and emerging communication systems 4.4 evaluate possible potential for emerging technologies 4.5 demonstrate conservation measures when using technology 4.6 demonstrate an understanding of the basic principles and issues of e-commerce, including such topics as security and privacy, marketing, and implications for governments, businesses and consumers alike 4.7 use current, reliable information sources from around the world 4.8 analyze and assess the impact of technology on the global community
F3 **Students will demonstrate a moral and ethical approach to the use of technology.**	**F3** 4.1 demonstrate an understanding of how changes in technology can benefit or harm society 4.2 record relevant data for acknowledging sources of information, and cite sources correctly 4.3 respect ownership and integrity of information
F4 **Students will become discerning consumers of mass media and electronic information.**	**F4** 4.1 discriminate between style and content in a presentation 4.2 evaluate the influence and results of digital manipulation on our perceptions 4.3 identify and analyze a variety of factors that affect the authenticity of information derived from mass media and electronic communication
F5 **Students will practise the concepts of ergonomics and safety when using technology.**	**F5** 4.1 assess new physical environments with respect to ergonomics 4.2 identify safety regulations specific to the technology being used
F6 **Students will demonstrate a basic understanding of the operating skills required in a variety of technologies.**	**F6** 4.1 continue to demonstrate the outcomes addressed within the previous divisions. Students interested in pursuing advanced study in such areas as electronics, programming, computer-aided design and drafting (CADD), robotics and other industrial applications of technology will find opportunities in Career and Technology Studies (CTS) courses

Division 4 ICT Outcomes (continued)

Category: Processes for Productivity

General Outcomes	Specific Outcomes
P1 **Students will compose, revise and edit text.**	**P1** 4.1 continue to demonstrate the outcomes achieved in prior grades and course subjects
P2 **Students will organize and manipulate data.**	**P2** 4.1 manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases and/or spreadsheets
P3 **Students will communicate through multimedia.**	**P3** 4.1 select and use, independently, multimedia capabilities for presentations in various subject areas 4.2 support communication with appropriate images, sounds and music 4.3 apply general principles of graphic layout and design to a document in process
P4 **Students will integrate various applications.**	**P4** 4.1 integrate a variety of visual and audio information into a document to create a message targeted for a specific audience 4.2 apply principles of graphic design to enhance meaning and audience appeal 4.3 use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text
P5 **Students will navigate and create hyperlinked resources.**	**P5** 4.1 create multiple-link documents appropriate to the content of a particular topic 4.2 post multiple-link pages on the World Wide Web or on a local or wide area network
P6 **Students will use communication technology to interact with others.**	**P6** 4.1 select and use the appropriate technologies to communicate effectively with a targeted audience

SCIENCE 20

Science 20 consists of four units of study:

A. Chemical Changes
B. Changes in Motion
C. The Changing Earth
D. Changes in Living Systems

Attitude Outcomes

Students will be encouraged to develop positive attitudes that support the responsible acquisition and application of knowledge related to science and technology. The following attitude outcomes are to be developed throughout Science 20, in conjunction with the specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills in each unit.

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.,*

- *research the answers to questions they generate*
- *explore and use a variety of methods and resources to increase their knowledge and skills*
- *be critical and constructive when considering new theories and techniques*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*
- *be interested in science and technology topics not directly related to their formal studies*
- *recognize the importance of making connections among various science disciplines*
- *maintain interest in pursuing further studies in science*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that many careers require science- and technology-related knowledge and skills.*

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.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *research carefully and discuss openly ethical dilemmas associated with the applications of science and technology*
- *explore personal perspectives, attitudes and beliefs toward scientific and technological advancements*
- *recognize the contribution of science and technology to the progress of civilizations*
- *show support for the development of technologies and science as they relate to human needs*
- *recognize that Western approaches to science are not the only ways of viewing the universe*
- *recognize the research contributions of both men and women*
- *recognize the research contributions of Canadians*.

Scientific Inquiry

Students will be encouraged to:
seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *consider the social and cultural contexts in which a theory developed*
- *appreciate how scientific problem solving and the development of new technologies are related*
- *insist on evidence before accepting a new idea or a new explanation*
- *assess, critically, their opinion of the value of science and its applications*
- *question arguments in which evidence, explanations or positions do not reflect the diversity of perspectives that exist*
- *criticize arguments that are based on faulty, incomplete or misleading use of numbers*
- *recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen*
- *insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged*
- *evaluate inferences and conclusions, being cognizant of the many variables involved in experimentation*
- *ask questions and conduct research to ensure understanding*
- *expend the effort and time needed to make valid inferences*
- *seek new models, explanations and theories when confronted with discrepant events.*

Collaboration

Students will be encouraged to:
work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*
- *use appropriate communication technology to elicit feedback from others*
- *participate in a variety of electronic group formats.*

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.,*

- *assume part of the collective responsibility for the impact of humans on the environment*
- *participate in civic activities related to the preservation and judicious use of the environment and its resources*
- *encourage their peers or members of their community to participate in a project related to sustainability*
- *consider all perspectives when addressing issues, weighing scientific, technological and ecological factors*
- *discuss both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans*
- *participate in the social and political systems that influence environmental policy in their community*
- *promote actions that are not injurious to the environment*

- *make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations*
- *be critical-minded regarding the short- and long-term consequences of sustainability*.

Safety

Students will be encouraged to:
show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information; *e.g.,*

- *consider safety a positive limiting factor in scientific and technological endeavours*
- *read the labels on materials before using them, interpret the WHMIS symbols and consult a reference document if safety symbols are not understood*
- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*
- *assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials according to safety guidelines*
- *seek assistance immediately for any first-aid concerns, such as cuts, burns or unusual reactions*
- *keep the work station uncluttered, ensuring that only appropriate laboratory materials are present*
- *criticize a procedure, a design or materials that are not safe or that could have a negative impact on the environment*
- *use safety and waste disposal as criteria for evaluating an experiment*
- *write safety and waste-disposal precautions into a laboratory procedure*.

Unit A: Chemical Changes

Themes: Matter, Change and Energy

Overview: Chemical changes involve a change in energy. In order for students to understand how numerous useful materials are produced, they need to develop an understanding of concentrations of aqueous solutions, oxidation-reduction (redox) processes and the characteristics of hydrocarbons. Economically important industries in Alberta and other parts of Canada are based upon the application of chemical principles.

This unit builds on:
- Science 10, Unit A: Energy and Matter in Chemical Change

This unit provides a background for:
- Science 30, Unit B: Chemistry and the Environment

Unit A will require approximately 25% of the time allotted for Science 20.

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

Topics:	These topics may be found in the following courses:
• linear equations	Applied Mathematics 10, specific outcome 5.1
• measurement	Applied Mathematics 10, specific outcomes 1.2 and 1.3; Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: What is concentration? How has knowledge about oxidation-reduction in aqueous solutions been applied to solve practical problems? What characteristics of hydrocarbons are important to industry in Alberta?

General Outcomes: There are three major outcomes in this unit.

Students will:

1. investigate aqueous solutions to determine conductivity and to calculate concentration
2. explain oxidation, reduction and spontaneity and apply this knowledge to voltaic and electrolytic cells and to industrial processes
3. describe the properties of simple hydrocarbons and describe hydrocarbon-based industrial processes that are important in Alberta.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- electrolytes
- nonelectrolytes
- concentration
- dilution
- oxidation/anode
- reduction/cathode
- spontaneity
- applications of oxidation-reduction reactions
- voltaic cell
- electrolytic cell
- naming and drawing structural formulas for saturated/unsaturated hydrocarbons (containing up to eight carbon atoms in the parent chain)
- hydrocarbon reactions important to industry in Alberta

General Outcome 1
Students will investigate aqueous solutions to determine conductivity and to calculate concentration.

Specific Outcomes for Knowledge

Students will:

20–A1.1k explain how dissolving substances in water is often a prerequisite for chemical reactions and chemical changes; *e.g., batteries, baking, medications*

20–A1.2k differentiate, on the basis of properties, between electrolytes and nonelectrolytes

20–A1.3k compare and explain how concentrations of solutions are expressed in moles per litre, percent by volume and parts per million

20–A1.4k determine the concentration of solutions in moles per litre, percent by volume and parts per million

20–A1.5k determine the concentration of diluted solutions and the quantities of a concentrated solution and of water to use when diluting.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

20–A1.1sts explain how science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.8]**

- *identify properties of aqueous solutions that enable chemical reactions important for industry*

20–A1.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**

- *compare the ways in which concentrations are expressed in chemistry laboratories, industrial processes, household products and environmental studies*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will investigate aqueous solutions to determine conductivity and to calculate concentration.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

20–A1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a procedure to identify a solution as an electrolyte or a nonelectrolyte **(IP–NS2) [ICT F1–4.2]**.

Performing and Recording

Students will:

20–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- use a conductivity apparatus to identify a solution as an electrolyte or a nonelectrolyte **(PR–NS2)**
- use a pipette and volumetric glassware to prepare a solution **(PR–NS2, PR–NS5)**.

Analyzing and Interpreting

Students will:

20–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use experimental data to determine the concentration of a solution **(AI–NS3) [ICT C6–4.1]**
- evaluate the risk involved in the handling, storage and disposal of solutions that are in common use in the laboratory, in the home and in industry across Alberta **(AI–SEC2, PR–NS5)**.

Communication and Teamwork

Students will:

20–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate International System of Units (SI) notation, fundamental and derived units and significant digits **(CT–ST2)**★
- *compare personal data on electrolytes and nonelectrolytes with the data of other students* **(CT–NS3)**
- *research, in teams, the impact of the release of effluent into waterways* **(IP–SEC3, PR–SEC1, AI–SEC3, CT–SEC1) [ICT C1–4.1]**.

★To be developed throughout the course.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will explain oxidation, reduction and spontaneity and apply this knowledge to voltaic and electrolytic cells and to industrial processes.

Specific Outcomes for Knowledge

Students will:

20–A2.1k balance provided single-replacement reaction equations, building on knowledge from Science 10, Unit A

20–A2.2k determine the reactivity of metals by comparing their reaction in various aqueous solutions

20–A2.3k relate single-replacement reactions to oxidation-reduction and apply mole ratios from given equations to predict moles of metals consumed or produced

20–A2.4k define, operationally, oxidation and reduction and spontaneous and nonspontaneous reactions; i.e., loss of electrons is oxidation, gain of electrons is reduction, a spontaneous oxidation-reduction reaction produces electrical energy from chemical change, and a nonspontaneous oxidation-reduction reaction requires electrical energy to produce chemical change

20–A2.5k apply the principles of oxidation-reduction and half-reactions to describe, in general terms, the operation of voltaic and electrolytic cells; *e.g., batteries, metal extraction, cathodic protection, galvanizing, electroplating*
Note: Students are not expected to construct oxidation-reduction reaction equations; i.e., combining two half-reactions to produce a net equation.

20–A2.6k compare modern and traditional methods for the extraction of metals and for protection from corrosion; *e.g., development of glazes in traditional Aboriginal pottery manufacturing*.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–A2.1sts illustrate how science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8, F3–4.1]**
- *analyze the importance of voltaic, electrolytic and fuel cells and predict their future importance in society and industry*

20–A2.2sts describe applications of science and technology that have developed in response to human and environmental needs **(SEC1)**
- *investigate the use of technology to solve practical problems related to oxidation-reduction, considering cathodic protection, galvanizing, electroplating and extraction of metals*

20–A2.3sts illustrate how technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3) [ICT C6–4.5, F3–4.1]**
- *describe the need for industrial processes to make use of efficient designs to provide optimal yields within constraints of cost and requirements for sustainability (production of smaller and longer-lasting batteries, for example, and considerations for their disposal)*
- *analyze technological products and processes related to batteries, metal extraction and anti-corrosion in terms of scientific principles and environmental stewardship.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will explain oxidation, reduction and spontaneity and apply this knowledge to voltaic and electrolytic cells and to industrial processes.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–A2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- describe procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3, PR–NS5)**
- design a voltaic cell, with the aid of an activity series chart, to illustrate a spontaneous oxidation-reduction reaction **(IP–NS2, IP–NS3)**.

