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

BIOLOGY 20–30
Program of Studies
2007 (Updated 2014)

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)

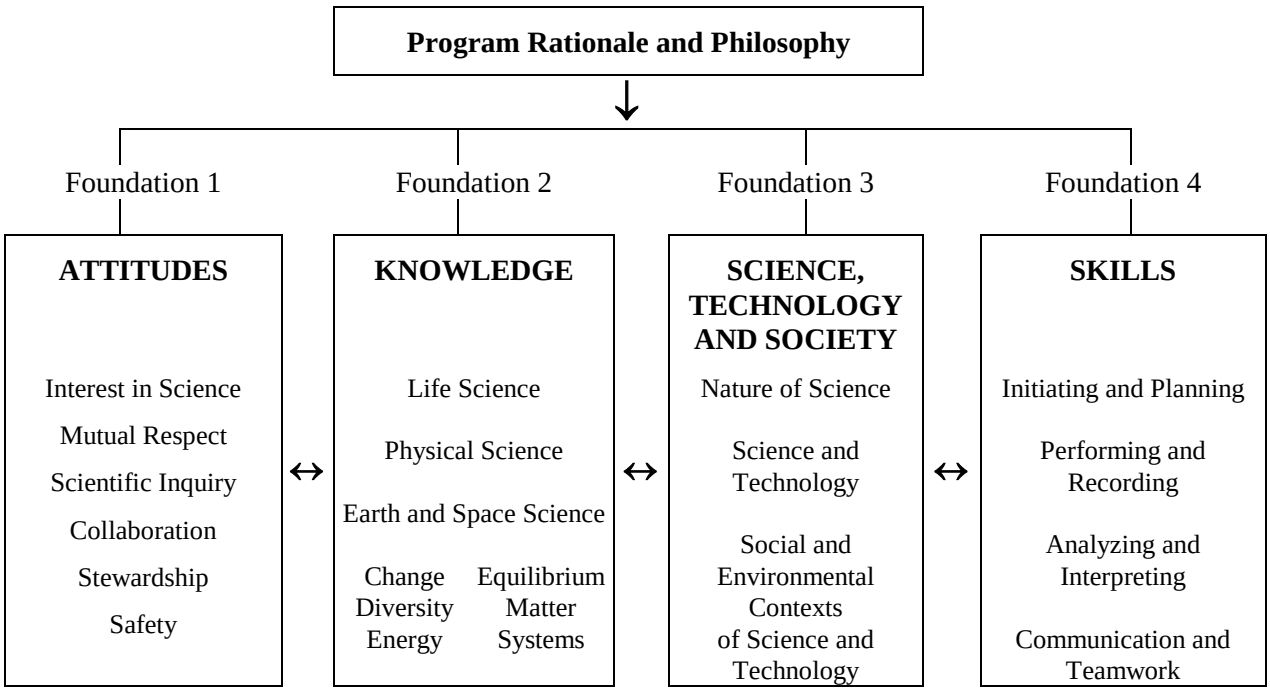
Selected curriculum outcomes from Alberta Education's Information and Communication Technology (ICT) Program of Studies are infused throughout the 20-level and 30-level sciences so that students will develop a broad perspective on the nature of technology, learn how to use and apply a variety of technologies, 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.

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.

Links to Mathematics

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

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

BIOLOGY 20

Biology 20 consists of four units of study:

A. Energy and Matter Exchange in the Biosphere
B. Ecosystems and Population Change
C. Photosynthesis and Cellular Respiration
D. Human 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 Biology 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 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 a particular use of materials that is 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: Energy and Matter Exchange in the Biosphere

Themes: Energy, Equilibrium, Matter and Systems

Overview: The constant flow of energy and cycling of matter in the biosphere leads to a balanced or steady state. This balance is achieved through various biogeochemical cycles and the processes of photosynthesis and cellular respiration.

In this unit, students become familiar with the maintenance of this balance and explore how various human activities have affected the balance.

This unit builds on:
- Grade 7 Science, Unit A: Interactions and Ecosystems
- Grade 9 Science, Unit A: Biological Diversity
- Science 10, Unit D: Energy Flow in Global Systems

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

Links to Mathematics: Refer to page 24.

Focusing Questions: How are carbon, oxygen, nitrogen and phosphorus cycled in the biosphere? How is the flow of energy balanced in the biosphere? How have human activities and technological advances affected the balance of energy and matter in the biosphere?

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

Students will:

1. explain the constant flow of energy through the biosphere and ecosystems
2. explain the cycling of matter through the biosphere
3. explain the balance of energy and matter exchange in the biosphere, as an open system, and explain how this maintains equilibrium.

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.

- biosphere
- equilibrium
- trophic levels
- food chains, food webs and ecological pyramids (energy, biomass and numbers)
- carbon, nitrogen, oxygen and phosphorus cycles
- water properties

General Outcome 1
Students will explain the constant flow of energy through the biosphere and ecosystems.

Specific Outcomes for Knowledge

Students will:

20–A1.1k explain, in general terms, the one-way flow of energy through the biosphere and how stored energy in the biosphere, as a system, is eventually "lost" as heat; *e.g.,*
- *photosynthesis/chemosynthesis*
- *cellular respiration (muscle-heat generation, decomposition)*
- *energy transfer by conduction, radiation and convection*

20–A1.2k explain how energy in the biosphere can be perceived as a balance between both photosynthetic and chemosynthetic activities and cellular respiratory activities; i.e.,
- energy flow in photosynthetic environments
- energy flow in deep sea vent (chemosynthetic) ecosystems and other extreme environments

20–A1.3k explain the structure of ecosystem trophic levels, using models such as food chains and food webs

20–A1.4k explain, quantitatively, the flow of energy and the exchange of matter in aquatic and terrestrial ecosystems, using models such as pyramids of numbers, biomass and energy.

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

Students will:

20–A1.1sts explain that the process of scientific investigation includes analyzing evidence and providing explanations based upon scientific theories and concepts **(NS5f) [ICT C6–4.2]**
- *evaluate the evidence for the influence of ice and snow on the trapping of solar energy (albedo effect) and hypothesize on the consequences of fluctuations for biological systems*
- *explain how metabolic heat release from harvested grain can be reduced by drying processes prior to grain storage and explain the scientific principles involved in this technology*
- *explain, in terms of energy flow, the advantage of vegetarianism in densely populated countries.*

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 constant flow of energy through the biosphere and ecosystems.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- *propose a relationship between producers and available energy of a system* **(IP–SEC1)**
- *predict a relationship between solar energy storage by plants and varying light conditions* **(IP–NS3) [ICT C6–4.1]**.

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

- perform an experiment to demonstrate solar energy storage by plants **(PR–NS3, PR–NS4, PR–NS5)**
- *draw, by hand or using technology, annotated diagrams of food chains, food webs and ecological pyramids* **(PR–NS4)**.

Analyzing and Interpreting

Students will:

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

- analyze data on the diversity of plants, animals and decomposers of an endangered ecosystem, *e.g., wetlands, short grass prairie,* and predict long-term outcomes **(AI–SEC1) [ICT C6–4.1]**
- compare alternative ways of presenting energy flow data for ecosystems; i.e., pyramids of energy, biomass and numbers **(AI–SEC1, AI–NS4, AI–NS6) [ICT C6–4.2]**
- *analyze data on the storage of solar energy by plants* **(AI–NS2, AI–NS3, AI–NS4, AI–NS6)**.

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 *Système international* (SI) units, 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)**¬
- *use appropriate notation units in the data presented in an energy pyramid* **(CT–NS2)**
- *work cooperatively as a team to investigate, synthesize and present information on the effect of organism diversity on an ecosystem* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, C7–4.2]**.

¬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 the cycling of matter through the biosphere.

Specific Outcomes for Knowledge

Students will:

20–A2.1k explain and summarize the biogeochemical cycling of carbon, oxygen, nitrogen and phosphorus and relate this to general reuse of all matter in the biosphere

20–A2.2k explain water's primary role in the biogeochemical cycles, considering its chemical and physical properties; i.e., universal solvent, hydrogen bonding.

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

Students will:

20–A2.1sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- *discuss the influence of human activities on the biogeochemical cycling of phosphorus, sulfur, iron and nitrogen:*
  - *feedlot operations*
  - *composting*
  - *fertilizer applications*
  - *waste and sewage disposal*
  - *vehicle and refinery emissions*
  - *acid deposition*
  - *persistent organic pollutants*
- *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:*
  - *manufacturing and processing*
  - *petrochemical industry*
  - *agricultural systems*
  - *mining industry*
  - *domestic daily water consumption*
- *analyze the relationship between heavy metals released into the environment and matter exchange in natural food chains/webs and analyze the impact of this relationship on quality of life.*

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 the cycling of matter through the biosphere.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- design an experiment to compare the carbon dioxide production of plants with that of animals **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**
- hypothesize how alterations in the carbon cycle, resulting from the burning of fossil fuels, might affect other cycling phenomena; *e.g., sulfur, iron, water* **(IP–NS3) [ICT C6–4.1]**
- predict disruptions in the nitrogen and phosphorus cycles that are caused by human activities **(IP–NS3) [ICT C6–4.1]**.

Performing and Recording

Students will:

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

- measure and record the pH and the amount of nitrates, phosphates, iron or sulfites in water samples **(PR–NS2, PR–NS3, PR–NS4) [ICT P2–4.1]**.