Performing and Recording

Students will:

20–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform metals-in-aqueous-solutions experiments to observe the spontaneity of a series of oxidation-reduction reactions **(IP–ST3, PR–ST3) [ICT C6–4.1, C6–4.2]**
- create a chart or table that presents the results of oxidation-reduction experiments **(PR–NS4) [ICT C6–4.3]**
- construct a voltaic cell to illustrate a spontaneous oxidation-reduction reaction **(PR–ST2, PR–ST3)**.

Analyzing and Interpreting

Students will:

20–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- determine the relative strengths of the oxidizing and reducing agents for a series of oxidation-reduction reactions **(AI–ST3) [ICT C6–4.1]**
- draw and label sketches of operating voltaic and electrolytic cells, identifying the anode, the cathode, oxidation, reduction and electron flow **(PR–NS4, CT–NS2)**.

Communication and Teamwork

Students will:

20–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *analyze, constructively, the designs for operating voltaic and electrolytic cells developed by others* **(CT–NS3) [ICT C6–4.5]**
- *participate in a variety of electronic group formats to investigate an electrically powered device (battery-powered vehicles, watches or the effect of different batteries on the operation of listening devices, for example)* **(CT–SEC2) [ICT C3–4.1, C5–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will describe the properties of simple hydrocarbons and describe hydrocarbon-based industrial processes that are important in Alberta.

Specific Outcomes for Knowledge

Students will:

20–A3.1k identify materials used in daily life that are based upon Alberta's petrochemical industry and that involve changes in energy; *e.g., plastics, cosmetics, gasoline*

20–A3.2k identify the physical characteristics of hydrocarbons, including trends with respect to melting and boiling points and solubility of alkanes, alkenes and alkynes

20–A3.3k provide International Union of Pure and Applied Chemistry (IUPAC) names and structural formulas for simple and noncyclic hydrocarbons in the homologous series of alkanes, alkenes and alkynes that contain up to eight carbon atoms in the parent chain

20–A3.4k identify hydrocarbons as a source of fossil fuels and explain the processes of fractional distillation to refine petroleum and catalytic cracking to produce ethene (ethylene)

20–A3.5k classify, balance and apply mole ratios to important hydrocarbon reactions:
- combustion of hydrocarbons to produce carbon dioxide, water vapour and energy
- production of ethene (ethylene) from catalytic cracking
- hydrogenation of alkenes (unsaturated) to produce alkanes (saturated)
- polymerization of ethene (ethylene) to polyethene (polyethylene).

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–A3.1sts develop an understanding that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.8]**
- *describe some major reactions of the petrochemical industry in Alberta, such as the production of methanol and polyethene*
- *describe processes, such as catalytic cracking, for obtaining economically important compounds from fossil fuels*
- *explain the traditional uses of tar sands (pitch) as caulking for canoes and the use of animal oils and fats as fuels*

20–A3.2sts discuss the appropriateness, risks and benefits of technologies, assessing each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F2–4.2, F3–4.1]**
- *identify challenges when taking scientific knowledge from the laboratory and applying the knowledge to large-scale manufacturing processes or to the development of products, considering such things as the supply of raw materials, energy, labour and the storage and disposal of waste products.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will describe the properties of simple hydrocarbons and describe hydrocarbon-based industrial processes that are important in Alberta.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–A3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- describe procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3, PR–NS5)**
- design a procedure to identify types of selected hydrocarbons **(IP–NS1, IP–NS2)**.

Performing and Recording

Students will:

20–A3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to compare reactivities of selected hydrocarbons **(PR–NS2, PR–NS3, PR–NS5) [ICT C6–4.1]**
- build molecular models, depicting the structures of selected hydrocarbons **(NS6a, PR–NS4)**.

Analyzing and Interpreting

Students will:

20–A3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *collect data on melting and boiling points of hydrocarbons and illustrate trends using charts, graphs or tables* **(PR–NS4, AI–NS2) [ICT C1–4.1**, **C6–4.3, C7–4.2]**.

Communication and Teamwork

Students will:

20–A3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- follow appropriate IUPAC guidelines in writing the names and formulas of selected hydrocarbons **(CT–NS2)**
- *use teamwork to collect information and write a report that describes fractional distillation to refine petroleum and catalytic cracking to produce ethene* **(CT–NS1, CT–NS2) [ICT C1–4.1, C1–4.4]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit B: Changes in Motion

Themes: Change, Energy and Systems

Overview: Motion is an important aspect of our lives, and the understanding of the effects of force on motion has many technological applications. Students learn that these applications can range from the design of safer roads and sports equipment to the investigation of traffic accidents. In this unit, students investigate the concepts of displacement, velocity, acceleration, force, momentum and mechanical energy and consider the relationships among them.

This unit builds on:
- Grade 8 Science, Unit D: Mechanical Systems
- Science 10, Unit B: Energy Flow in Technological Systems

This unit provides a background for:
- Science 30, Unit C: Electromagnetic Energy

Unit B will require approximately 25% of the time allotted for Science 20.

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

Topics:	These topics may be found in the following courses:
• properties of linear functions	Pure Mathematics 10, specific outcome 4.6; Applied Mathematics 10, specific outcomes 5.1, 5.2 and 5.7
• vector addition	Pure Mathematics 10, specific outcomes 6.1 and 6.2; Applied Mathematics 30, specific outcomes 5.1 to 5.4
• formula manipulation	Applied Mathematics 10, specific outcome 5.1
• graphing and interpreting data	Pure Mathematics 10, specific outcome 3.1; Applied Mathematics 10, specific outcome 3.1

Focusing Questions: How does the design of safety equipment and systems take into account concepts of changes in motion and forces? What has been the influence of society on the development of safety technology, and what are the contextual constraints and limits of these technological solutions?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. describe one-dimensional motion of objects in terms of displacement, time, velocity and acceleration
2. describe and analyze the law of conservation of momentum for one-dimensional collisions and change in momentum (impulse) to explain how force affects motion.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.
- displacement, time, velocity, acceleration
- conservation of momentum in one dimension
- impulse and force
- Newton's laws of motion
- application of laws of motion and principles of momentum in the design of sports equipment and transportation safety devices

General Outcome 1
Students will describe one-dimensional motion of objects in terms of displacement, time, velocity and acceleration.

Specific Outcomes for Knowledge

Students will:

20–B1.1k distinguish between scalar and vector quantities, including distance and displacement, speed and velocity

20–B1.2k define velocity and acceleration as $\vec{v} = \Delta\vec{d} / \Delta t$ and $\vec{a} = \Delta\vec{v} / \Delta t$, respectively

20–B1.3k compare and contrast displacement in uniform motion and uniformly accelerated motion, using the following relationships: $\Delta\vec{d} = \vec{v}_i \Delta t + \frac{1}{2}\vec{a}\Delta t^2$ and $\Delta\vec{d} = \frac{\left(\vec{v}_i + \vec{v}_f\right)}{2}\Delta t$.

Note: Students are not expected to rearrange formulas if they require the quadratic equation.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–B1.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**

- *apply principles of one-dimensional uniform motion to relevant traffic safety design features, such as safe lengths of freeway entrance and exit ramps, traffic lights with advance warning flashers, types of intersections and length of time lights stay yellow*
- *analyze the design of stop-and-go zones and propose improvements to the design of traffic lights and intersections*

20–B1.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**

- *describe the influence of societal perceptions of risk and the influence of scientific knowledge on the development of safety technologies designed to control changes in motion*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will describe one-dimensional motion of objects in terms of displacement, time, velocity and acceleration.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–B1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *determine what needs to be measured and select the proper procedures, tools and technologies for investigating the relationships among displacement, velocity and acceleration* **(IP–ST3) [ICT C6–4.4]**
- *design a study to assess the design of traffic lights and intersections* **(IP–ST1)**.

Performing and Recording

Students will:

20–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- manipulate and present data, using appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets, for analyzing displacement, velocity and acceleration **(PR–NS4) [ICT P2–4.1]**
- use technologies effectively and accurately for collecting data on motion; *e.g., photogate, computer-based laboratories, stopwatches, weighing balances* **(PR–NS2) [ICT F1–4.2]**
- *use library and electronic research tools to collect information in determining risks associated with sporting activities and transportation-related activities* **(PR–SEC1) [ICT C1–4.1, C3–4.2]**.

Analyzing and Interpreting

Students will:

20–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- analyze position-time and velocity-time graphs to infer the relationships among displacement, velocity and acceleration **(AI–NS2) [ICT C7–4.2]**
- solve, quantitatively, one-dimensional uniform motion and uniformly accelerated motion problems using $\Delta\vec{d} = \vec{v}_i\Delta t + \frac{1}{2}\vec{a}\Delta t^2$ and $\Delta\vec{d} = \frac{\left(\vec{v}_i + \vec{v}_f\right)}{2}\Delta t$ **(AI–NS3) [ICT C6–4.1]**.

Communication and Teamwork

Students will:

20–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within a word processor to insert tables, graphs, text and graphics into a report* **(CT–ST2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe and analyze the law of conservation of momentum for one-dimensional collisions and change in momentum (impulse) to explain how force affects motion.

Specific Outcomes for Knowledge

Students will:

20–B2.1k define momentum as a vector quantity equal to the product of the mass and velocity of an object ($\vec{p} = m\vec{v}$)

20–B2.2k apply the law of conservation of momentum to one-dimensional collisions and explosions

20–B2.3k define change in momentum as impulse $\left(\Delta\vec{p} = m\Delta\vec{v} = \vec{F}_{ave}\Delta t\right)$, relate impulse to acceleration and Newton's second law of motion $\left(\Delta\vec{p}/\Delta t = m\vec{a} = \vec{F}\right)$, and apply the concept of impulse to explain the functioning of a variety of safety devices; *e.g., air bags, collapsible frames, bumpers, seat belts in cars, restraining nets and crash barriers on highways, collapsible steering wheels, padded dashboards, padded helmets, padded goggles and padded gloves, all of which are designed to increase the stopping time or time of contact by reducing acceleration and, thereby, force*

20–B2.4k explain how an unbalanced force causes change in motion and apply Newton's first law of motion to explain an object's state of rest or uniform motion; *e.g., movement of passengers in a moving car that accelerates or is coming to a stop*

20–B2.5k apply Newton's second law of motion and use it to relate force, mass and motion; *e.g., as an explanation of a whiplash injury from a rear-end collision*

20–B2.6k apply Newton's third law of motion to explain the interaction between two objects; *e.g., collision between two cars*

20–B2.7k relate, quantitatively, potential and kinetic energy to work done.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–B2.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**

- *explain the need for safety technologies and regulations for transportation and sporting situations*
- *trace the development of safety technologies in sports or transportation over the past 50 years, and compare the functioning of first- and current-generation safety technologies, such as sports safety equipment (helmets, shin guards, gloves) and automobile safety devices (lap belts, shoulder belts, air bags)*

20–B2.2sts explain that decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations **(SEC4b) [ICT F2–4.2, F2–4.8, F3–4.1]**

- *analyze automobile and sports equipment safety features with a view to reducing risks within contextual constraints, such as costs, materials, weight, requirements for sustainability, rules and regulations*

20–B2.3sts explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F3–4.1]**

- *list and assess the risks in a variety of day-to-day transportation and sporting situations, and describe the technologies designed to reduce the risk of injury.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe and analyze the law of conservation of momentum for one-dimensional collisions and change in momentum (impulse) to explain how force affects motion.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–B2.1s formulate 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., "How can sports equipment be made to increase its protective capacity?", "Do you increase protection or change the rules to make sports such as soccer or hockey safer?"* **(IP–ST1)**
- *use spreadsheets to analyze the law of conservation of momentum* **(IP–ST3) [ICT C6–4.2, P2–4.1]**.

Performing and Recording

Students will:

20–B2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- compile and organize data on the risk of injury and death related to seat belt and air bag use **(PR–NS4) [ICT C6–4.2, P2–4.1]**
- *test materials for use as seat belts or as padding for sports equipment* **(PR–ST2)**.

Analyzing and Interpreting

Students will:

20–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- solve one-dimensional collision and explosion problems, using scale diagrams and numerical calculations; *e.g., apply* $m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$ *to traffic accidents involving two vehicles* **(AI–ST3) [ICT C6–4.1, P2–4.1]**
- *delineate cause and effect or correlation among the use of seat belts or air bags, seat belt legislation and reduction of fatalities* **(AI–NS6) [ICT C7–4.2]**
- *suggest a variety of alternatives to reduce whiplash injury caused by rear-end collisions and evaluate each alternative* **(AI–ST2) [ICT C2–4.1]**
- *develop criteria and use them to assess a device for reducing whiplash injury* **(AI–ST1)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe and analyze the law of conservation of momentum for one-dimensional collisions and change in momentum (impulse) to explain how force affects motion.

Communication and Teamwork

Students will:

20–B2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *consult a wide variety of sources that reflect varied viewpoints on particular topics, such as legislation of seat belt use* **(CT–SEC4) [ICT C2–4.1]**
- *work cooperatively with team members, using library and electronic research tools to collect information in determining risks associated with sports- and transportation-related activities* **(PR–SEC2, CT–NS1) [ICT C1–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit C: The Changing Earth

Themes: Change, Diversity, Energy and Systems

Overview: The history of our planet is one of change. There is evidence not only that Earth's surface is changing but that this change has, in turn, dramatically impacted the climate and life forms on Earth over time. In this unit, students examine scientific evidence for natural causes of climate change, for changing life forms and for continual changes to the Earth's surface.

This unit builds on:
- Grade 7 Science, Unit E: Planet Earth
- Science 10, Unit D: Energy Flow in Global Systems

This unit provides a background for:
- Science 30, Unit D: Energy and the Environment

Unit C will require approximately 25% of the time allotted for Science 20.

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

Topics:	These topics may be found in the following courses:
• graphing and interpreting data	Pure Mathematics 10, specific outcome 3.1; Applied Mathematics 10, specific outcome 3.1
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: What is the scientific evidence of change to Earth? How has this evidence been used to formulate scientific theories? What are the limitations of current theories in making predictions about future changes to Earth?

General Outcomes: There are four major outcomes in this unit.

Students will:

1. analyze the scientific evidence and explanations for geologic phenomena that occurred long ago or are taking place over a long period of time
2. analyze and assess the evidence to explain the theory of plate tectonics and the internal structure of Earth
3. analyze and assess the evidence provided by the fossil record of change in the environment and life forms over a period of 3.5 billion years
4. analyze the evidence of, and assess the explanations for, natural variations in Earth's climate over the last two million years.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- Earth's internal structure
- theory of plate tectonics
- energy transmission in earthquakes
- fossilization, radiometric dating and half-life
- major characteristics and life forms of past eras
- gradualism compared to punctuated equilibrium
- mass extinctions
- evidence of variations in Earth's climate

General Outcome 1
Students will analyze the scientific evidence and explanations for geologic phenomena that occurred long ago or are taking place over a long period of time.

Specific Outcomes for Knowledge

Students will:

20–C1.1k describe the challenges in investigating the changes that take place over hundreds of millions of years to Earth's crustal plates, to past climates and to life forms

20–C1.2k describe, in general terms, how the theories of geologic processes have changed over time.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–C1.1sts explain that scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced, rejected or replaced **(NS4)**

- *refer to the contributions of Hutton, Lyell and Wegener to the development of theories of geologic processes*

20–C1.2sts explain that scientific knowledge may lead to the development of new technologies and that new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4, F2–4.8]**

- *explain the importance of technology in facilitating the study of changes to Earth's surface, climate and life forms (enhancing the gathering of data and the quality, accuracy and precision of data), considering such things as seismometers, radiometric dating technologies, sonar mapping of the ocean floor and the global positioning system (GPS) to measure plate movement.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze the scientific evidence and explanations for geologic phenomena that occurred long ago or are taking place over a long period of time.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–C1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- state a prediction and a hypothesis based on available evidence and background information or theory; *e.g., use available data to predict the position of land masses 1000 years from now* **(IP–NS3) [ICT C7–4.2]**.

Performing and Recording

Students will:

20–C1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *create a chart that shows the relationships among geological era, position of the continental plates and climate* **(PR–NS4) [ICT C6–4.3, C7–4.2]**.

Analyzing and Interpreting

Students will:

20–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *assess the authority, reliability and validity of electronically accessed information about changes to Earth* **(AI–NS4) [ICT C3–4.1]**.

Communication and Teamwork

Students will:

20–C1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate about the geology of Earth* **(CT–NS2)**
- *synthesize information about the changing Earth from multiple sources, or from complex and lengthy texts; record relevant data for acknowledging sources of information; and cite sources correctly* **(CT–NS2) [ICT F3–4.2, F3–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze and assess the evidence to explain the theory of plate tectonics and the internal structure of Earth.

Specific Outcomes for Knowledge

Students will:

20–C2.1k describe how energy from earthquakes is transmitted by seismic waves

20–C2.2k describe the relationship between the Richter scale and an earthquake's ground motion and energy

20–C2.3k identify primary and secondary seismic waves (P- and S-waves, respectively) and longitudinal and transverse surface waves on the basis of vibration and direction of propagation and potential for destruction

20–C2.4k explain how seismic waves are used to better understand the internal structure of Earth

20–C2.5k identify and describe the layers of Earth (i.e., lithosphere, asthenosphere, mesosphere, outer core and inner core) as classified by the physical properties of density, rigidity and thickness

20–C2.6k list and describe the evidence that supports the theory of plate tectonics; i.e., location of volcanoes and earthquakes, ocean floor spreading, mountain ranges, age of sediments, paleomagnetism

20–C2.7k explain how convection of molten material provides the driving force of plate tectonics, and explain the tentativeness of the explanation that radioactive decay is the source of geothermal energy for plate tectonics.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–C2.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

- *assess the theory of plate tectonics in terms of its ability to explain and predict changes to Earth's surface*

20–C2.2sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**

- *describe the limitations of current knowledge in predicting earthquakes and the need for more accurate predictions.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze and assess the evidence to explain the theory of plate tectonics and the internal structure of Earth.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- define and delimit problems, *e.g., how to locate the approximate epicentre of an earthquake,* using data provided to facilitate investigation **(IP–NS1)**
- *design an experiment to test the effect of a simulated earthquake on a model building* **(IP–NS2)**
- *investigate Canada's earthquake-prone areas and predict likely locations of a future earthquake* **(IP–NS3) [ICT C7–4.2]**.

Performing and Recording

Students will:

20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *compile and organize data to investigate monthly occurrences of earthquakes, their intensity and their locations around the world* **(PR–NS4) [ICT C7–4.2, P2–4.1]**.

Analyzing and Interpreting

Students will:

20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *estimate, predict, check and validate calculations when determining the location of earthquakes* **(AI–NS3) [ICT C6–4.1, F1–4.2]**
- *compare the theories of continental drift and plate tectonics* **(AI–SEC1) [ICT C2–4.2]**
- *investigate the application of seismic and surface waves in the design of earthquake-resistant buildings* **(AI–ST4)**.

Communication and Teamwork

Students will:

20–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within a word processor to insert tables, graphs, text and graphics and select and use multimedia capabilities for presentation* **(CT–NS2) [ICT P3–4.1, P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze and assess the evidence provided by the fossil record of change in the environment and life forms over a period of 3.5 billion years.

Specific Outcomes for Knowledge

Students will:

20–C3.1k explain how knowledge of radioisotopes, radioactive decay and half-lives are used to estimate the age of minerals and fossils

20–C3.2k describe common types of fossilization, i.e., actual remains, molds or imprints, tracks, trails or burrows, as direct evidence of evolution and describe the significance of the fossil record in Canada's Burgess Shale

20–C3.3k explain how sedimentary rock layers along with fossils can provide evidence of chronology, paleoclimate, evolution and mass extinctions; *e.g., index and transitional fossils, fossils of reptiles and certain types of plants usually indicate a warm, tropical climate*

20–C3.4k describe, in general terms, the major characteristics and life forms of the four eras: Precambrian, Paleozoic, Mesozoic and Cenozoic

20–C3.5k explain why oxygen became a significant component of Earth's atmosphere after the evolution of plants and chlorophyll.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–C3.1sts explain that scientific knowledge may lead to the development of new technologies and that new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4, F2–4.8]**

- *explain the importance of technology in facilitating the study of changes to Earth's climate and life forms (enhancing the gathering of data and the quality, accuracy and precision of data), considering such things as radiometric dating technologies, sonar mapping of the ocean floor and the global positioning system (GPS) to measure plate movement*

20–C3.2sts explain that scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced, rejected or replaced **(NS4) [ICT C7–4.2]**

- *discuss probable causes of, and geologic evidence for, mass extinctions and contrast these causes with the forces driving the current decline in species.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze and assess the evidence provided by the fossil record of change in the environment and life forms over a period of 3.5 billion years.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–C3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- use stratigraphic evidence of one location to predict geologic structures in a neighbouring region **(IP–NS3) [ICT C6–4.1, C7–4.2]**.

Performing and Recording

Students will:

20–C3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *compile and organize data, using appropriate formats and data treatments to facilitate interpretation, when determining climatic conditions based on fossil evidence* **(PR–NS4) [ICT C6–4.2, P2–4.1]**.

Analyzing and Interpreting

Students will:

20–C3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- interpret simple stratigraphic sequences **(AI–NS2) [ICT C7–4.2]**
- apply units of geological time; i.e., eras, periods and epochs **(AI–NS1)**
- interpret decay curves of elements commonly used for radioactive dating **(AI–NS2) [ICT C7–4.2]**
- *describe earlier life forms on the basis of fossil evidence, identify and explain sources of error, and express results in a form that acknowledges the degree of uncertainty* **(AI–NS4)**.

Communication and Teamwork

Students will:

20–C3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *prepare a group presentation, summarizing the arguments for gradualism and punctuated equilibrium as two possible patterns of evolution* **(CT–NS1) [ICT P6–4.1]**
- *evaluate individual and group processes used in planning and carrying out an investigation, based on fossil evidence, into changes in life forms* **(CT–NS3)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 4
Students will analyze the evidence of, and assess the explanations for, natural variations in Earth's climate over the last two million years.

Specific Outcomes for Knowledge

Students will:

20–C4.1k describe the geologic evidence for repeated glaciation over large areas of Canada and in their local area; *e.g., the Cypress Hills, gold deposits in the Yukon, topography, drainage patterns, erratics, U-shaped valleys*

20–C4.2k explain how ice cores from polar icecaps provide evidence of warming and cooling in the past hundred thousand years

20–C4.3k explain, in general terms, how changes to Earth's climate and how mass extinctions could be caused by changes or variation in the following: Earth's orbit around the sun, the inclination of Earth's axis, solar energy output, Earth's geography due to crustal movement, volcanic activity, ocean currents, atmospheric composition or asteroid impact.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–C4.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

- *describe the limitations of current geological models in predicting future changes to climate.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 4
Students will analyze the evidence of, and assess the explanations for, natural variations in Earth's climate over the last two million years.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–C4.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a plan for surveying data on ice core samples from ice fields around the world for a study of climate over the last two million years **(IP–NS1, IP–NS4)**.

Performing and Recording

Students will:

20–C4.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- select relevant ice-core data for a study of climate over the last two million years **(PR–NS4)**
- *view a glacier in aerial photographs and document the changes that have occurred over time* **(PR–NS4) [ICT C7–4.2]**.

Analyzing and Interpreting

Students will:

20–C4.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- identify and explain sources of error and uncertainty in measurement when describing past climates based on ice-core data and express results in a form that acknowledges the degree of uncertainty **(AI–NS4)**
- *distinguish between correlation and cause and effect when describing the relationship between climate change and mass extinction* **(AI–NS6) [ICT C7–4.2]**
- *identify new questions or problems that arise from what was learned, such as: "Is the current rate of species extinction the same as in periods of mass extinction in the past?"* **(AI–NS5)**.

Communication and Teamwork

Students will:

20–C4.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *synthesize information from multiple sources when making inferences about global warming and climate change, recording relevant data, acknowledging sources of information and citing sources correctly* **(CT–SEC2) [ICT C7–4.2, F3–4.2, F3–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit D: Changes in Living Systems

Themes: Energy, Equilibrium, Change and Systems

Overview: Matter cycles and energy dissipates through the biosphere and its component ecosystems. The concept of an ecosystem is used to explain energy flow and nutrient recycling and to quantify large-scale and long-term processes. Students will study habitat destruction, ecological succession and changes to populations, focusing on the need to balance the interests of a growing human population with sustainable ecosystems.

This unit builds on:
- Grade 9 Science, Unit A: Biological Diversity
- Science 10, Unit D: Energy Flow in Global Systems

This unit provides a background for:
- Science 30, Unit A: Living Systems Respond to Their Environment

Unit D will require approximately 25% of the time allotted for Science 20.