Analyzing and Interpreting

Students will:

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

- analyze data collected on water consumption and loss in plants and animals **(AI–NS2, AI–NS3, AI–NS4) [ICT C7–4.2]**.

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

- *work cooperatively in a group to investigate the influence of human activities on the biogeochemical cycles and use appropriate multimedia to present the information to a group* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.2, F2–4.7, 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 explain the balance of energy and matter exchange in the biosphere, as an open system, and explain how this maintains equilibrium.

Specific Outcomes for Knowledge

Students will:

20–A3.1k explain the interrelationship of energy, matter and ecosystem productivity (biomass production); *e.g.,*
- *Antarctic Ocean versus tropical seas*
- *tropical rain forest versus desert*
- *taiga versus tundra*
- *intertidal zone versus deep-sea benthos*
- *Arctic versus Antarctic*

20–A3.2k explain how the equilibrium between gas exchanges in photosynthesis and cellular respiration influences atmospheric composition

20–A3.3k describe the geologic evidence (stromatolites) and scientific explanations for change in atmospheric composition, with respect to oxygen and carbon dioxide, from anoxic conditions to the present, and describe the significance to current biosphere equilibrium.

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

Students will:

20–A3.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**
- *evaluate the technology of a closed system in terms of energy and matter:*
  - *space stations and spaceships*
  - *Biosphere experiments*
  - *manned exploration of Mars' surface*

20–A3.2sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**
- *describe how human activities can have a disrupting influence on the balance in the biosphere of photosynthetic and cellular respiratory activities:*
  - *fossil fuel combustion*
  - *depletion of stratospheric ozone*
  - *forest destruction.*

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 explain the balance of energy and matter exchange in the biosphere, as an open system, and explain how this maintains equilibrium.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

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

- predict the effects of changes in carbon dioxide and oxygen concentration on the atmospheric equilibrium due to a significant reduction of photosynthetic organisms through human activity **(IP–NS3) [ICT C6–4.1]**.

Performing and Recording

Students will:

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

- *collect evidence from various print and electronic sources on how human activities can have a disrupting influence on photosynthetic and cellular respiratory activities* **(PR–SEC1, PR–SEC2) [ICT C1–4.1]**.

Analyzing and Interpreting

Students will:

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

- design and evaluate a model of a closed biological system in equilibrium with respect to carbon dioxide, water and oxygen exchange **(PR–ST2, AI–ST1)**
- *compare and contrast the flow of energy and the cycling of matter in Biosphere 2 with that in Earth's biosphere* **(AI–SEC2)**.

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

- *work cooperatively as a group to investigate, synthesize and present information on the effects of changes to stratospheric ozone levels on society, agriculture, plants and animals* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, C7–4.2, F2–4.7]**.

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.

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

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

Unit B: Ecosystems and Population Change

Themes: Energy, Matter and Systems

Overview: In this unit, students become familiar with a range of ecosystems by studying their distinctive biotic and abiotic characteristics. Students are introduced to the concept of populations as a basic component of ecosystem structure and complete the unit by examining population change through the process of natural selection.

The content in Unit B prepares students for the study of populations and community dynamics in Biology 30.

This unit builds on:
- Grade 7 Science, Unit A: Interactions and Ecosystems
- Grade 8 Science, Unit E: Freshwater and Saltwater Systems
- Grade 9 Science, Unit A: Biological Diversity

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

Links to Mathematics: Refer to page 30.

Focusing Questions: What are the major biotic and abiotic characteristics that distinguish aquatic and terrestrial ecosystems? What data would one need to collect in a field study to illustrate the major abiotic characteristics and diversity of organisms? What mechanisms are involved in the change of populations over time? In what ways do humans apply their knowledge of ecosystems to assess and limit the impact of human activities?

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

Students will:

1. explain that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics
2. explain the mechanisms involved in the change of populations over time.

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.

- ecosystem
- niche
- biotic/abiotic characteristics
- limiting factors
- binomial nomenclature
- adaptation and variation
- population
- natural selection
- species
- evidence for evolution

General Outcome 1
Students will explain that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics.

Specific Outcomes for Knowledge

Students will:

20–B1.1k define species, population, community and ecosystem and explain the interrelationships among them

20–B1.2k explain how terrestrial and aquatic ecosystems support a diversity of organisms through a variety of habitats and niches; *e.g.,*
- *terrestrial: canopy, sub-canopy, forest floor, soil*
- *aquatic: littoral, limnetic, profundal and benthic zones*

20–B1.3k identify biotic and abiotic characteristics and explain their influence in an aquatic and a terrestrial ecosystem in the local region; *e.g., stream, lake, prairie, boreal forest, vacant lot, sports field*

20–B1.4k explain how limiting factors influence organism distribution and range; *e.g.,*
- *abiotic factors: soil, relative humidity, moisture, ambient temperature, sunlight, nutrients, oxygen*
- *biotic factors: competitors, predators and parasites*

20–B1.5k explain the fundamental principles of taxonomy and binomial nomenclature, using modes of nutrition at the kingdom level and morphological characteristics at the genus species level.

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

Students will:

20–B1.1sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**
- *evaluate the impact that human activity has had, or could have, on the biodiversity in an ecosystem:*
  - *wetlands management*
  - *land use*
  - *interbasin water transfer*
  - *habitat fragmentation*
  - *urbanization*
  - *slash-and-burn and clearcutting practices*
  - *monoculturing of forests, lawns, field crops*
- *assess the environmental consequences of the introduction of new species into established ecosystems (such as tropical fish in Banff Hot Springs, starlings, quack grass, scented chamomile, purple loosestrife) and discuss the responsibility of society to protect the environment through science and technology*

20–B1.2sts explain how conventions of mathematics, nomenclature and notation provide a basis for organizing and communicating scientific theory, relationships and concepts **(NS6b)**
- *research the historical development of the modern classification system*
- *research plant and animal systems of classification developed by Aboriginal peoples in their cultural practices.*

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 that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–B1.1s formulate questions about observed relationships; plan investigations of questions, ideas, problems and issues; and define and delimit problems to facilitate investigation

- hypothesize the role of biotic and abiotic factors in ecosystems; *e.g., competition and chinooks* **(IP–NS3) [ICT C6–4.1]**
- *plan a field study to gather and evaluate biotic and abiotic characteristics associated with an ecosystem, such as the effects that dominant plants have on abiotic conditions such as soil and microclimate* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

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

- perform a field study to measure, quantitatively, appropriate abiotic characteristics of an ecosystem and to gather, both quantitatively and qualitatively, evidence for analysis of the diversity of life in the ecosystem studied **(PR–NS3, PR–NS4, PR–NS5) [ICT F2–4.1]**
- *research and develop a land reclamation strategy for a disturbed area, as a solution to environmental damage; e.g., open-pit mine, garbage dump, school yard reclamation* **(PR–SEC1, PR–NS1, PR–NS4) [ICT C1–4.1]**.

Analyzing and Interpreting

Students will:

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

- apply classification and binomial nomenclature systems in a field study **(AI–NS1)**
- analyze the interrelationship of biotic and abiotic characteristics that make up the ecosystem studied **(AI–NS2, AI–NS3, AI–NS6)**
- evaluate the accuracy and reliability of instruments used for measurement and identify the degree of error in the field-study data **(AI–NS4)**
- *compile and organize evidence from a variety of sources, for or against human activity being responsible for ecosystem change, and analyze the relationship between human activity and changing ecosystems* **(AI–NS2, AI–NS6, AI–SEC2) [ICT C2–4.1, C7–4.2]**.

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

- *work cooperatively to gather and share data on a field trip* **(CT–NS1, CT–NS2)**
- *work cooperatively to make clear and logical arguments to defend a decision on a given issue, such as human impact on ecosystems, land reclamation or wildlife habitat preservation* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4]**
- *develop, present and defend a strategy to improve wildlife habitats* **(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.

General Outcome 2
Students will explain the mechanisms involved in the change of populations over time.

Specific Outcomes for Knowledge

Students will:

20–B2.1k explain that variability in a species results from heritable mutations and that some mutations may have a selective advantage

20–B2.2k discuss the significance of sexual reproduction to individual variation in populations and to the process of evolution

20–B2.3k compare Lamarckian and Darwinian explanations of evolutionary change

20–B2.4k summarize and describe lines of evidence to support the evolution of modern species from ancestral forms; i.e., the fossil record, Earth's history, biogeography, homologous and analogous structures, embryology, biochemistry

20–B2.5k explain speciation and the conditions required for this process

20–B2.6k describe modern evolutionary theories; i.e., punctuated equilibrium, gradualism.

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

Students will:

20–B2.1sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**

- *discuss the nature of science as a way of knowing (contributions of Buffon, Lyell, Malthus and Wallace to evolution and contributions of Aristotle, Galileo and Popper to the philosophy of science)*
- *describe how paleontology and the role of evidence in the accumulation of knowledge have provided invaluable data for theories explaining observable variations in organisms over time (Burgess Shale)*
- *discuss geologic evidence and probable causes for past mass extinctions and contrast these to 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 2
Students will explain the mechanisms involved in the change of populations over time.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–B2.1s 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)**
- hypothesize the adaptive significance of the variations in a range of homologous structures in extant and extinct organisms **(IP–NS3)**.