Links to Mathematics: None

Focusing Questions: What are the characteristics of an ecosystem? How does matter cycle and energy flow through the biosphere and through ecosystems, and what are the implications of this knowledge in terms of protecting the environment for future generations? How do ecosystems and organisms change over time and respond to natural and human interventions?

General Outcomes: There are three major outcomes in this unit.

Students will:

1. analyze ecosystems and ecological succession in the local area and describe the relationships and interactions among subsystems and components
2. analyze and investigate the cycling of matter and the flow of energy through the biosphere and ecosystems as well as the interrelationship of society and the environment
3. analyze and describe the adaptation of organisms to their environments, factors limiting natural populations, and evolutionary change in an ecological context.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- biotic and abiotic factors
- population size
- primary and secondary succession
- habitat destruction, reclamation
- species diversity
- human interventions in biogeochemical (nitrogen, carbon, water) cycles
- autotrophs, heterotrophs, food chains, food webs
- trophic levels, biomass, energy and pyramids
- human population growth, biodiversity and carrying capacity
- adaptation of organisms, natural selection
- evidence for the theory of evolution

General Outcome 1
Students will analyze ecosystems and ecological succession in the local area and describe the relationships and interactions among subsystems and components.

Specific Outcomes for Knowledge

Students will:

20–D1.1k investigate and analyze an aquatic or a terrestrial local ecosystem, distinguish between biotic and abiotic factors, describe how these factors affect population size and
- infer the abiotic effects on life; *e.g., light, nutrients, water, temperature*
- infer biotic interactions; *e.g., predator-prey relationships, competition, symbiotic relationships*
- infer the influence of biota on the local environment; *e.g., microclimates, soil, nutrients*

20–D1.2k describe the key stages of primary succession in a specific ecosystem and the nature of its climax community; *e.g., spruce bog, sand dune, pond, prairie*

20–D1.3k differentiate between primary and secondary succession in a specific aquatic and a specific terrestrial ecosystem, *e.g., pond, river, lake, forest, parkland*, and compare natural and artificial means to initiate secondary succession in an ecosystem, *e.g., reforestation or regrowth after a forest fire, flood or other natural disaster, strip mining, clearcutting, controlled burns by some Aboriginal groups promoting grassland biome regeneration*

20–D1.4k describe the potential impact of habitat destruction on an ecosystem

20–D1.5k describe the effects of introducing a new species into, or largely removing an established species from, an environment; *e.g., zebra mussel, carp and the Eurasian milfoil in Canada's lakes, purple loosestrife in Alberta, the horse or the buffalo in the plains region of Alberta*.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

20–D1.1sts describe how society provides direction for scientific and technological development **(SEC4) [ICT F2–4.4]**
- *discuss public support of scientific work on predator-prey relationships as part of wildlife management in national and provincial parks (introduction of wolves, for example)*

20–D1.2sts explain that society and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F2–4.8, F3–4.1]**
- *discuss, in terms of scientific principles, how reforestation projects change the direction of secondary succession in a natural ecosystem*
- *assess the long-term implications of fire control and prevention on population and ecosystem stability, diversity and productivity*
- *assess habitat loss and the responsibility of society to protect the environment for future generations*
- *analyze the need for habitat reclamation, such as recreating wetlands and swamps, forests, and prairie grasslands, and describe steps to ensure species diversity.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze ecosystems and ecological succession in the local area and describe the relationships and interactions among subsystems and components.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

20–D1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design a model to explain the relationship between populations of predator and prey, outlining the characteristics of each that adapt them to their trophic level* **(IP–NS2)**
- *inquire into the effect of logging on predation levels of deer as well as on food sources for deer* **(IP–NS1)**
- *design an experiment and identify specific variables to investigate relationships between biotic and abiotic elements of a micro-ecosystem* **(IP–NS2)**
- *evaluate and select appropriate procedures and technology to measure the impact of introducing species X into a specific environment* **(IP–NS4) [ICT C6–4.5]**.

Performing and Recording

Students will:

20–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform a field study; measure, qualitatively and quantitatively, appropriate biotic and abiotic factors in the aquatic or terrestrial ecosystem chosen; and present data in a form that describes, in general terms, the structure of the ecosystem; *e.g., pH, temperature, precipitation, water hardness, turbidity, dissolved oxygen content, humidity, wind, light intensity, soil composition, plants, animals, micro-organisms* **(PR–NS4) [ICT C6–4.2]**
- *use library and electronic research tools to collect information on a given topic, such as:*
  - *protection of the environment as a priority over economic interest*
  - *endangered species of the world*
  - *the Convention on Biological Diversity*
  - *sustainable development initiatives* **(PR–NS4) [ICT C1–4.1, C3–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze ecosystems and ecological succession in the local area and describe the relationships and interactions among subsystems and components.

Analyzing and Interpreting

Students will:

20–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- analyze field study data to identify the interrelationships of biotic and abiotic components of the ecosystem studied; *e.g., dominant plants, micro-climates and habitats, niches and interrelationships of biota* **(AI–NS1, AI–NS2) [ICT C7–4.2]**
- *tabulate, graph and interpret relevant data collected from observations of succession in a micro-climate (hay infusion, for example)* **(AI–NS2) [ICT C6–4.3]**
- *analyze statistical data in diagrams, tables and graphs as part of a briefing for a public hearing on a proposed mineral exploration in an ecologically or a culturally sensitive area* **(AI–NS2, AI–NS3, AI–NS4) [ICT C7–4.2]**
- *analyze the information presented by opposing sides on an environmental issue, such as that of an environmental group and that of an industry representative, to determine bias* **(AI–NS4, AI–SEC1) [ICT C2–4.1, C2–4.2]**
- *identify new questions that arise from investigations, such as: "Should naturally occurring forest fires be fought?"* **(AI–NS5)**.

Communication and Teamwork

Students will:

20–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *elicit feedback from others on an environmental issue* **(CT–NS1)**
- *participate in a variety of electronic group formats to gather and share information about environmental issues* **(CT–NS1) [ICT C5–4.2]**
- *prepare a visual display that explains initiatives undertaken by industry to protect the environment* **(CT–NS2) [ICT P4–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze and investigate the cycling of matter and the flow of energy through the biosphere and ecosystems as well as the interrelationship of society and the environment.

Specific Outcomes for Knowledge

Students will:

20–D2.1k outline the biogeochemical cycles of nitrogen, carbon, oxygen and water and, in general terms, describe their interconnectedness, building on knowledge of the hydrologic cycle from Science 10, Unit D

20–D2.2k describe artificial and natural factors that affect the biogeochemical cycles:

- nitrogen cycle; *e.g., automobile, agricultural and industrial contributions to NO_x combining with water to produce nitric acid, nitrogen in manure and fertilizers*
- carbon cycle; *e.g., emissions of carbon oxides from extraction, distribution and combustion of fossil fuels, releases associated with deforestation and cement industries*
- water cycle; *e.g., extraction of ground water, dams for hydro-electricity and irrigation*

20–D2.3k analyze and describe how energy flows in an ecosystem, using the concepts of conservation of energy (second law of thermodynamics); energy input and output through trophic levels, food webs, chains and pyramids; and specific examples of autotrophs and heterotrophs

20–D2.4k explain why population size and biomass are both directly related to the trophic level of the species and explain how trophic levels can be described in terms of pyramids of numbers, biomass or energy.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

20–D2.1sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F2–4.8, F3–4.1]**

- *assess whether the efforts to reduce human impact on biogeochemical cycles are viable, taking into consideration a variety of perspectives (considerations for deep-well and deep-ocean injection of wastes, for example, include properties of waste, concentration, uncertainty, environmental concerns, risks and benefits to human health and organisms, costs)*
- *evaluate the influence of society, and the impact of a variety of technologies, on the nitrogen cycle*
- *discuss the use of water by society, the impact such use has on water quality and quantity in ecosystems, and the need for water purification and conservation, considering such things as manufacturing, the oil industry, agricultural systems, the mining industry and domestic daily water consumption*

20–D2.2sts explain that science and technology are developed to meet societal needs and expand human capabilities **(SEC1) [ICT F2–4.8]**

- *contrast the diet of people in developing countries and that of people in developed countries in terms of energy efficiency and environmental impact, and describe ways to address potential food shortages in the future.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze and investigate the cycling of matter and the flow of energy through the biosphere and ecosystems as well as the interrelationship of society and the environment.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

20–D2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design an investigation to compare the carbon dioxide production of plants with that of animals* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**
- *hypothesize how alternations in the carbon cycle as a result of the burning of fossil fuels might affect other biogeochemical cycles (sulfur, iron and water, for example)* **(IP–NS3)**
- *predict disruptions in the nitrogen cycle that are caused by human activities* **(IP–NS3)**.

Performing and Recording

Students will:

20–D2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- draw, by hand or using technology, annotated diagrams of energy flow in food chains, webs and pyramids **(PR–NS4)**.

Analyzing and Interpreting

Students will:

20–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- describe alternative ways of presenting energy-flow data for ecosystems: pyramid of biomass, of numbers or of energy **(AI–NS4, AI–NS5, AI–NS6)**
- *evaluate the relevance, reliability and adequacy of data and data-collection methods, including assessing the authority, reliability and validity of electronically accessed information* **(AI–NS4) [ICT C3–4.1, C3–4.2]**
- *evaluate the appropriateness of a technology, such as deep-well injection of wastes, to solve a problem* **(AI–SEC2) [ICT C6–4.5]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze and investigate the cycling of matter and the flow of energy through the biosphere and ecosystems as well as the interrelationship of society and the environment.

Communication and Teamwork

Students will:

20–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within a word processor to insert tables, graphs, text and graphics in food webs and energy budgets for various trophic levels in an ecosystem* **(CT–NS2) [ICT P4–4.3]**
- *make arguments on an issue such as the expansion of housing and other amenities in Banff National Park or Jasper National Park* **(CT–SEC3) [ICT C2–4.1, C7–4.2]**
- *work cooperatively in a group to investigate the influence of human activities on the biogeochemical cycles and, using appropriate multimedia, present the findings* **(CT–SEC1, CT–SEC2) [ICT P3–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze and describe the adaptation of organisms to their environments, factors limiting natural populations, and evolutionary change in an ecological context.

Specific Outcomes for Knowledge

Students will:

20–D3.1k describe mutation as the principal cause for variation of genes in species and populations, identify the role of sexual reproduction in generating variability among individuals and describe the forces that drive evolution

20–D3.2k describe the adaptation of species over time due to variation in a population, population size and environmental change; *e.g., bacterial resistance to antibiotics, giraffe neck length, gazelle speed*

20–D3.3k describe evidence for evolution by natural selection; *e.g., fossils, biogeography, embryology, homologous and vestigial structures, biochemical research*

20–D3.4k compare gradual evolution with punctuated equilibrium

20–D3.5k describe how factors including space, accumulation of wastes (*e.g., salinization of soil*), competition, technological innovations, irrigation practices (*e.g., Hohokam farmers*) and the availability of food impact the size of populations

20–D3.6k compare the growth pattern of the human population to that of other species.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–D3.1sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence through investigation and the ability to provide explanations **(NS2)**

- *discuss the nature of science as a way of knowing, considering the contributions of Buffon, Lyell, Malthus and Wallace to the theory of evolution*
- *describe how paleontology has provided invaluable data in the attempt to explain observable variations in organisms (horse, fish) over time*
- *compare Lamarckian and Darwinian explanations of evolutionary change*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze and describe the adaptation of organisms to their environments, factors limiting natural populations, and evolutionary change in an ecological context.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–D3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design an investigation to measure or describe an inherited variation in a plant or an animal population* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

20–D3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- gather data, actual or simulated, on organisms to demonstrate how inherited characteristics change over time; *e.g., Darwin's finches, bacteria, domestic plants and animals* **(PR–NS1, PR–NS4)**.

Analyzing and Interpreting

Students will:

20–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- analyze data, actual or simulated, on organisms to demonstrate how inherited characteristics change over time; *e.g., Darwin's finches, bacteria, domestic plants and animals* **(AI–NS2) [ICT C7–4.2]**
- demonstrate and assess the effect of environmental factors on population growth curves **(AI–NS2, AI–NS6) [ICT C7–4.2]**
- *use calculated or actual data to graph the growth of populations that demonstrate exponential growth and logistic growth* **(AI–NS2) [ICT C6–4.2, C6–4.3]**
- *apply the growth curve for open populations to identify the long-term impact on Earth's carrying capacity and the demands on natural resources for a growing human population* **(AI–NS2, AI–NS4, AI–NS6)**
- *analyze the processes governing the growth pattern of human populations that are different from those governing naturally occurring populations* **(AI–NS2) [ICT C7–4.2]**.

Communication and Teamwork

Students will:

20–D3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *discuss Darwin's impact on modern science and society* **(CT–NS1)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

SCIENCE 30

Science 30 consists of four units of study:

A. Living Systems Respond to Their Environment
B. Chemistry and the Environment
C. Electromagnetic Energy
D. Energy and the Environment

Attitude Outcomes

Students will be encouraged to develop positive attitudes that support the responsible acquisition and application of knowledge related to science and technology. The following attitude outcomes are to be developed throughout Science 30, in conjunction with the specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills in each unit.

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.,*

- *research the answers to questions they generate*
- *explore and use a variety of methods and resources to increase their knowledge and skills*
- *be critical and constructive when considering new theories and techniques*
- *use scientific vocabulary and principles in everyday discussions*
- *recognize the usefulness of being skilled in mathematics and problem solving*
- *be interested in science and technology topics not directly related to their formal studies*
- *recognize the importance of making connections between various science disciplines*
- *maintain interest in pursuing further studies in science*
- *explore where further science- and technology-related studies and careers can be pursued*
- *recognize that part-time jobs require science- and technology-related knowledge and skills.*

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.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *research carefully and discuss openly ethical dilemmas associated with the applications of science and technology*
- *explore personal perspectives, attitudes and beliefs toward scientific and technological advancements*
- *recognize the contribution of science and technology to the progress of civilizations*
- *show support for the development of technologies and science as they relate to human needs*
- *recognize that the scientific approach is one of many ways of viewing the universe*
- *recognize the research contributions of both men and women*
- *recognize the research contributions of Canadians*.

Scientific Inquiry

Students will be encouraged to:
seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *consider the social and cultural contexts in which a theory developed*
- *appreciate how scientific problem solving and the development of new technologies are related*
- *insist on evidence before accepting a new idea or a new explanation*
- *assess, critically, their opinion of the value of science and its applications*
- *question arguments in which evidence, explanations or positions do not reflect the diversity of perspectives that exist*
- *criticize arguments that are based on faulty, incomplete or misleading use of numbers*
- *recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen*
- *insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged*
- *evaluate inferences and conclusions, being cognizant of the many variables involved in experimentation*
- *ask questions and conduct research to ensure understanding*
- *expend the effort and time needed to make valid inferences*
- *seek new models, explanations and theories when confronted with discrepant events.*

Collaboration

Students will be encouraged to:
work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *provide the same attention and energy to the group's product as they would to a personal assignment*
- *be attentive when others speak, seek the point of view of others, and consider a multitude of perspectives*
- *use appropriate communication technology to elicit feedback from others*
- *participate in a variety of electronic group formats.*

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.,*

- *assume part of the collective responsibility for the impact of humans on the environment*
- *participate in civic activities related to the preservation and judicious use of the environment and its resources*
- *encourage their peers or members of their community to participate in a project related to sustainability*
- *consider all perspectives when addressing issues, weighing scientific, technological and ecological factors*
- *discuss both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans*
- *participate in the social and political systems that influence environmental policy in their community*
- *promote actions that are not injurious to the environment*

- *make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations*
- *be critical-minded regarding the short- and long-term consequences of sustainability*.

Safety

Students will be encouraged to:
show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information; *e.g.,*

- *consider safety a positive limiting factor in scientific and technological endeavours*
- *read the labels on materials before using them, interpret the WHMIS symbols and consult a reference document if safety symbols are not understood*
- *manipulate materials carefully, being cognizant of the risks and consequences of their actions*
- *assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials according to safety guidelines*
- *seek assistance immediately for any first aid concerns, such as cuts, burns or unusual reactions*
- *keep the work station uncluttered, ensuring that only appropriate laboratory materials are present*
- *criticize a procedure, a design or materials that are not safe or that could have a negative impact on the environment*
- *use safety and waste disposal as criteria for evaluating an experiment*
- *write safety and waste-disposal precautions into a laboratory procedure*.

Unit A: Living Systems Respond to Their Environment

Themes: Energy, Equilibrium, Matter and Systems

Overview: The human body continually interacts with the external environment. In this unit, students learn that the circulatory system assists in this interaction between the blood cells and the external environment and, in combination with the immune system, defends the body against pathogens. Students apply the principles of heredity and molecular genetics to explain human disorders and to assess the risks and benefits of genetic technologies.

This unit builds on:

- Science 10, Unit C: Cycling of Matter in Living Systems
- Science 20, Unit D: Changes in Living Systems

Unit A will require approximately 25% of the time allotted for Science 30.

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

Topics:	These topics may be found in the following courses:
• probability	Applied Mathematics 30, specific outcomes 2.4, 2.5, 2.6 and 2.7
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: How do the structure and function of the human circulatory system help to maintain human health? What are the defense mechanisms of the human body? What are the basic principles of Mendelian genetics and how can they be applied to treat genetic diseases? What are the risks, benefits and associated ethical issues of current genetic technology?

General Outcomes: There are three major outcomes in this unit.

Students will:

1. analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health
2. analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment
3. apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the learning outcomes.

- structure and function of the circulatory system
- composition of human blood tissue and the role of blood
- immune response and defense mechanisms to pathogens
- cardiovascular health
- chromosomal behaviour
- principles of Mendelian genetics
- deoxyribonucleic acid DNA and protein synthesis
- mutations and gene therapy

General Outcome 1
Students will analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health.

Specific Outcomes for Knowledge

Students will:

30–A1.1k describe the principal structures and associated blood vessels of the heart; i.e., ventricles, atria, septum, valves (specific names of valves not required), aorta, vena cavae, pulmonary arteries and veins, coronary arteries

30–A1.2k describe the rhythmic contraction of the heart and its function in the general circulation of blood through pulmonary and systemic pathways

30–A1.3k describe the structure and function of blood vessels and the flow of blood through arteries, arterioles, venules, veins and capillaries

30–A1.4k describe the main components of blood (i.e., plasma, red blood cells, white blood cells, platelets, blood proteins that include antibodies, hemoglobin and hormones) and their role in the transportation of substances (e.g., nutrients, wastes, gases, hormones), blood clotting, the defence against pathogens and the distribution of thermal energy.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–A1.1sts describe how society provides direction for scientific and technological development **(SEC4) [ICT F2–4.4, F2–4.8]**

- *investigate and explain the relationship between exercise, lifestyle, diet, gender and cardiovascular health by examining blood pressure, heart rate and cholesterol levels*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–A1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to determine the effects of exercise, emotion, gender or chemicals such as caffeine on blood pressure and heart rate **(IP–NS2) [ICT C7–4.2]**.

Performing and Recording

Students will:

30–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- measure resting heart rate and blood pressure and determine the effects of exercise on both factors **(PR–NS2, PR–NS3)**
- observe prepared slides or electronic images of human blood **(PR–NS2) [ICT C1–4.2]**
- *perform a heart dissection to identify the major parts and to determine the directional flow of blood through the organ* **(PR–NS2, PR–NS4)**
- *use computer software or video programs to view the mechanics of heart function and associated blood flow including the functioning of the valves that control venous blood flow* **(PR–NS1) [ICT C6–4.4]**.

Analyzing and Interpreting

Students will:

30–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- map blood flow through a mammalian heart **(PR–NS4)**
- *research and plot the relationship between heart rate and the size of an organism* **(AI–NS2) [ICT C1–4.1, C6–4.3, C7–4.2]**
- *evaluate the validity of the hypothesis that blood flow can be explained on the basis of tidal forces* **(AI–NS6)**
- *extrapolate the number of heartbeats per year, or the volume of blood circulated in a year, based on their resting heart rate* **(AI–NS3) [ICT C6–4.1]**
- *compare a healthy person, an athlete and a person with cardiac disease in terms of oxygen demand, cardiac output and vessel blockage, using a simulation* **(AI–NS2, AI–NS6) [ICT C7–4.2, F1–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze how the human circulatory system facilitates interaction between blood cells and the external environment and investigate cardiovascular health.

Communication and Teamwork

Students will:

30–A1.4s work collaboratively in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate International System of Units (SI) notation, fundamental and derived units and significant digits **(CT–NS2)★**
- use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results **(CT–NS2)★**
- *select and use multimedia capabilities to present findings on the influential role of various factors such as lifestyle and genetics on blood pressure* **(CT–NS2) [ICT C1–4.4, C7–4.3, P3–4.1, P6–4.1]**.

★To be developed throughout the course.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment.

Specific Outcomes for Knowledge

Students will:

30–A2.1k describe how pathogens in the environment *(e.g., mosquito-borne parasites, bacteria, viruses)* enter the circulatory system and may have an adverse affect on health

30–A2.2k describe, in general terms, the function of various body mechanisms, including the skin and body secretions (i.e., tears and stomach acid), in preventing pathogens from entering body tissues

30–A2.3k describe, in general terms, how immunity to pathogens develops, how the immune system responds to a foreign antigen and the roles of macrophages, B cells, helper T cells, killer T cells, suppressor T cells, memory cells and antibodies

30–A2.4k explain the interrelationship of autoimmune diseases and the human immune system; *e.g., multiple sclerosis, arthritis, lupus*

30–A2.5k analyze how vaccines defend against disease-causing bacteria and viruses.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–A2.1sts describe how society provides direction for scientific and technological development **(SEC4) [ICT F2–4.4, F2-4.8]**

- *describe how vaccination programs are beneficial in controlling epidemics or dealing with concerns about the spread of possible infection, such as tetanus, smallpox and influenza*
- *describe how improvements to sanitation, personal hygiene and the availability of potable water have greatly reduced the incidence of communicable diseases and discuss the ongoing need for vigilance and research into modes of transmission of such diseases as typhoid, cholera and gastrointestinal diseases.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze the defense mechanisms used by the human body to protect itself from pathogens found in the external environment.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–A2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *select appropriate procedures and instruments to investigate the various ways the human body protects itself from diseases* **(IP–NS4) [ICT C6–4.4, C6–4.5]**
- *design a study to test the effectiveness of a drug, incorporating the use of a placebo into a double-blind study* **(IP–NS1, IP–NS2, IP–NS4)**.

Performing and Recording

Students will:

30–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *conduct research and synthesize information on the various ways the human body protects itself from diseases* **(PR–NS1) [ICT C7–4.2]**
- *perform a biogeographical study to compare the incidence of disease, such as West Nile encephalitis, Ebola hemorrhagic fever or leprosy (Hansen's disease), in different regions of the world* **(PR–NS1) [ICT C7–4.2]**
- *simulate an immune response, using a model and/or computer simulation* **(PR–NS3)**.

Analyzing and Interpreting

Students will:

30–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *evaluate research on the development of a vaccine for the human immunodeficiency virus (HIV)* **(AI–SEC1)**
- *evaluate the use of anecdotal versus statistical evidence in validating a scientific interpretation or conclusion* **(NS5d, AI–NS4) [ICT C2–4.2]**
- *evaluate implications of findings to questions, such as why some individuals choose not to be vaccinated or why the incidence of tuberculosis is rising* **(AI–SEC4)**
- *assess both ethical and practical implications of using animals to test a drug or treatment intended for human application* **(AI–SEC4)**.