Performing and Recording

Students will:

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

- *gather data, actual or simulated, on organisms to demonstrate how inherited characteristics change over time, as illustrated by Darwin's finches, peppered moths, bacteria and domesticated plants and animals* **(PR–NS1, PR–NS4)**.

Analyzing and Interpreting

Students will:

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

- analyze data, actual or simulated, on plants and animals to demonstrate how morphology changes over time; *e.g., Darwin's finches, peppered moths, bacteria, domesticated plants or animals* **(AI–NS2) [ICT C6–4.2, C7–4.2]**
- *analyze DNA sequences from online or other sources to infer the relationship between different organisms at various classification levels* **(AI–NS2) [ICT C1–4.1]**
- *state a conclusion or generalization based on research data, suggesting how it supports or refutes an explanation for biological change, and identify new questions or problems that arise from what was learned* **(AI–NS5, AI–NS6) [ICT C7–4.2**].

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

- use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results **(CT–NS2)**.

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.

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

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10-3, Measurement, Specific Outcome 1
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1

Unit C: Photosynthesis and Cellular Respiration

Themes: Energy, Matter and Systems

Overview: The life processes of photosynthesis and cellular respiration allow for the transfer of energy and matter. Students learn, in general terms, how energy from sunlight is transferred into adenosine triphosphate (ATP) and reduced nicotinamide adenine dinucleotide phosphate (NADPH) and eventually into glucose, and how carbohydrates are oxidized to produce reduced nicotinamide adenine dinucleotide (NADH), reduced flavin adenine dinucleotide (FADH) and eventually ATP. A detailed knowledge of metabolic intermediates is not required.

Students extend their understanding by examining how these cellular processes impact and are impacted by global systems.

This unit builds on:
- Grade 7 Science, Unit B: Plants for Food and Fibre
- Science 10, Unit C: Cycling of Matter in Living Systems

Unit C will require approximately 15% of the time allotted for Biology 20.

Links to Mathematics: Refer to page 36.

Focusing Questions: How does light energy from the environment enter living systems? How is the energy from light converted to chemical potential in organic matter? How is the energy in organic matter released for use by living systems? How do humans in their application of technologies impact photosynthesis and cellular respiration?

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

Students will:

1. relate photosynthesis to storage of energy in organic compounds
2. explain the role of cellular respiration in releasing potential energy from organic compounds.

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.

- absorption of light by pigments
- light-dependent and independent reactions
- glycolysis
- Krebs cycle
- electron transport systems
- aerobic and anaerobic respiration

General Outcome 1
Students will relate photosynthesis to storage of energy in organic compounds.

Specific Outcomes for Knowledge

Students will:

20–C1.1k explain, in general terms, how energy is absorbed by pigments, transferred through the reduction of nicotinamide adenine dinucleotide phosphate (NADP) to NADPH, and then transferred as chemical potential energy to ATP by chemiosmosis; and describe where in the chloroplast these processes occur

20–C1.2k explain, in general terms, how the products of the light-dependent reactions, NADPH and ATP, are used to reduce carbon in the light-independent reactions for the production of glucose; and describe where in the chloroplast these processes occur.

Note: Detailed knowledge of metabolic intermediates is not required.

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

Students will:

20–C1.1sts explain how 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]**

- *analyze the role of photosynthesis as the biological basis of agriculture and forestry*

20–C1.2sts 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 F3–4.1]**

- *research and analyze the effects of herbicides on the biochemistry of photosynthesis.*

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 relate photosynthesis to storage of energy in organic compounds.

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

- *identify a testable factor that would affect the rate of photosynthesis* **(IP–NS1)**
- *predict and hypothesize the effect of changes in carbon dioxide and oxygen concentration on photosynthesis* **(IP–NS3) [ICT C6–4.1]**.

Performing and Recording

Students will:

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

- *use local histories obtained from Aboriginal Elders to describe the importance of plant productivity to human sustainability* **(PR–SEC2)**
- *measure rates of evapotranspiration under various environmental conditions and relate these rates to photosynthetic activity* **(PR–NS2, PR–NS3, PR–NS4)**
- *investigate and integrate, from print and electronic sources, information on the C_3 and C_4 photosynthetic mechanisms or on the applications of cellular biochemistry in medicine or industry* **(PR–NS1, PR–NS4) [ICT C1–4.1]**.

Analyzing and Interpreting

Students will:

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

- collect and interpret data from chromatography experiments and calculate reference flow (R_f) values **(PR–NS3, AI–NS2, AI–NS3, AI–NS4) [ICT F1–4.2]**
- *draw an analogy between the storage of energy by photosynthesis and the storage of energy by solar generating systems* **(AI–NS6)**
- *explain how data supports or refutes the hypothesis on how changes in carbon dioxide and oxygen concentration affect photosynthesis* **(AI–NS4)**
- *collect and interpret experimental data that demonstrates that plant leaves produce starch in the presence of light* **(PR–NS3, AI–NS2)**.

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

- *work cooperatively as a group to investigate, synthesize and present information on the effects of herbicides on the biochemistry of photosynthesis* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, C7–4.2]**.

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 explain the role of cellular respiration in releasing potential energy from organic compounds.

Specific Outcomes for Knowledge

Students will:

20–C2.1k explain, in general terms, how glucose is oxidized during glycolysis and the Krebs cycle to produce reducing power in NADH and FADH; and describe where in the cell these processes occur

Note: Detailed knowledge of metabolic intermediates is not required.

20–C2.2k explain, in general terms, how chemiosmosis converts the reducing power of NADH and FADH to store chemical potential energy as ATP; and describe where in the mitochondrion these processes occur

Note: Detailed knowledge of metabolic intermediates is not required.

20–C2.3k distinguish, in general terms, between aerobic and anaerobic respiration and fermentation in plants, animals and yeast

20–C2.4k summarize and explain the role of ATP in cellular metabolism; *e.g.,*

- *active transport*
- *cytoplasmic streaming*
- *phagocytosis*
- *biochemical synthesis*
- *muscle contraction*
- *heat production.*

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

Students will:

20–C2.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**

- *research applications of cellular biochemistry in health and industry:*
  - *aerobic and anaerobic fitness*
  - *methane gas production from organic waste*
  - *alcohol production*
  - *bread making*
  - *yogurt*

20–C2.2sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- *discuss how pollutants such as hydrogen sulfide and cyanide are by-products of industrial processes and explain the specific metabolic effects of these pollutants on aerobic 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 2
Students will explain the role of cellular respiration in releasing potential energy from organic compounds.

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

- *identify factors affecting the rate of cellular respiration* **(IP–NS1)**
- *design an experiment to demonstrate that heat is a by-product of cellular respiration* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**
- *predict and hypothesize the effect of oxic and anoxic conditions on the rate of cellular respiration in unicellular organisms such as yeast and bacteria* **(IP–NS3) [ICT C6–4.1]**.

Performing and Recording

Students will:

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

- use experimental methods to demonstrate, quantitatively, the oxygen consumption of germinating seeds **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- measure temperature change over time of germinating and non-germinating seeds **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- investigate and integrate, from print and electronic sources, information on the action of metabolic toxins on cellular respiration **(PR–NS1, PR–NS4) [ICT C1–4.1]**.

Analyzing and Interpreting

Students will:

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

- *evaluate the reliability, accuracy and validity of sources used to collect information on metabolic toxins and cellular respiration* **(AI–NS4) [ICT C3–4.1]**
- *interpret data on the oxygen consumption of an animal and relate this to metabolic rate* **(AI–NS2, AI–NS3, AI–NS4, AI–NS6)**
- *interpret data that illustrate the effect of oxic and anoxic conditions on cellular respiration* **(AI–NS6) [ICT C7–4.2]**
- *relate the Aboriginal metaphor "the trees are the lungs of Mother Earth" to the complementary role of the carbon and oxygen cycles* **(AI–NS6)**.

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

- *create a concept map or flow chart to illustrate how the carbon, hydrogen and oxygen atoms in glucose are ultimately released as carbon dioxide and water*
- *work cooperatively to research and investigate cellular respiration in oxic and anoxic conditions and metabolic toxins* **(CT–SEC1) [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.

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

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10-3, Measurement, Specific Outcome 1
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcomes 1 and 4; Mathematics 20-3, Statistics, Specific Outcome 1

Unit D: Human Systems

Themes: Energy, Equilibrium, Matter and Systems

Overview: Maintenance of metabolic equilibrium in organisms involves a number of physical and biochemical processes. The human organism is used as a model system to examine how energy and matter are exchanged with the environment through the processes of gas exchange, digestion, excretion, circulation and the function of the motor system. A defence system contributes to equilibrium by eliminating pathogenic organisms.

The content in Unit D prepares students for further studies regarding the functioning of human systems.

This unit builds on:
- Grade 8 Science, Unit B: Cells and Systems
- Science 10, Unit C: Cycling of Matter in Living Systems

Unit D will require approximately 40% of the time allotted for Biology 20.

Links to Mathematics: Refer to page 47.

Focusing Questions: How do specialized structures function in the overall biochemical balance of the living system? What conditions result if these structures do not function normally? How does knowledge of living systems and medical technology support the prevention and treatment of disorders?

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

Students will:

1. explain how the human digestive and respiratory systems exchange energy and matter with the environment
2. explain the role of the circulatory and defence systems in maintaining an internal equilibrium
3. explain the role of the excretory system in maintaining an internal equilibrium in humans through the exchange of energy and matter with the environment
4. explain the role of the motor system in the function of other body systems.