Communication and Teamwork

Students will:

30–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *select and use multimedia capabilities to present findings on the effectiveness of vaccination on specific forms of disease, such as tuberculosis* **(CT–NS2) [ICT C1–4.4, C7–4.3, P3–4.1, P6–4.1].**

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

Specific Outcomes for Knowledge

Students will:

30–A3.1k describe, in general, the behaviour of chromosomes during mitosis, meiosis and fertilization

30–A3.2k explain, with the aid of Punnett squares, the inheritance of single traits by applying current understanding of the gene, segregation and dominance

30–A3.3k distinguish autosomal from sex-linked patterns of inheritance

30–A3.4k describe the structure of DNA by:
- identifying the structure of DNA as a double helix
- listing the essential components of DNA as nucleotides
- identifying the base pairings between the strands of the double helix

30–A3.5k explain the general process of DNA replication

30–A3.6k describe a primary function of DNA by describing how an amino acid sequence of a polypeptide (protein) is determined by the sequence of DNA triplet codes, i.e., use of a table of DNA triplets matched with amino acids

30–A3.7k describe the role of proteins in the human body as regulatory molecules (enzymes), as structural molecules and as a source of energy

30–A3.8k describe how mutations in DNA affect the proteins produced resulting in human diseases; *e.g., sickle-cell anemia, hemophilia, Huntington's disease, cystic fibrosis*

30–A3.9k describe, in general terms, genetic engineering and its application to gene therapy and the development of genetically modified organisms

30–A3.10k describe the development of resistance in bacteria and viruses, based on the concepts of mutation, plasmid transfer, transformation and natural selection.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–A3.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.8]**
- *explore the potential medical and ethical implications of the Human Genome project and other genome sequencing projects on society*
- *trace the development of plant and animal breeding techniques, starting with traditional practices (e.g., Hopi/Huron/Iroquois maize breeding), to Mendel's work on inheritance, to the contributions of many scientists on the discovery of the molecular structure of DNA and the development of recombinant DNA technology*

30–A3.2sts explain that decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations **(SEC4b)**
- assess the risks and benefits of genetic technology and the need for ethical considerations; *e.g., stem-cell research, access to genetic screening, genetically modified organisms.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–A3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *make predictions about the probability of inheriting specific traits* **(IP–NS3) [ICT C6–4.1]**
- *define a testable question that would show environmental influences on diseases, such as type 2 diabetes, in different populations* **(IP–NS1)**
- *devise an experimental procedure to investigate a characteristic of an organism acquired through genetic engineering, such as genetically modified canola, corn or soybean* **(IP–NS4)**.

Performing and Recording

Students will:

30–A3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- investigate, with the aid of a pedigree chart, the familial inheritance of a specific trait that is controlled by a single pair of genes **(PR–NS2)**
- *collect data on the frequency of hereditary diseases such as sickle cell anemia or Tay-Sachs disease in different populations of people* **(PR–NS1) [ICT C7–4.2]**
- *research, integrate and synthesize information on the relationship between mutagens found in the environment and the rate of mutation* **(PR–NS1) [ICT C7–4.2]**
- *research the relationship between the virulence of a pathogen and the degree of genetic heterogeneity within a population, such as the impact of disease introduced by Europeans to Indigenous North American peoples* **(PR–NS1) [ICT C7–4.2]**
- *simulate the production of proteins, using models* **(PR–NS3)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will apply the principles of heredity and molecular genetics to explain how human diseases can arise from inherited traits, the risks and benefits of genetic technology, and the need for ethical considerations in the application of scientific knowledge.

Analyzing and Interpreting

Students will:

30–A3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- interpret patterns and trends in data associated with autosomal and sex-linked inheritance **(AI–NS2) [ICT C6–4.2, C7–4.2]**
- predict, quantitatively, the probability of acquiring a particular trait in autosomal and sex-linked patterns of inheritance **(AI–NS2) [ICT C6–4.1]**
- *identify and evaluate potential applications of genetic engineering to health and agriculture* **(AI–SEC4) [ICT C2–4.1, F2–4.4]**
- *research and evaluate the long-term effect of the use of antibacterial soaps and antibiotics on bacterial populations* **(AI–NS2) [ICT C6–4.1, C7–4.2]**.

Communication and Teamwork

Students will:

30–A3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *work cooperatively to investigate the inheritance of a human trait that is controlled by a single pair of genes, such as tongue rolling, attached earlobes* **(CT–NS1, CT–NS2)**
- *research, present and defend a position on genetically modified organisms* **(CT–SEC3) [ICT C1–4.4]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit B: Chemistry and the Environment

Themes: Change, Energy, Systems

Overview: In maintaining quality of life, society is becoming increasingly reliant upon chemical substances of life. These chemicals and their by-products can also adversely affect the environment and living systems. A knowledge of chemistry is essential to fully understand the benefits and risks of chemicals to humankind and in monitoring the emission of these substances into the environment. In this unit, students examine the impacts of acids and bases, organic compounds and air pollutants on aquatic and terrestrial ecosystems.

This unit builds on:
- Science 10, Unit A: Energy and Matter in Chemical Change
- Science 20, Unit A: Chemical Changes

Unit B will require approximately 25% of the time allotted for Science 30.

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

Topics:	These topics may be found in the following courses:
• nonlinear equations	Pure Mathematics 10, specific outcomes 3.1 and 4.2; Pure Mathematics 20, specific outcome 3.1; Pure Mathematics 30, specific outcome 2.4; Applied Mathematics 10, specific outcomes 3.1, 3.2, 3.3 and 5.1; Applied Mathematics 20, specific outcomes 2.1, 2.3 and 2.4
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: What are some of the important effects of acids, bases and synthetic organic compounds on the environment and living systems? What are the chemical principles and perspectives involved in the assessment of the technologies designed to reduce the production and emission of these compounds into the environment? How does society look beyond a technological fix in deciding how to best meet human needs while sustaining the environment?

General Outcomes: There are three major outcomes in this unit.

Students will:

1. analyze the sources of acids and bases and their effects on the environment
2. analyze the sources of organic compounds and their effects on the environment
3. analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the learning outcomes.

- acids and bases
- pH and hydronium ion concentration
- stoichiometry and titration of strong monoprotic acids and strong monoprotic bases
- buffers and buffering capacity
- sources and environmental impact of SO_x, NO_x, acid deposition and photochemical smog
- sources, uses and environmental effects of organic compounds
- biomagnification and persistence of pollutants

General Outcome 1
Students will analyze the sources of acids and bases and their effects on the environment.

Specific Outcomes for Knowledge

Students will:

30–B1.1k define acids and bases in terms of proton donors and proton acceptors

30–B1.2k differentiate among acids, bases, neutral ionic compounds, neutral molecular compounds and strong and weak acids, based on appropriate diagnostic tests

30–B1.3k describe the relationship between pH and hydronium ion concentration

30–B1.4k explain, qualitatively, how buffers maintain a relatively constant pH when a small amount of acid or base is added to an aqueous system

30–B1.5k explain the importance of maintaining a relatively constant pH in a living system; *e.g., the role of the hydrogen carbonate ion in maintaining the pH of blood, the evolution of the Arctic herb Artemisia tilesii in resisting acidic moisture by extracting calcium from the soil and pumping the calcium to its leaves*

30–B1.6k trace the historical use of acid-base indicators; *e.g., early Aboriginal methods of using extracts from natural substances*

30–B1.7k explain what is meant by buffering capacity; *e.g., soil or bedrock*

30–B1.8k outline the chemical reactions (*e.g., combustion reactions*) that produce air pollutants (i.e., sulfur dioxide and nitrous oxides) that, when combined with water, ultimately result in acid deposition

30–B1.9k describe impacts on the biotic and abiotic components of the environment caused by acid deposition; *e.g., lowered pH in water systems, accelerated corrosion, metal leaching from bedrock, the impact of leached metals on plants and the food chain*.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–B1.1sts demonstrate an understanding that science and technology developed to meet societal needs and expand human capacity **(SEC1) [ICT F2–4.4, F2–4.8]**

- describe, in general terms, the uses of acids and bases in industry; *e.g., hydrochloric acid used to extract metals from ores; sulfuric acid used to make fertilizers, paints, plastics, dyes and detergents; and sodium hydroxide used to make soaps and drain and oven cleaners*

30–B1.2sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- identify and explain how human activities and natural events contribute to acid deposition in the environment.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will analyze the sources of acids and bases and their effects on the environment.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–B1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues
- design a procedure to identify acidic, basic, neutral ionic and molecular solutions **(IP–ST3) [ICT C6–4.1, C6–4.4]**
- design an experiment for determining the buffering capacity of local soil or pond samples **(IP–NS4) [ICT F1–4.2]**.

Performing and Recording

Students will:

30–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information
- use a pH meter and/or pH paper and indicators to measure the pH of solutions; *e.g., collect pH data to study an aquatic ecosystem* **(PR–NS2) [ICT C6–4.4]**
- use indicators and a conductivity meter to differentiate between a strong acid and a weak acid **(PR–NS3, PR–NS5) [ICT C6–4.4]**
- perform a titration using a strong monoprotic acid and a strong monoprotic base **(PR–NS2) [ICT C6–4.4]**
- *use computer-based probes and/or a graphing calculator to measure the pH of water and/or aqueous solutions* **(PR–NS2) [ICT C6–4.4, P2–4.1]**.

Analyzing and Interpreting

Students will:

30–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- use titration data to determine the concentration of a strong acid or a strong base **(PR–NS2, PR–NS3) [ICT C6–4.2]**
- research and plot on a map the distribution patterns of acid deposition as influenced by prevailing winds **(A1–ST4) [ICT C6–4.3]**
- calculate pH from hydronium ion concentration and hydronium ion concentration from pH **(AI–NS3)**
- calculate the concentration of strong monoprotic acids and strong monoprotic bases from empirical data **(AI–NS3)**.

Communication and Teamwork

Students will:

30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results
- compare collected titration data with that of other individuals and groups **(CT–NS3)**
- use appropriate scientific conventions when communicating solutions to titration problems **(CT–ST2) [ICT F1–4.3]**
- *research protocols for transporting acidic and caustic materials through populated areas* **(CT–SEC4)**
- *prepare a group visual display explaining initiatives taken by industry to reduce emissions that can cause acid deposition* **(CT–SEC2) [ICT C1–4.4, P4–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze the sources of organic compounds and their effects on the environment.

Specific Outcomes for Knowledge

Students will:

30–B2.1k identify and name carbon compounds, using International Union of Pure and Applied Chemistry (IUPAC) nomenclature that contain up to three carbon atoms in the parent chain and a single occurrence of one type of functional group, including simple halogenated hydrocarbons *(e.g., 2-chloropropane)*, alcohols *(e.g., propan-1-ol)*, carboxylic acids *(e.g., propanoic acid)* and esters *(e.g., methyl propanoate)*

30–B2.2k describe the common uses of hydrocarbons, including simple halogenated hydrocarbons, alcohols, carboxylic acids and esters; *e.g., chlorofluorocarbons (CFCs) as refrigerants, as propellants and in the manufacture of plastic foam products; ethanol as a solvent and as a gasoline additive; ethanoic acid as vinegar; ethyl ethanoate as nail-polish remover*

30–B2.3k identify organic compounds commonly considered to be environmental pollutants; i.e., hydrocarbons, organic waste, CFCs, polychlorinated biphenyls (PCBs), dioxins and furans

30–B2.4k list the sources of, and analyze the hazards posed by, halogenated hydrocarbons and benzene derivatives

30–B2.5k identify and explain how human activities and natural events contribute to the production of photochemical smog, the depletion of the ozone layer and increased concentrations of organic compounds in the environment; *e.g., driving a car, use of CFCs, agricultural practices*

30–B2.6k explain the mechanism and significance of biomagnification.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–B2.1sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F2–4.8, F3–4.1]**

- explain how the introduction of environmental contaminants, i.e., herbicides, pesticides, dichlorodiphenyltrichloroethane (DDT), CFCs, $SO_2(g)$, $CO_2(g)$, particularly persistent organic pollutants (POPs), affects living systems globally
- interpret information describing biomagnification and environmental persistence of organic pollutants on biological systems; *e.g., lethal dose (LD, LD 50), PCBs, DDT*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will analyze the sources of organic compounds and their effects on the environment.

Specific Outcomes for Skills (Social and Environmental Emphasis)

Initiating and Planning

Students will:

30–B2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design an investigation of alternatives to the use of pesticides or herbicides* **(IP–ST2) [ICT C2–4.1]**
- *predict the impact of synthetic organic compounds on a local aquatic or terrestrial ecosystem* **(IP–NS3)**.

Performing and Recording

Students will:

30–B2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *search and record initiatives designed to reduce the impact of halogenated hydrocarbons on the environment* **(PR–SEC1)**
- *investigate the action of a pesticide or herbicide, considering toxicity, volatility, target specificity and resistance development* **(PR–SEC1)**
- *prepare a synthetic organic compound (e.g., an alcohol, an ester or a soap) and investigate its properties* **(PR–NS3)**.

Analyzing and Interpreting

Students will:

30–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use current reliable information sources to analyze technologies used to reduce the release of POPs into the environment **(A1–ST4) [ICT C7–4.2]**.