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.

- structure and function of major systems: respiratory, digestive, excretory, circulatory and motor
- chemical nature of carbohydrates, proteins, lipids
- chemical and physical digestion
- digestive enzymes
- gas exchange
- composition of blood
- immune response
- renal function
- muscle contraction

General Outcome 1
Students will explain how the human digestive and respiratory systems exchange energy and matter with the environment.

Specific Outcomes for Knowledge

Students will:

20–D1.1k identify the principal structures of the digestive and respiratory systems; i.e.,
- mouth, esophagus, stomach, sphincters, small and large intestines, liver, pancreas, gall bladder
- nasal passages, pharynx, larynx, epiglottis, trachea, bronchi, bronchioles, alveoli, diaphragm, rib muscles, pleural membranes

20–D1.2k describe the chemical nature of carbohydrates, lipids and proteins and their enzymes; i.e., carbohydrases, lipases and proteases

20–D1.3k explain enzyme action and factors influencing their action; i.e., temperature, pH, substrate concentration, feedback inhibition, competitive inhibition

20–D1.4k describe the chemical and physical processing of matter through the digestive system into the circulatory system

20–D1.5k explain the exchange of matter and the transfer of thermal energy between the body and the environment, using the mechanism of breathing in gas exchange, removal of foreign material and heat loss.

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

Students will:

20–D1.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4, F2–4.8]**
- *discuss and evaluate the role of food additives and/or food treatment to solve the problems of food spoilage (antioxidants, irradiation technology)*
- *explain the biological basis of nutritional deficiencies, including that of anorexia nervosa, and the technological means available to restore internal equilibrium*
- *identify specific pathologies of the digestive system and technologies used to treat the conditions*
- *identify specific pathologies of the respiratory system and technologies used to treat the conditions*

20–D1.2sts explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6) [ICT F2–4.4]**
- *assess the physiological effects of smoking and exposure to second-hand smoke and the limitations of technologies available to deal with these conditions or diseases*
- *assess the short- and long-term impacts of smoking in society, such as the cost of health care and insurance.*

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 how the human digestive and respiratory systems exchange energy and matter with the environment.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- *design an investigation to examine food energy through calorimetry, to examine enzyme action or to examine the mechanics of breathing* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

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

- observe, through dissection or computer simulations, the digestive and respiratory systems of a representative mammal and identify the major structural components **(PR–NS2, PR–NS4, PR–NS5)**
- perform experiments, using qualitative tests, to detect the presence of carbohydrates, proteins and lipids **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- *perform an experiment to investigate the influence of enzyme concentration, temperature or pH on the activity of enzymes such as pepsin and pancreatin* **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- *perform an experiment to examine the mechanics of breathing, such as lung volume, breathing rate* **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**.

Analyzing and Interpreting

Students will:

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

- *analyze and draw conclusions and assess validity of data from an investigation on calorimetry or enzyme action* **(AI–NS2, AI–NS3, AI–NS4, AI–NS6) [ICT C7–4.2]**
- *analyze and draw conclusions and assess validity of data from an investigation on the mechanics of breathing* **(AI–NS2, AI–NS3, AI–NS4, AI–NS6) [ICT C7–4.2]**.

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

- use appropriate notation and units to present data from investigations on digestion and respiration **(CT–NS1, CT–NS2)**
- *work cooperatively with team members to investigate how Aboriginal peoples and ranchers have used their observations of the excrement of game and farm animals to assess the health of these animals* **(CT–NS1)**
- *work cooperatively with team members to research the contributions from various cultures to our current understanding of digestion or respiration and healing, such as research on the use of traditional remedies to treat respiratory illness* **(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.

General Outcome 2
Students will explain the role of the circulatory and defence systems in maintaining an internal equilibrium.

Specific Outcomes for Knowledge

Students will:

20–D2.1k identify the principal structures of the heart and associated blood vessels; i.e., atria, ventricles, septa, valves, aorta, venae cavae, pulmonary arteries and veins, sinoatrial node, atrioventricular node, Purkinje fibres

20–D2.2k describe the action of the heart, blood pressure and the general circulation of blood through coronary, pulmonary and systemic pathways

20–D2.3k describe the structure and function of blood vessels; i.e., arteries, veins and capillaries

20–D2.4k describe the main components of blood and their role in transport, clotting and resisting the influence of pathogens; i.e., plasma, erythrocytes, platelets, leucocytes

20–D2.5k explain the role of the circulatory system at the capillary level in aiding the digestive, excretory, respiratory and motor systems' exchange of energy and matter with the environment

20–D2.6k explain the role of blood in regulating body temperature

20–D2.7k describe and explain, in general terms, the function of the lymphatic system

20–D2.8k list the main cellular and noncellular components of the human defence system and describe their role; i.e., skin, macrophage, helper T cell, B cell, killer T cell, suppressor T cell, memory T cell

20–D2.9k describe the ABO and Rh blood groups on the basis of antigens and antibodies.

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

Students will:

20–D2.1sts explain how Canadian society supports scientific research and technological development to facilitate a sustainable society, economy and environment **(SEC4a) [ICT F2–4.2, F2–4.8]**

- *identify specific pathologies of the circulatory and defence systems, the technologies used to treat the conditions and the reasons society supports the development of these technologies*
- *evaluate the effects that the needs, interests and financial support of society have on preventing the spread of pathogens such as staphylococcus, smallpox virus, E. coli and human immunodeficiency virus (HIV)*
- *assess the physiological effects of drugs such as caffeine and nicotine on the circulatory system and discuss why habitual use of these drugs is a societal concern*
- *evaluate the risks and benefits associated with blood transfusion*

20–D2.2sts explain that decisions regarding the application of scientific and technological developments involve a variety of perspective, including social, cultural, environmental, ethical and economic considerations **(SEC4b) [ICT F2–4.2, F3–4.1]**

- *evaluate the ethical implications of organ and tissue transplants, in terms of the needs, interests and financial support of society, on scientific and technological research in this field*
- *assess the implications of technological advances that assist in maintaining internal equilibrium with respect to:*
  - *pathogens (vaccinations)*
  - *defective hearts (artificial valves, artificial hearts, xenotransplantation, stem cell culture).*

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 the role of the circulatory and defence systems in maintaining an internal equilibrium.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- *design procedures to investigate factors affecting heart rate and blood pressure; e.g., physical activity, emotion, gender and chemicals such as caffeine* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

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

- measure blood pressure and observe blood flow in capillaries in an organism or through demonstration in a virtual laboratory **(PR–NS2, PR–NS3)**
- determine the morphology and abundance of cellular components in a prepared human blood slide **(PR–NS2, PR–NS3)**
- select and integrate information from various sources to observe the principal features of a mammalian circulatory system and the direction of blood flow, and identify structures from drawings; *e.g., valves, chambers* **(PR–NS1)**
- research and design a simulation or model of the functioning of the main components of the human immune system **(PR–NS1, PR–ST2) [ICT C6–4.4]**
- *compile and display information on blood pressure, heart rate and blood composition* **(PR–NS1, PR–NS4)**
- *carry out a heart dissection to identify the major parts and to determine the directional flow of blood through the organ* **(PR–NS3)**.

Analyzing and Interpreting

Students will:

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

- *determine, from available data, the relationship between blood pressure and exercise* **(AI–NS2) [ICT C7–4.2]**
- *investigate lifestyle behaviour, physical fitness and heart rate recovery, using available data, and account for discrepancies* **(AI–NS2, AI–NS3) [ICT C7–4.2]**
- *identify the limitations and evaluate the dependability of devices used to measure blood pressure* **(AI–NS4) [ICT C6–4.5]**
- *explore solutions to practical problems associated with the circulatory system, such as organ and tissue transplants and artificial blood* **(AI–ST2) [ICT C1–4.1]**
- *determine blood groups from samples of artificial blood or electronic resources* **(AI–NS6)**
- *predict compatibility of ABO and Rh blood types between donor and recipient* **(AI–NS6)**.

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 the role of the circulatory and defence systems in maintaining an internal equilibrium.

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

- *work cooperatively with team members to measure and record blood pressure, heart rate or any other factor relating to the circulatory system* **(CT–NS1, CT–NS2) [ICT C6–4.4]**.

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.

General Outcome 3
Students will explain the role of the excretory system in maintaining an internal equilibrium in humans through the exchange of energy and matter with the environment.

Specific Outcomes for Knowledge

Students will:

20–D3.1k identify the principal structures in the excretory system; i.e., kidneys, ureters, urinary bladder, urethra

20–D3.2k identify the major and associated structures of the nephron, including the glomerulus, Bowman's capsule, tubules, loop of Henle, collecting duct, afferent and efferent arterioles, and capillary net, and explain their function in maintaining plasma compositions (i.e., water, pH, ions)

20–D3.3k describe the function of the kidney in excreting metabolic wastes and expelling them into the environment

20–D3.4k identify the role of antidiuretic hormone (ADH) and aldosterone in water and sodium ion reabsorption, excretion and blood pressure regulation.

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

Students will:

20–D3.1sts explain that the goal of science is knowledge about the natural world **(NS1)**

- *examine how lifestyle factors contribute to hypertension and affect kidney function:*
  - *drugs, such as alcohol and nicotine*
  - *sedentary lifestyle*
  - *dietary excesses or deficiencies*
  - *stress*
- *explain how an understanding of nephron function is applied to renal and peritoneal dialysis*
- *identify specific pathologies of the excretory system and the scientific knowledge connected with the treatment*
  - *identify the physiological complexities and challenges of organ and tissue transplants.*

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 explain the role of the excretory system in maintaining an internal equilibrium in humans through the exchange of energy and matter with the environment.

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
- *predict how blood pressure affects urine composition and volume* **(IP–NS3) [ICT C6–4.1]**.

Performing and Recording

Students will:

20–D3.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information
- research and create a flowchart to describe how humans maintain homeostasis with respect to water and ions; *e.g.*,
  - *when water intake is increased or decreased*
  - *when diuretic compounds, such as caffeine or alcohol, are ingested*
  - *when excessive sodium is ingested*
  - *after periods of intense exercise, fever, hemorrhage* **(PR–NS1)**
- *perform a kidney dissection to identify major structures of the organ* **(PR–NS3)**.

Analyzing and Interpreting

Students will:

20–D3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- observe the principal features of a mammalian excretory system and identify structures from drawings obtained from various print and electronic sources **(AI–NS1) [ICT C1–4.1]**
- collect and interpret data in analysis of simulated urine, identify limitations of the data, compare the data to theoretical values and produce a generalization **(PR–NS2, PR–NS3, PR–NS4, PR–NS5, AI–NS2, AI–NS4, AI–NS6) [ICT C7–4.2]**
- *assess technological solutions to kidney failure, such as peritoneal dialysis, hemodialysis and kidney transplant, and identify the potential strengths and weaknesses of each* **(AI–ST2)**.

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
- *work cooperatively with team members to assess and record simulated urine composition* **(CT–NS1, CT–NS2)**.

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 explain the role of the motor system in the function of other body systems.

Specific Outcomes for Knowledge

Students will:

20–D4.1k explain how the motor system supports body functions (i.e., digestive, circulatory, respiratory, excretory and locomotory), referencing smooth, cardiac and striated muscle

20–D4.2k describe, in general, the action of actin and myosin in muscle contraction and heat production.

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

Students will:

20–D4.1sts explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

- *analyze the effects of exercise on muscle fibre*
- *describe the relationship between fitness and efficiency of muscle action*
- *assess the physiological effects on the motor system of anabolic steroids and energy-enhancing drugs such as creatine phosphate*

20–D4.2sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4, F2–4.8]**

- *identify specific pathologies of the motor system, such as muscle atrophy, fatigue, strain and tendonitis, and identify technologies used to treat the conditions.*

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 explain the role of the motor system in the function of other body systems.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–D4.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- *design an investigation to determine the relationship between muscle activity, energy consumption and fatigue* **(IP–NS1, IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

20–D4.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information

- identify smooth, cardiac and striated muscle tissue under magnification **(PR–NS2)**
- *design and construct a model of a muscle fibre* **(PR–ST2)**.

Analyzing and Interpreting

Students will:

20–D4.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- *obtain and interpret data to demonstrate a direct correlation between energy use by muscle cells and heat production* **(AI–NS2)**.

Communication and Teamwork

Students will:

20–D4.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate Système international (SI) units and fundamental and derived units **(CT–NS2)**
- *work cooperatively with team members to measure and record body temperature* **(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.

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

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10-3, Measurement, Specific Outcome 1; Mathematics 20-3, Algebra, Specific Outcome 3
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcome 1; Mathematics 20-3, Statistics, Specific Outcome 1

BIOLOGY 30

Biology 30 consists of four units of study:

A. Nervous and Endocrine Systems
B. Reproduction and Development
C. Cell Division, Genetics and Molecular Biology
D. Population and Community Dynamics

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 Biology 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 interest 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 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 of environmental changes caused by nature and by humans on human beings and society*
- *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 with reference to 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*
- *write safety and waste-disposal precautions into a laboratory procedure*
- *use safety and waste disposal as criteria for evaluating an experiment.*

Unit A: Nervous and Endocrine Systems

Themes: Equilibrium and Systems

Overview: This unit examines the biological processes that mediate the interactions between humans and their environment to maintain equilibrium. The nervous system contributes to homeostasis through its response to internal and external stimuli. Endocrine glands help to maintain homeostasis through the hormones they release into the blood. A study of the interactions between the nervous and endocrine systems leads to an examination of the functioning of the central and peripheral nervous systems and their ability to sense the environment and respond to it.

This unit builds on:

- Grade 8 Science, Unit B: Cells and Systems
- Science 10, Unit C: Cycling of Matter in Living Systems
- Biology 20, Unit D: Human Systems

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

Links to Mathematics: Refer to page 56.

Focusing Questions: How does the human body maintain equilibrium between its internal and external environments? What physiological processes and control systems are involved in maintaining homeostasis? What medical technologies are available to alleviate disorders of the nervous and endocrine systems?

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

Students will:

1. explain how the nervous system controls physiological processes
2. explain how the endocrine system contributes to homeostasis.

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.

- neuron
- nerve impulse transmission
- central and peripheral nervous systems
- reflex arcs
- sensory receptors
- endocrine system and hormones
- homeostasis and feedback systems
- endocrine and nervous system interactions

General Outcome 1
Students will explain how the nervous system controls physiological processes.

Specific Outcomes for Knowledge

Students will:

30–A1.1k describe the general structure and function of a neuron and myelin sheath, explaining the formation and transmission of an action potential, including all-or-none response and intensity of response; the transmission of a signal across a synapse; and the main chemicals and transmitters involved, i.e., norepinephrine, acetylcholine and cholinesterase

30–A1.2k identify the principal structures of the central and peripheral nervous systems and explain their functions in regulating the voluntary (somatic) and involuntary (autonomic) systems of the human organism; i.e., cerebral hemispheres and lobes, cerebellum, pons, medulla oblongata, hypothalamus, spinal cord, sympathetic and parasympathetic nervous systems, and the sensory-somatic nervous system

30–A1.3k describe, using an example, the organization of neurons into nerves and the composition and function of reflex arcs; *e.g., the patellar reflex, the pupillary reflex*

30–A1.4k describe the structure and function of the parts of the human eye; i.e., the cornea, lens, sclera, choroid, retina, rods and cones, fovea centralis, pupil, iris and optic nerve

30–A1.5k describe the structure and function of the parts of the human ear, including the pinna, auditory canal, tympanum, ossicles, cochlea, organ of Corti, auditory nerve, semicircular canals and Eustachian tube

30–A1.6k explain other ways that humans sense their environment and their spatial orientation in it; *e.g., olfactory receptors, proprioceptors, taste receptors, receptors in the skin.*

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

Students will:

30–A1.1sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- *discuss the biological basis of neurological diseases such as Alzheimer's or Parkinson's disease and how this relates to treatment*
- *evaluate the impact of photoperiod (light wavelength and duration) on humans and identify adaptations to light deprivation in northern communities*

30–A1.2sts explain that scientific investigation includes the process of analyzing evidence and providing explanations based upon scientific theories and concepts **(NS5f) [ICT C7–4.2]**
- *analyze experimental evidence regarding the influence of anesthetics, drugs and chemicals, natural and synthetic, on the functioning of the nervous system and relate this to addiction theories*
- *analyze the contribution of technological developments and physiological knowledge to longevity and quality of life*

30–A1.3sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**
- *investigate technologies available to correct eye defects such as myopia, hyperopia and astigmatism and ear defects such as hearing loss and tinnitus*
- *investigate the biological basis of neurotoxin action and their antidotes (snake venom, box jellyfish, botulin, reserpine [Rauwolfia serpentina])*
- *investigate the use of neurotoxins by Indigenous peoples*
- *discuss how advances in science have contributed to technologies that increase access to the world beyond normal sensory limits.*

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 how the nervous system controls physiological processes.

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 investigate heat, cold, pressure and touch receptors **(IP–NS1, IP–NS2, IP–NS3)**.

Performing and Recording

Students will:

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

- design and perform an experiment to investigate the physiology of reflex arcs **(IP–NS2, PR–NS2, PR–NS3, PR–NS4) [ICT F1–4.2]**
- perform experiments to measure the ability to discriminate objects visually and to hear a range of sounds **(PR–NS2, PR–NS3, PR–NS4)**
- use a microscope and prepared slides to observe neurons and synapses **(PR–NS2, PR–NS3, PR–NS4)**
- observe the principal features of a mammalian brain, eye and ear, using models, computer simulations or dissections, and identify the major structures of those organs **(PR–NS3, PR–NS4) [ICT C6–4.4]**
- *investigate and integrate, from library and electronic sources, information on the impact of photoperiod and wavelength on humans* **(PR–NS1, PR–NS4) [ICT C1–4.1]**
- *compile and display, in appropriate format, data collected from investigations on reflex arcs, stimulus strength versus force of muscle contraction, and/or auditory range* **(PR–NS4) [ICT P2–4.1]**.