Communication and Teamwork

Students will:

30–B2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *develop a plan to study the impact of organic compounds on an aquatic or a terrestrial ecosystem and make revisions, based on group feedback, before implementing the plan* **(CT–SEC1, CT–SEC4)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

Specific Outcomes for Knowledge

Students will:

30–B3.1k describe the risks and benefits of using chemical processes that may produce products and/or by-products that have the potential to harm the environment

30–B3.2k describe technologies used to reduce the production and emission of chemical compounds that have the potential to harm the environment; *e.g., activities related to internal combustion engines, smelting, pesticide production, sweetening of sour gas*

30–B3.3k describe alternatives to the use of chemical technologies; *e.g., bioremediation for contaminated soil, biological controls for pests, biodegradable products.*

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–B3.1sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F2–4.8, F3–4.1]**

- explain the role of concentration in a risk-benefit analysis for determining the safe limits of particular substances; *e.g., pesticide residues, chlorinated or fluorinated compounds*

30–B3.2sts explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability (**ST7**) **[ICT F2–4.2, F3–4.1]**

- *explain the meaning of technological fix and explain the need for broader considerations in reducing the environmental impact of the by-products of chemical processes*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

30–B3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- plan an evaluation, including a risk-benefit analysis, of a chemical process or an issue related to its use **(IP–SEC2) [ICT F3–4.1]**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with references to WHMIS and consumer product labelling information **(IP–SEC3) [ICT F5–4.2]**
- *hypothesize about seasonal variations in water quality in the community* **(IP–NS3) [ICT C7–4.2]**.

Performing and Recording

Students will:

30–B3.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- debate the issue of whether protecting the environment should have priority over economic interests **(PR–SEC1) [ICT C1–4.4, C2–4.2]**
- collect information from a wide selection of resources relating to a chemical process or an issue related to its use **(PR–SEC1) [ICT F3–4.1]**

Analyzing and Interpreting

Students will:

30–B3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- interpret data from water quality tests, such as pH, BOD, dissolved oxygen and organic compounds
- analyze alternatives to the use of chemical technologies; *e.g., bioremediation for contaminated soil, biological controls for pests, biodegradable products* **(AI–SEC2)**
- evaluate methods used to reduce the incidence of acid deposition and photochemical smog; *e.g., reducing sulfur content in fuels, using catalytic converters in automobiles, smokestack scrubbers* **(AI–SEC2)**
- *present statistical data in diagrams, tables and graphs as part of a briefing for a public hearing on a proposed chemical industry in an ecologically sensitive area* **(AI–ST1) [ICT P2–4.1, P4–4.3, P6–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 3
Students will analyze, from a variety of perspectives, the risks and benefits of using chemical processes in meeting human needs and assess technologies for reducing the impact of chemical compounds on the environment.

Communication and Teamwork

Students will:

30–B3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- consult and evaluate a wide variety of sources that reflect varied viewpoints on the risks and benefits of using particular chemicals; *e.g., the use of DDT in countries where malaria is a major cause of death* **(CT–SEC1) [ICT C2–4.1, C2–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit C: Electromagnetic Energy

Themes: Diversity and Energy

Overview: Electrical energy transmission and transformation technologies, based on field theory and on an understanding of electromagnetic radiation (EMR), play an important role in meeting human needs. These technologies are also useful in furthering our understanding of the universe. In this unit, students investigate the functioning of these technologies, the principles of field theory and the properties of EMR. This unit provides a foundation for further studies of electromagnetism.

This unit builds on:
- Science 9, Unit D: Electrical Principles and Technologies
- Science 10, Unit D: Energy Flow in Global Systems
- Science 20, Unit B: Changes in Motion

Unit B will require approximately 25% of the time allotted for Science 30.

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

Topics:	These topics may be found in the following courses:
• properties of linear functions	Pure Mathematics 10, specific outcome 4.6; Applied Mathematics 10 specific outcomes 5.2 and 5.7
• formula manipulation	Pure Mathematics 10, specific outcome 4.4; Applied Mathematics 10 specific outcome 5.1
• nonlinear equations	Pure Mathematics 20, specific outcome 3.1; Applied Mathematics 20, specific outcome 2.1

Focusing Questions: How can field theory be used to explain the function of electrical devices in the home and in the workplace? How are the specific properties of the electromagnetic spectrum applied to medical, communication and remote-sensing technologies? How do imaging technologies reveal the structure and the history, and shape our understanding, of the universe?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explain field theory and analyze its applications in technologies used to produce, transmit and transform electrical energy
2. describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the learning outcomes.
- devices based on electric and magnetic fields (electric motors, generators and transformers)
- the electromagnetic spectrum, its properties and its effects on living tissue
- basic properties of field theory for the comparison of gravitational, electric and magnetic fields
- principles of field theory and applications in technology
- technologies used to study the structure and history of the universe
- circuitry

General Outcome 1
Students will explain field theory and analyze its applications in technologies used to produce, transmit and transform electrical energy.

Specific Outcomes for Knowledge

Students will:

30–C1.1k define a field as a property of space around a mass, an electric charge or a magnet that causes another mass, electric charge or magnet introduced in to this region to experience a force

30–C1.2k compare the interaction between static electric charges with the interaction between magnetic poles and with the interaction between two masses at a distance

30–C1.3k compare the basic properties (source, direction and strength) of vector fields (gravitational, electric and magnetic), as determined by a test object

30–C1.4k describe gravitational and electric field strength at a given distance from a mass or a point charge, using the equations $\left|\vec{g}\right| = Gm / r^2$ and $\left|\vec{E}\right| = kq / r^2$

30–C1.5k describe the effect of a conductor moving through a magnetic field and inducing an electrical current

30–C1.6k describe the relationships, for up to three resistors, among power, current, voltage and resistance for series and parallel circuits, using the equations $V = IR$, $P = VI$, $P = I^2R$, $R_T = R_1 + R_2 + R_3$, and $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

30–C1.7k describe electrical energy in kilowatt hours and joules, using the equation $E_e = Pt$ for electrical energy and the equation $P = VI$ for power

30–C1.8k distinguish between alternating current (AC) and direct current (DC) in terms of electron flow and electric field

30–C1.9k describe the operation of a transformer, in terms of the relationship among current, voltage and the number of turns in the primary and secondary coils, using the equation $N_p / N_s = V_p / V_s = I_s / I_p$

30–C1.10k describe the advantage of AC over DC for transmitting and using electrical energy

30–C1.11k compare the general design and function of a DC electric motor and a generator

30–C1.12k describe, in terms of design and electrical energy, the functioning of safety technologies; *e.g., circuit fuses and breakers, polarized plugs and ground wiring*.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–C1.1sts explain that the goal of technologies, based on the application of field theory, is to provide solutions to practical problems (**ST1**) **[ICT F2–4.4, F2–4.8]**

- describe, in general terms, examples of technological devices based on electrical current and describe their impact on daily life; *e.g., light bulbs, electrical devices and electromagnets in the home, the workplace and in industry*
- describe, in general terms, examples of technological devices based on electric and magnetic fields and describe their impact on daily life; *e.g., telephones, cellular telephones, CD players, photocopiers, electrostatic filters and scrubbers*

30–C1.2sts explain that technological development may involve the creation of prototypes, the testing of prototypes and the application of knowledge from related and interdisciplinary fields **(ST2) [ICT C6–4.5, F2–4.8]**

- *explain the significance of a simple electric generator or motor in society*
- *investigate the use of nanotubes in the production of wires to transmit electricity*.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain field theory and analyze its applications in technologies used to produce, transmit and transform electrical energy.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–C1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- evaluate and select appropriate instruments for measuring current, voltage and resistance **(IP–ST3) [ICT C6–4.4, C6–4.5, F1–4.2]**
- design an experiment and identify specific variables to measure current, voltage and resistance **(PR–NS4) [ICT C6–4.1]**.

Performing and Recording

Students will:

30–C1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- investigate the interactions between static electric charges, between magnetic poles and between two masses **(PR–NS3)**
- construct an electric circuit to measure current, voltage and resistance, using a voltmeter or an ammeter **(PR–NS3) [ICT F1–4.2]**
- construct a simple electric generator or a DC motor **(PR–ST2)**
- draw diagrams to represent fields (*e.g., gravitational, electric or magnetic fields*), using field lines **(PR–NS4)**
- *investigate the effects of a conductor moving through a magnetic field by manipulating variables such as current, velocity and magnetic field strength* **(PR–NS2, PR–NS3)**.

Analyzing and Interpreting

Students will:

30–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- test and evaluate a self-constructed, simple electric generator or motor in terms of design, ruggedness and ability to perform a specific function **(AI–ST1)**
- calculate the values for $\left|\vec{g}\right|$ and $\left|\vec{E}\right|$, using the corresponding field-strength equations **(AI–ST3) [ICT C6–4.1]**
- calculate the resistance of series and parallel circuits for a maximum of three resistors **(AI–ST3) [ICT C6–4.1]**
- calculate values for power, current, voltage and resistance **(AI–ST3) [ICT C6–4.1]**
- calculate the value of E_e, P, t, I, V, using the related equations **(AI–ST3) [ICT C6–4.1]**
- calculate current voltage and the number of turns in the primary and secondary coils of electrical transformers **(AI–ST3) [ICT C6–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain field theory and analyze its applications in technologies used to produce, transmit and transform electrical energy.

Communication and Teamwork

Students will:

30–C1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *work cooperatively in designing and constructing a simple electric generator or motor and troubleshoot problems as they arise* **(CT–ST1)**
- *present research and defend a position, using multimedia capabilities, on the effect of high-voltage power lines in their community* **(CT–ST2) [ICT C1–4.4, C7–4.3, P3–4.1, P6–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.

Specific Outcomes for Knowledge

Students will:

30–C2.1k describe the range of the electromagnetic spectrum from long, low-frequency radio waves through microwaves, infrared (IR) rays, visible light rays and ultraviolet (UV) radiation to very short, high-frequency waves, such as X-rays and gamma rays

30–C2.2k compare and contrast, to each other, the various constituents of the electromagnetic spectrum, on the basis of source, frequency, wavelength and energy, and their effect on living tissue; *e.g., UV radiation on human skin and photosynthetic organisms; gamma radiation on living cells; visible light on plants, phytoplankton and humans; artificial illumination on the growth of plants*

30–C2.3k recognize that Earth's atmosphere absorbs certain frequencies of EMR

30–C2.4k investigate and describe, qualitatively, the phenomena of reflection, refraction, diffraction and polarization of visible light

30–C2.5k compare and contrast the properties of radiation, from any region of the electromagnetic spectrum, with those of visible light; i.e., wavelength, frequency, speed, reflection, refraction, diffraction, penetrability

30–C2.6k investigate and describe the relationships of the variables in the universal wave equation $v = \lambda f$

30–C2.7k explain, in general terms, the design of telescopes that are used to gather information about the universe through the collection of as much EMR as possible; i.e., reflecting and refracting optical and radio telescopes

30–C2.8k explain that nuclear fusion in the sun, represented by the equation ${}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$, produces a wide spectrum of EMR

30–C2.9k describe, in general terms, how a spectroscope can be used to determine the composition of incandescent objects or substances, and the conditions necessary to produce emission (bright line) and absorption (dark line) spectra, in terms of light source and temperature

30–C2.10k describe technologies used to study stars

- spectroscopes used to analyze the distribution of energy in a star's continuous emission spectrum can be used to estimate the surface temperature of the star
- Doppler-shift technology used to measure the speed of distant stars provides evidence that the universe is expanding

30-C2.11k describe, in general terms, the evolution of stars and the existence of black holes, white dwarves and neutron stars.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–C2.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1)** **[ICT F2–4.4]**

- identify examples of technologies that apply EMR to solve medical, communication, industrial and environmental problems; *e.g., use of UV radiation to kill bacteria; diagnostic use of MRIs and X-rays; use of radio waves, microwaves, fibre optics and infrared light in communications; use of remote-sensing technologies, including telescopes, space probes and satellites, in the study of the universe*
- *describe how lenses and/or laser surgery are used to correct vision problems*
- *describe technologies developed to protect astronauts from high-energy radiation*

30–C2.2sts explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery (**ST4**) **[ICT F2–4.4, F2–4.8]**

- explain, in general terms, how EMR-detection technologies have advanced scientific knowledge of our universe and the structure of matter

30–C2.3sts explain how the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7)** **[ICT F2–4.2, F3–4.1]**

- *assess the value to society of studying the structure and the history of the universe and the expense of building telescopes, such as the Hubble, or launching space probes*
- *conduct a risk-benefit analysis regarding the use of radiation treatment for cancer or the frequency of use of EMR in medical diagnostics.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

30–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment, identifying specific variables, to investigate the reflection, refraction or polarization of visible light **(IP–NS2)**
- calculate values for any of the variables in the universal wave equation **(AI–NS3)**
- *define a question regarding the frequency and duration of exposure to EMR from use of video terminals, cellular telephones and other devices* **(IP–ST1)**
- *state the qualitative relationship among optical density (refractive index), angle of incidence and total internal reflection* **(IP–NS3)**
- *evaluate and select appropriate instruments, such as a prism, a diffraction grating, a light meter or a spectroscope, for problem solving and inquiry* **(IP–ST3)** **[ICT C6–4.5]**.