Analyzing and Interpreting

Students will:

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

- *interpret patterns and trends in data on strength of stimuli versus force of muscle contraction* **(AI–NS2) [ICT C7–4.2]**
- *analyze and interpret aspects of vision, such as blind spot, acuity, accommodation, adaptation, binocular vision and peripheral vision* **(AI–NS2) [ICT C7–4.2]**
- *analyze a hearing aid as a device that simulates a sensory function* **(AI–ST1)**
- *pose new questions, such as: "Why are some people more tolerant to pain than others?"* **(AI–NS5)**
- *collect and analyze class data on colour charts* **(PR–NS4, AI–NS2) [ICT C7–4.2]**
- *analyze data that shows the interrelationship between taste and smell receptors* **(AI–NS2) [ICT C7–4.2]**.

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 Système international (SI) units, 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)**¬
- *work cooperatively with group members to investigate neurological disorders such as Alzheimer's or Parkinson's disease* **(CT–NS1)**.

¬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 how the endocrine system contributes to homeostasis.

Specific Outcomes for Knowledge

Students will:

30–A2.1k identify the principal endocrine glands of humans; i.e., the hypothalamus/pituitary complex, thyroid, parathyroid, adrenal glands and islet cells of the pancreas

30–A2.2k describe the function of the hormones of the principal endocrine glands, i.e., thyroid-stimulating hormone (TSH)/thyroxine, calcitonin/parathyroid hormone (PTH), adrenocorticotropic hormone (ACTH)/cortisol, glucagon/insulin, human growth hormone (hGH), antidiuretic hormone (ADH), epinephrine, aldosterone, and describe how they maintain homeostasis through feedback

30–A2.3k explain the metabolic roles hormones may play in homeostasis; i.e., thyroxine in metabolism; insulin, glucagon and cortisol in blood sugar regulation; hGH in growth; ADH in water regulation; aldosterone in sodium ion regulation

30–A2.4k explain how the endocrine system allows humans to sense their internal environment and respond appropriately; *e.g., calcium balance, osmotic pressure of blood*

30–A2.5k compare the endocrine and nervous control systems and explain how they act together; *e.g., stress and the adrenal gland*

30–A2.6k describe, using an example, the physiological consequences of hormone imbalances; i.e., diabetes mellitus *(e.g., diabetes insipidus, gigantism, goitre, cretinism, Graves' disease).*

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

Students will:

30–A2.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.8]**

- *compare the function of technological control systems, such as computer control systems for car emissions, with electrochemical control systems in organisms*
- *assess the impact of research into biochemical control systems on human performance*
- *describe the current treatments for type 1 and type 2 diabetes*

30–A2.2sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F2–4.8, F3–4.1]**

- *evaluate the use of biotechnology to solve practical problems (hormone synthesis for diabetes mellitus, dwarfism, milk yield in cows)*
- *evaluate the use of hormone therapy in the treatment of humans (growth hormone and aging, anabolic steroids and human performance)*
- *explain the relationship between pigment deposition within skin cells and ultraviolet light as influenced by stratospheric ozone.*

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 how the endocrine system contributes to homeostasis.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

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

- formulate a hypothesis, from published data, on an environmental factor that can be detected and responded to by humans; *e.g., stress and hormonal disruption, ultraviolet light and pigment deposition, diet and thyroid function* **(IP–NS3)**.

Performing and Recording

Students will:

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

- *research seasonal affective disorder (SAD) or general adaptation syndrome and identify the main hormonal and nervous components* **(PR–NS4)**.

Analyzing and Interpreting

Students will:

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

- infer the role of ADH and aldosterone in the maintenance of water and ions, using the analysis and interpretation of data on blood and urine composition **(AI–NS6) [ICT C7–4.2]**
- infer the role of insulin in the regulation of blood sugar by performing an experiment to investigate the presence of glucose in simulated urine and comparing the results with normal urinalysis data, and/or investigate the role of insulin in the regulation of blood sugar by using a computer simulation **(AI–NS6) [ICT C7–4.2]**.

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

- *evaluate individual and group processes used in planning and carrying out group investigations of hormone therapy or the use of biotechnology to solve practical problems* **(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.

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

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10-3, Measurement, Specific Outcome 1
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcome 1; Mathematics 20-3, Statistics, Specific Outcome 1

Unit B: Reproduction and Development

Themes: Change and Systems

Overview: This unit investigates the human reproductive system as a representative mammalian system responsible for propagating the organism and perpetuating the species. The processes associated with human reproduction and development, as well as the regulation of these processes by hormones, are reviewed. The influence of environmental factors on embryonic and fetal development is examined, as are various reproductive technologies.

This unit builds on:
- Grade 8 Science, Unit B: Cells and Systems
- Grade 9 Science, Unit A: Biological Diversity
- Science 10, Unit C: Cycling of Matter in Living Systems
- Biology 20, Unit D: Human Systems

Unit B will require approximately 20% of the time allotted for Biology 30.

Links to Mathematics: Refer to page 64.

Focusing Questions: How do the reproductive systems function to ensure survival of the species? What mechanisms are responsible for regulating the reproductive systems? What are the major processes and events of human embryonic and fetal development? How do reproductive technologies affect functioning of the reproductive systems, and what impact do these technologies have on society?

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

Students will:

1. explain how survival of the human species is ensured through reproduction
2. explain how human reproduction is regulated by chemical control systems
3. explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental factors.

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.
- male and female reproductive systems
- reproductive hormones
- reproductive technologies
- embryonic and fetal development
- parturition
- lactation

General Outcome 1
Students will explain how survival of the human species is ensured through reproduction.

Specific Outcomes for Knowledge

Students will:

30–B1.1k identify the structures in the human female reproductive system and describe their functions; i.e., ovaries, Fallopian tubes, uterus, endometrium, cervix, vagina

30–B1.2k identify the structures in the human male reproductive system and describe their functions; i.e., testes, seminiferous tubules, interstitial cells, Sertoli cells, epididymides, vasa (ductus) deferentia, Cowper's glands, seminal vesicles, prostate gland, ejaculatory duct, urethra, penis

30–B1.3k distinguish sperm and egg from their supporting structures; i.e., seminiferous tubules, interstitial cells, Sertoli cells, follicle, corpus luteum

30–B1.4k describe the chromosomal factors and hormonal influence on the formation of the gonads and reproductive organs in the female and male embryo and fetus; i.e., Y chromosome and role of testosterone

30–B1.5k explain how sexually transmitted infections (STIs) can interfere with fertility and reproduction; *e.g., chlamydia, gonorrhea, human papilloma virus.*

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

Students will:

30–B1.1sts 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)**

- *evaluate the implications of a reproductive technology for human biology*
- *consider the application of long-term scientific and technological solutions to population control, using the Aboriginal concept of seven generations*
- *discuss society's expectations of the scientific community with respect to reproductive technologies*
- *discuss the impact of STIs on individuals, considering the physiological damage they cause.*

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 how survival of the human species is ensured through reproduction.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

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

- *identify ethical concerns about reproductive technologies, infertility and the transmission of STIs* **(IP–SEC1)**.

Performing and Recording

Students will:

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

- observe the principal features of the human reproductive system, using models or computer simulations, and identify the major structures from drawings **(PR–NS4) [ICT C6–4.4]**
- use a microscope to observe prepared slides of ovaries and testes so as to distinguish eggs and sperm from their supporting structures; i.e., follicle, corpus luteum, interstitial cells, Sertoli cells, seminiferous tubules **(PR–NS2, PR–NS4)**.

Analyzing and Interpreting

Students will:

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

- evaluate practical solutions to decreased fertility; i.e., low sperm count, difficulty in egg production, hormonal imbalance **(AI–ST2, AI–SEC2)**
- *evaluate information collected from library and electronic sources on the implications of reproductive technologies such as surrogacy, sperm banks and cloning* **(AI–SEC2, AI–SEC4) [ICT C1–4.1, C3–4.1, C3–4.2]**.

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

- *work cooperatively as a team to research the damage to reproductive organs caused by STIs and use appropriate multimedia to present the findings to the class* **(CT–SEC1, CT–SEC2) [ICT C1–4.4, 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 2
Students will explain how human reproduction is regulated by chemical control systems.

Specific Outcomes for Knowledge

Students will:

30–B2.1k describe the role of hormones, i.e., gonadotropic-releasing hormone (GnRH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), estrogen, progesterone, testosterone, in the regulation of primary and secondary sex characteristics in females and males

30–B2.2k identify the principal reproductive hormones in the female and explain their interactions in the maintenance of the menstrual cycle; i.e., estrogen, progesterone, FSH, LH

30–B2.3k identify the principal reproductive hormones in the male and explain their interactions in the maintenance and functioning of the male reproductive system; i.e., testosterone, FSH, LH.

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

Students will:

30–B2.1sts explain how science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2)**

- *research and assess the effects of the medical use of reproductive hormones on humans*
- *research and assess the implications for humans of producing and using reproductive hormones in domestic animals, such as cattle and horses*

30–B2.2sts explain why 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]**

- *explain how reproductive hormone homeostasis is disrupted by the natural aging process and discuss whether available technologies, such as hormone treatment for menopause and andropause, should be used to restore balance.*

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 how human reproduction is regulated by chemical control systems.

Specific Outcomes for Skills (Social and Environmental Contexts 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 to determine at which point during the menstrual cycle a female is most fertile* **(IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

30–B2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information
- graph the changes in estrogen, progesterone, FSH and LH levels in the blood of a female through a single menstrual cycle **(PR–NS4) [ICT C6–4.2]**
- identify the follicle and corpus luteum within the ovary, using models, diagrams or computer simulations **(PR–NS4) [ICT C6–4.4]**.

Analyzing and Interpreting

Students will:

30–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- analyze blood hormone data and physiological events for a single menstrual cycle, inferring the roles of female sex hormones **(AI–NS2, AI–NS6)**
- analyze blood hormone data and physiological events, inferring the roles of male sex hormones **(AI–NS2, AI–NS6) [ICT C7–4.2]**
- *research and assess the effects of the medical use of reproductive hormones on conditions such as menopause, andropause and infertility* **(PR–SEC1, AI–SEC2, AI–SEC4) [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
- select and use appropriate numerical and graphical modes of representation to communicate information on changing reproductive hormone levels in the blood **(CT–ST2)**
- *work cooperatively with team members to investigate the impact of the use of reproductive hormones in agriculture on the environment (such as the feminization of fish) and, using appropriate multimedia, present the information to the class* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, 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 explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental factors.

Specific Outcomes for Knowledge

Students will:

30–B3.1k trace the processes of fertilization, implantation and extra-embryonic membrane formation, i.e., placenta, amnion, chorion, allantois, followed by embryonic and fetal development, parturition and lactation, and describe the control mechanisms of these events, i.e., progesterone, LH, human chorionic gonadotropin (hCG), prostaglandins, oxytocin, prolactin

30–B3.2k describe development from fertilization to parturition in the context of the main physiological events that occur in the development of organ systems during each major stage (trimester); i.e., zygote, blastocyst, gastrulation, general morphogenesis

30–B3.3k identify major tissues and organs that arise from differentiation and morphological development of the ectoderm, mesoderm and endoderm in the embryo; i.e.,

- ectoderm: nervous system, epidermis
- mesoderm: skeleton, muscles, reproductive structures
- endoderm: lining of the digestive and respiratory systems, endocrine glands

30–B3.4k describe the influence of environmental factors on embryonic and fetal development; *e.g., maternal lifestyle, teratogens such as alcohol, drugs, viral infections and radiation*

30–B3.5k describe the physiological or mechanical basis of different reproductive technologies; i.e., conception control, in vitro fertilization, infertility reversal.

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

Students will:

30–B3.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1)**

- *analyze the use of technology to solve problems of immunological incompatibility between fetus and mother*

30–B3.2sts explain why 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 use of technologies such as ultrasound, chorionic villus sampling (CVS), amniocentesis and a fetal heart rate monitor in monitoring fetal development*
- *assess the effects of a conception control technology on population demographics in developed and developing countries*
- *discuss how knowledge of embryonic/fetal development has influenced the value that society places on human life*
- *discuss the societal impact of environmental contaminants (such as polychlorinated biphenyls [PCBs], heavy metals, dioxins and furans) and teratogens.*

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 explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental factors.

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

- *design an experiment to investigate hormonal changes during pregnancy* **(IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

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

- investigate, using library and electronic sources, the effects of environmental factors on human embryonic and fetal development; *e.g., alcohol, cocaine, cigarette smoke, diet, and prescription and nonprescription drugs* **(PR–SEC1) [ICT C1–4.1]**
- *research the societal impact of technology such as ultrasound, amniocentesis, in vitro fertilization and CVS* **(PR–SEC1) [ICT F3–4.1]**
- *investigate, using library and electronic sources, how embryonic cells communicate during development* **(PR–NS1) [ICT C1–4.1]**.

Analyzing and Interpreting

Students will:

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

- observe the changes during embryo development, using preserved material such as chicken embryos, models or computer simulations, and extrapolate these events to the development of a human **(PR–NS3, AI–NS2) [ICT C6–4.1, C6–4.4]**
- interpret hormonal data from published investigations; *e.g., pregnancy testing* **(AI–NS2) [ICT C7–4.2]**
- *evaluate, from published data, the effectiveness and safety of various reproductive technologies* **(AI–SEC1, AI–SEC2)**
- *analyze the stages of embryonic and fetal development* **(AI–NS2)**.

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 explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental factors.

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

- *develop clear and logical arguments, based on published data, to defend a given decision on the effectiveness and safety of available reproductive technologies* **(CT–SEC3) [ICT C1–4.4]**.

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

Concept	Mathematics Course, Strand and Specific Outcome
Data Collection and Analysis	Grade 9 Mathematics, Statistics and Probability (Data Analysis), Specific Outcome 3
Measurement and Unit Conversions	Mathematics 10-3, Measurement, Specific Outcome 1
Graph Analysis	Mathematics10C, Relations and Functions, Specific Outcome 1; Mathematics 20-3, Statistics, Specific Outcome 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: Cell Division, Genetics and Molecular Biology

Themes: Change and Diversity

Overview: This unit examines the two types of cell division, mitosis and meiosis. Students learn about chromosomal behaviour during cell division and expand their knowledge of chromosomes by studying classical genetics. Classical genetics is further extended to a molecular level by exploring the basic structure of deoxyribonucleic acid (DNA), its role in protein synthesis and the impact of mutation.

This unit builds on:

- Grade 9 Science, Unit A: Biological Diversity

Unit C will require approximately 40% of the time allotted for Biology 30.

Links to Mathematics: Refer to page 73.

Focusing Questions: What cellular processes allow for growth and reproduction of an organism? What regulates the transmission of genetic information from one generation to the next? How is DNA responsible for the production of proteins? How has knowledge of the molecular nature of genes and DNA led to new biotechnologies and the treatment of genetic disorders?

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

Students will:

1. describe the processes of mitosis and meiosis
2. explain the basic rules and processes associated with the transmission of genetic characteristics
3. explain classical genetics at the molecular level.

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.

- cell cycle
- mitosis and meiosis
- chromosome number
- karyotype
- alternation of generations
- Mendel's laws of heredity
- probability
- monohybrid, dihybrid and sex-linked inheritance
- incomplete dominance and codominance
- polygenic and multiple allelic traits
- gene linkage
- model of DNA
- replication
- transcription
- translation
- mutation
- genetic engineering

General Outcome 1
Students will describe the processes of mitosis and meiosis.

Specific Outcomes for Knowledge

Students will:

30–C1.1k define and explain the significance of chromosome number in somatic and sex cells; i.e., haploidy, diploidy and polyploidy

30–C1.2k explain, in general terms, the events of the cell cycle; i.e., interphase, mitosis and cytokinesis

30–C1.3k describe the process of meiosis (spermatogenesis and oogenesis) and the necessity for the reduction of chromosome number

30–C1.4k compare the processes of mitosis and meiosis

30–C1.5k describe the processes of crossing over and nondisjunction and evaluate their significance to organism inheritance and development

30–C1.6k compare the formation of fraternal and identical offspring in a single birthing event

30–C1.7k describe the diversity of reproductive strategies by comparing the alternation of generations in a range of organisms; *e.g., Daphnia, sea anemone, moss, pine.*

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

Students will:

30–C1.1sts explain that science and technology are developed to meet societal needs and expand human capability **(SEC1)**

- *discuss the role of mitosis and biotechnology in regenerating whole, damaged or missing parts of organisms (stem cells, skin tissue)*
- *evaluate how knowledge of cell division or development of nanotechnology might be applied to the regulation of cancerous growth in plants or animals*
- *discuss and assess the impact of research in plant and animal reproduction on our understanding of mitosis and meiosis in humans (cloning, chromosome shortening)*
- *discuss the types and sources of teratogenic compounds found in the environment and the technological means by which they can be removed or controlled to ensure quality of life for future generations.*

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 the processes of mitosis and meiosis.

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

- *define questions related to mitosis and meiosis, such as chromosome shortening, conditions/stimuli for meiosis, aging and mitosis, cytokinesis* **(IP–NS1)**.

Performing and Recording

Students will:

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

- perform a simulation to demonstrate the behaviour of chromosomes during mitosis **(PR–NS3)**
- use a microscope and prepared slides of onion root tip cells to identify the stages of a cell cycle and calculate the duration of each stage **(PR–NS3, AI–NS2)**
- research and compare a range of reproductive strategies in organisms and present them in the form of charts, tables or diagrams; *e.g., binary fission, budding, the sexual and asexual phases of alternation of generations* **(PR–NS1, PR–NS4) [ICT C6–4.3]**
- *prepare microscope slides to demonstrate some stages of mitosis and meiosis* **(PR–NS2, PR–NS3, PR–NS4)**.

Analyzing and Interpreting

Students will:

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

- prepare and interpret models of human karyotypes by using hard-copy or online resources **(AI–NS2)**
- *analyze the similarities and differences of cell division in plants and animals* **(AI–NS2) [ICT C7–4.2]**.

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 describe the processes of mitosis and meiosis.

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 collaboratively in the preparation of mitosis slides* **(CT–NS1)**
- *present two contrasting reproductive strategies, emphasizing the differences* **(CT–ST2) [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.

General Outcome 2
Students will explain the basic rules and processes associated with the transmission of genetic characteristics.

Specific Outcomes for Knowledge

Students will:

30–C2.1k describe the evidence for dominance, segregation and the independent assortment of genes on different chromosomes, as investigated by Mendel

30–C2.2k compare ratios and probabilities of genotypes and phenotypes for dominant and recessive, multiple, incompletely dominant, and codominant alleles

30–C2.3k explain the influence of gene linkage and crossing over on variability

30–C2.4k explain the relationship between variability and the number of genes controlling a trait; *e.g., one pair of genes, as for Rh factor, versus two or more pairs of genes, as for skin colour and height*

30–C2.5k compare the pattern of inheritance produced by genes on the sex chromosomes to that produced by genes on autosomes, as investigated by Morgan and others.