Performing and Recording

Students will:

30–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- investigate the reflection, refraction or polarization of visible light **(PR–NS3)**
- create data tables from investigations into polarization, reflection or refraction of visible light or draw diagrams to illustrate these phenomena **(PR–NS4)**
- create a summary table or a diagram of spectral lines observed from gas discharge tubes **(PR–NS4) [ICT P2–4.1]**
- *record observations of the colour changes of an incandescent object, such as a light bulb, as temperature is changed* **(PR–NS3)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the properties of the electromagnetic spectrum and their applications in medical technologies, communication systems and remote-sensing technologies used to study the universe.

Analyzing and Interpreting

Students will:

30–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- observe and analyze the various spectra of an artificial light source, using a spectroscope, prism or diffraction grating **(AI–NS2)**
- *assess the bias, reliability and validity of electronically accessed information on exposure to EMR emitted by video terminals, cellular telephones and other devices* **(AI–NS4) [ICT C2–4.2, C3–4.1, C3–4.2]**
- *propose solutions to reduce human exposure to EMR, emitted by such devices as radio telephones, laptop computers and video terminals, and identify the strengths and weaknesses of each solution* **(AI–ST2)**
- *pose new questions, such as "What is the relationship between the polarization of light and the ability of insects to use this property to navigate?" or "How are emission and absorption spectra used in determining the spectral classification of stars?"* **(AI–ST4)**.

Communication and Teamwork

Students will:

30–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *present multiple perspectives on the value of studying the structure and history of the universe and the expense of building telescopes or launching space probes* **(CT–ST2) [ICT C1–4.4, P6–4.1]**
- *use appropriate communication technology to elicit information on recent advances in the study of the universe* **(CT–NS1) [ICT C5–4.1]**
- *participate in a variety of electronic group formats when developing criteria to assess telescopes designed to study the universe* **(CT–ST3) [ICT C5–4.2]**
- *select and use multimedia capabilities for presenting research on the effect of locating a communications tower in a community* **(CT–ST2) [ICT C1–4.4, C7–4.3, P3–4.1, P6–4.1]**
- *take and defend a position in support for or against the location of a communications tower in their local community* **(CT–ST3) [ICT C1–4.4]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit D: Energy and the Environment

Themes: Energy and Systems

Overview: Sustainable development requires balancing global energy demands with maintaining a viable biosphere. Students investigate and analyze the sources of renewable and nonrenewable energy and, in doing so, explore the need for multiple perspectives and the need to develop energy-efficient technologies. This unit provides an opportunity for students to address the demand for environmentally sustainable solutions to meet global energy needs.

This unit builds on:
- Science 10, Unit D: Energy Flow in Global Systems
- Science 20, Unit A: Chemical Changes, Unit B: Changes in Motion, Unit C: The Changing Earth and Unit D: Changes in Living Systems

Unit D will require approximately 25% of the time allotted for Science 30.

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

Topics:	These topics may be found in the following courses:
• properties of linear functions	Pure Mathematics 10, specific outcome 4.6; Applied Mathematics 10, specific outcomes 5.1, 5.2 and 5.7
• graphing quadratic functions	Pure Mathematics 20, specific outcomes 2.3 and 2.4; Applied Mathematics 20, specific outcomes 2.1 and 2.3

Focusing Questions: How can Canadians and other members of the international community conserve energy and maintain quality of life? What are the benefits and costs of available nonrenewable energy sources and of developing renewable energy sources? What is our energy future?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explain the need for balancing the growth in global energy demands with maintaining a viable biosphere
2. describe the sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal and other energy sources into useable forms.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the learning outcomes.

- global energy consumption and its impact on the biosphere
- sources of renewable energy
- balancing energy use with sustainable development
- conversion of solar energy, fossil fuels and wind and water power into thermal and electrical energy
- fission and fusion, nuclear change
- heats of formation and Hess's law
- nuclear, wind, hydro, biomass, tidal, solar, fuel cell and geothermal alternative energy technologies

General Outcome 1
Students will explain the need for balancing the growth in global energy demands with maintaining a viable biosphere.

Specific Outcomes for Knowledge

Students will:

30–D1.1k compare the energy consumption of contemporary society with that of traditional cultures and precontact Aboriginal societies, and investigate and analyze the exponential growth of global energy consumption in recent history

30–D1.2k compare Canada's per-capita energy consumption with developed and developing countries and identify factors that affect consumption; *e.g., economy, lifestyle, level of technology, geography, climate*

30–D1.3k apply the concept of sustainable development to increasing the efficient use of energy; *e.g., efficient use of energy in the home, in industry and in transportation*

30–D1.4k explain the need to develop technologies that use renewable and nonrenewable energy sources to meet the increasing global demand

30–D1.5k describe the environmental impact of developing and using various energy sources; i.e., conventional oil, oil sands, solar power, wind power, biomass, hydroelectricity, coal-burning power, nuclear power, geothermal

30–D1.6k describe how the Aboriginal perspective of an interconnected environment demonstrates the need to balance resource extraction with environmental impact.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–D1.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**

- investigate and assess the need for strategies (*e.g., co-generation, waste-energy recovery, electrical load scheduling)* and policies to increase energy efficiency as a means of balancing global energy demands with maintaining a viable biosphere.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain the need for balancing the growth in global energy demands with maintaining a viable biosphere.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

30–D1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- identify questions to investigate that arise from science- and technology-related issues; *e.g., "Which energy sources and technologies best balance the need for global energy demand with acceptable environmental impacts?"* **(IP–SEC1) [ICT F2–4.8]**
- *predict the time frame by which world oil reserves may reach near-depletion levels, based on the current rates of consumption and estimates of resources* **(IP–NS3) [ICT C7–4.2]**.

Performing and Recording

Students will:

30–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *research current information relevant to global oil and gas reserves or sustainable development initiatives* **(PR–SEC1) [ICT C2–4.1, F2–4.7]**
- *compile and organize findings as part of a briefing for a public hearing on an issue such as the proposed development of an energy source in an ecologically sensitive area* **(PR–NS4) [ICT C6–4.2, P2–4.1]**.

Analyzing and Interpreting

Students will:

30–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- analyze data charts, tables and graphs on global energy consumption in the past, in the present and predicted for the future **[ICT C7–4.2]**
- *evaluate the bias, reliability and validity of electronically accessed information on alternative and renewable energy sources* **(AI–SEC1) [ICT C2–4.2, C3–4.1, C3–4.2]**
- *identify new questions, such as those that relate to humanity's global energy future or those that relate to energy consumption by various sectors, such as metallurgy, petrochemical, pulp and paper, transportation* **(AI–SEC4)**
- *assess policies intended to facilitate efficient use of energy and reliance on renewable energy sources* **(AI–SEC2)**.

Communication and Teamwork

Students will:

30–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *present a visual display of initiatives taken by industry to protect the environment* **(CT–SEC2) [ICT C1–4.4, P6–4.1]**
- *develop and present an energy policy, based upon a set of criteria, in relation to a possible energy crisis in Canada* **(CT–SEC3)**

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal and other energy sources into useable forms.

Specific Outcomes for Knowledge

Students will:

30–D2.1k explain how Hess's Law, $\Delta H^\circ = \sum \Delta_f H^\circ$ (products) – $\sum \Delta_f H^\circ$ (reactants), leads to prediction of heats of combustion

30–D2.2k contrast the proportion of solar energy that creates wind and drives the water cycle with the small proportion captured by photosynthesis as chemical potential energy

30–D2.3k describe the conversion of solar energy into renewable forms (e.g., wind, hydropower, chemical potential energy by photosynthesis) and nonrenewable forms (e.g., coal, oil and gas) and further conversion into electrical and thermal energy

30–D2.4k describe the functioning of renewable energy technologies and assess their advantages and disadvantages, including active and passive solar-heating technologies, wind turbines, hydroelectric power, biomass energy, geothermal energy, hydrogen fuel cells

30–D2.5k explain the difference between fission and fusion and balance simple nuclear reaction equations to show the conservation of nucleons; *e.g.,*
$^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 3\,{}^{1}_{0}\mathrm{n}$; ${}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$

30–D2.6k describe the main types and sources of radioactive decay and resulting ionizing radiation; i.e., alpha (α), beta (β) and gamma (γ) decay

30–D2.7k describe mass-energy changes in fission and fusion reactions, as represented by the formula $E = mc^2$

30–D2.8k describe, in general terms, the operation of a fission reactor (*e.g., the Canadian Deuterium Uranium [CANDU] Reactor*) and the current state of fusion research

30–D2.9k trace the relationship between nuclear energy and geothermal energy

30–D2.10k compare and contrast conventional coal, oil-fired or hydroelectric power stations with nuclear power stations, in terms of purpose, process of energy conversions, design and function

30–D2.11k contrast, quantitatively, the orders of magnitude of energy produced by nuclear, chemical and phase changes

30–D2.12k explain the source of tides, in terms of gravitational attraction and the relative motions of the sun, moon and Earth

30–D2.13k describe the energy transformations involved in converting tidal energy to electrical energy and compare tidal power to hydroelectric power; *e.g., tidal generating stations at the Bay of Fundy, Canada and La Rance, France*.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–D2.1sts explain that decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations **(SEC4b) [ICT F2–4.2, F3–4.1]**

- evaluate the environmental and economic implications of energy transformation technologies; *e.g., nuclear, geothermal, fossil fuel, hydroelectric, wind, tidal power or hydrogen-cell power in a risk-benefit analysis*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal and other energy sources into useable forms.

30–D2.2sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**

- *determine how the allocation of funds for research into the development of new energy conversion devices and sources balances the needs of society with preservation of the environment.*

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

30–D2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design an experiment and identify specific variables to compare the heat produced by various fuels* **(IP–NS2) [ICT C6–4.2]**.

Performing and Recording

Students will:

30–D2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- *research, integrate and synthesize information from various print and electronic sources on sustainable development initiatives, such as fuel cells* **(PR–SEC1) [ICT C1–4.1, C2–4.1, C3–4.1, C3–4.2]**.

Analyzing and Interpreting

Students will:

30–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- calculate heats of combustion using Hess's Law; *e.g., calculate and compare fuels currently used with those used in the past* **(AI–NS3) [ICT C6–4.1]**
- calculate mass-energy changes in fission and fusion reactions, using the equation $E = mc^2$ **(AI–NS3) [ICT C6–4.1]**
- investigate, quantitatively, the efficiency of a device, using energy input and energy output data; *e.g., solar collector, photovoltaic cell, fossil fuel or biomass burner, biogas generator* **(AI–ST1)**
- *identify new questions, such as those that relate to nuclear fusion becoming a global source of energy* **(AI–SEC4)**
- *assess risks and benefits of scientific and technological developments, such as cogeneration, hybrid vehicles, fuel efficiency, waste-energy recovery, electrical load scheduling* **(AI–SEC2) [ICT F3–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the sun as Earth's main source of energy and explain the functioning of some conventional and alternative technologies that convert solar, nuclear, tidal and other energy sources into useable forms.

Communication and Teamwork

Students will:

30–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within word processing software to insert tables and energy budgets for a risk-benefit analysis of an energy transformation technology* **(CT–ST2) [ICT P4–4.3]**
- *consult a wide variety of sources to evaluate varied perspectives on topics such as cogeneration, fuel efficiency, waste-energy recovery, electrical load scheduling and policies that facilitate energy efficiency and increase reliance on renewable energy sources* **(CT–SEC1) [ICT C2–4.1, C2–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.