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

Students will:

30–C2.1sts 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 needs and interests of society and the role of genetic counselling and technology in the identification and treatment of potentially disabling genetic disorders (phenylketonuria, cystic fibrosis, germ-cell modification)*
- *discuss the contributions of Aboriginal peoples in the development of early plant hybrids*
- *discuss the application of genetic crosses in the development of specific breeds or hybrids (wheat and corn).*

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 the basic rules and processes associated with the transmission of genetic characteristics.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues
- design a plan for collecting data to demonstrate human inheritance **(IP–NS2)**.

Performing and Recording

Students will:

30–C2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information
- perform an experiment to demonstrate inheritance of a trait controlled by a single pair of genes; *e.g., albino corn, Drosophila or Arabidopsis* **(PR–NS2, PR–NS3, PR–NS4)**
- *design and perform an experiment to demonstrate that an environmental factor can cause a change in the expression of genetic information in an organism* **(IP–NS2, IP–NS3, IP–NS4, PR–NS3, PR–NS4, PR–NS5) [ICT F1–4.2]**.

Analyzing and Interpreting

Students will:

30–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- interpret patterns and trends of inheritance of traits and predict, quantitatively, the probability of inheritance of traits illustrated in monohybrid, dihybrid and sex-linked inheritance, using pedigrees and Punnett squares **[ICT C7–4.2]**
- perform experiments to record and explain predicted phenotypic ratios versus actual counts in genetic crosses to show a relationship between chance and genetic results **(PR–NS2, PR–NS3, PR–NS4, AI–NS3)**
- draw and interpret pedigree charts from data on human single-allele and multiple-allele inheritance patterns; *e.g., hemophilia, blood types* **(PR–NS4, AI–NS2) [ICT C7–4.2]**
- analyze crossover data for a single pair of chromosomes to create a chromosome map showing gene arrangement and relative distance **(AI–NS2) [ICT C7–4.2]**
- *identify limitations of data associated with phenotypic ratios for small populations in which the ratios may not conform with the theoretical ratios expected* **(AI–NS4)**.

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
- *work cooperatively with team members to investigate a monohybrid cross (tongue rolling, attached earlobes) and solve problems as they arise* **(CT–NS1, CT–NS2)**.

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 explain classical genetics at the molecular level.

Specific Outcomes for Knowledge

Students will:

30–C3.1k summarize the historical events that led to the discovery of the structure of the DNA molecule, including the work of Franklin and Watson and Crick

30–C3.2k describe, in general, how genetic information is contained in the sequence of bases in DNA molecules in chromosomes and how the DNA molecules replicate themselves

30–C3.3k describe, in general, how genetic information is transcribed into sequences of bases in RNA molecules and is finally translated into sequences of amino acids in proteins

30–C3.4k explain, in general, how restriction enzymes cut DNA molecules into smaller fragments and how ligases reassemble them

30–C3.5k explain, in general, how cells may be transformed by inserting new DNA sequences into their genomes

30–C3.6k explain how a random change (mutation) in the sequence of bases results in abnormalities or provides a source of genetic variability

30–C3.7k explain how base sequences in nucleic acids contained in the nucleus, mitochondrion and chloroplast give evidence for the relationships among organisms of different species.

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

Students will:

30–C3.1sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- *discuss the implications for society of corporations being able to patent genes, such as the gene for herbicide resistance in canola*
- *assess the concerns and benefits of genetically modified organisms, such as transgenic food organisms or tree cloning for reforestation*

30–C3.2sts explain that scientific research and technological development help achieve a sustainable society, economy and environment **(SEC4a) [ICT F2–4.2, F2–4.8]**

- *discuss the Human Genome Project and the potential of proteomic technologies, in terms of the needs, interests and financial support of society*
- *discuss biotechnology and gene replacement therapy in the treatment of human genetic disorders*
- *assess the impact and value of DNA sequencing on the study of genetic relationships and variations in population ecology*
- *explore the application of nanotechnology and its implications for clinical diagnostics, pharmacology, biological research or proteomic programs.*

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 explain classical genetics at the molecular level.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–C3.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues
- *design an experiment to identify the proteins produced in a cell at a particular point in time or development* **(IP–NS2, IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

30–C3.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information
- construct models of DNA to demonstrate the general structure and base arrangement **(PR–ST2) [ICT C6–4.4]**
- perform simulations to demonstrate the replication of DNA and the transcription and translation of its information **(PR–NS2, PR–NS4)**
- perform simulations to demonstrate the use of restriction enzymes and ligases **(PR–NS3, PR–NS4)**
- *perform an investigation to extract DNA from cells in green peas, beans, bananas or onions* **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- *research gel electrophoresis techniques and their applications in medical diagnostics and forensics* **(PR–ST1)**.

Analyzing and Interpreting

Students will:

30–C3.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- analyze, from published data, relationships between human activities and changes in genetic information that lead to heritable mutations and cancer **(AI–NS2) [ICT C7–4.2]**
- *analyze DNA fingerprints* **(AI–NS2)**
- *compare and contrast homologous DNA sequences to infer ancestry of various species* **(AI–NS2)**.

Communication and Teamwork

Students will:

30–C3.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results
- *work cooperatively with team members to investigate the impact of an environmental factor on the expression of a gene and to solve problems as they arise* **(CT–NS1)**
- *debate the advantages and disadvantages of corporate funding and patenting of genetic research results, including Aboriginal and other perspectives of ownership* **(CT–SEC2, 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.

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

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

Unit D: Population and Community Dynamics

Themes: Systems, Equilibrium and Change

Overview: Population change over time can be examined through a study of population genetics (Hardy-Weinberg principle) and population growth. Both of these can be expressed quantitatively. Individual members of populations interact with each other as well as with members of other populations, which can have an impact on the populations involved. Communities are a sum of all the different populations living together. Communities may change over time as a result of natural or artificial events.

This unit builds on:
- Grade 9 Science, Unit A: Biological Diversity
- Biology 20, Unit A: Energy and Matter Exchange in the Biosphere and Unit B: Ecosystems and Population Change

Unit D will require approximately 15% of the time allotted for Biology 30.

Links to Mathematics: Refer to page 81.

Focusing Questions: How does one determine if populations are changing over time? In what ways may individual members of a population interact with one another or with members of a different population? What quantitative measures indicate that populations change over time? What role does society play in managing wildlife populations?

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

Students will:

1. describe a community as a composite of populations in which individuals contribute to a gene pool that can change over time
2. explain the interaction of individuals in a population with one another and with members of other populations
3. explain, in quantitative terms, the change in populations over time.

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.

- Hardy-Weinberg principle
- gene pool
- natural selection
- symbiotic relationships and other interactions
- succession
- determiners of population size: natality, mortality, immigration, emigration
- population growth rate and population growth curves
- *r*- and *K*-selected reproductive strategies

General Outcome 1
Students will describe a community as a composite of populations in which individuals contribute to a gene pool that can change over time.

Specific Outcomes for Knowledge

Students will:

30–D1.1k describe the Hardy-Weinberg principle and explain its significance in population gene-pool stability and nonequilibrium values

30–D1.2k describe the factors that cause the diversity in the gene pool to change; i.e., natural selection, genetic drift, gene flow, nonrandom mating, bottleneck effect, founder effect, migration, mutation

30–D1.3k apply, quantitatively, the Hardy-Weinberg principle to observed and published data to determine allele and genotype frequencies, using the equations $p + q = 1$ and $p^2 + 2pq + q^2 = 1$

30–D1.4k describe the molecular basis of gene-pool change and the significance of these changes over time; i.e., mutations and natural selection *(e.g., drug-resistant bacteria, herbicide-resistant plants).*

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

Students will:

30–D1.1sts explain that science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- *discuss the introduction of exotic species into new ecosystems*
- *discuss the development of ecological reserves to preserve gene-pool diversity*
- *assess the bottleneck effect characteristic of small populations, such as in whooping crane and swift fox populations, and suggest strategies to counteract it*
- *investigate the role of gene banks in the preservation of endangered species and genotypes, particularly of plants and animals used in agriculture*
- *assess habitat loss and the responsibility of society to protect the environment for future generations*

30–D1.2sts explain how concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**

- *assess the role and importance of models in ecology, such as the Hardy-Weinberg principle, in explaining scientific phenomena such as changes in gene frequencies.*

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 a community as a composite of populations in which individuals contribute to a gene pool that can change over time.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- *identify a question about the resistance of bacteria to specific antibiotics or about the resistance of plants to specific herbicides* **(IP–NS1)**.

Performing and Recording

Students will:

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

- design and perform an investigation and/or a computer simulation to demonstrate population growth and gene-pool change **(IP–NS2, IP–NS3, IP–NS4, PR–NS3, PR–NS4, PR–NS5) [ICT C6–4.4, F1–4.2]**
- *research, integrate and synthesize information on a related topic, such as:*
  - *the development and persistence of deleterious genes in gene pools*
  - *the development of bacterial resistance to antibiotics* **(PR–NS1) [ICT C7–4.2]**.

Analyzing and Interpreting

Students will:

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

- calculate and interpret results based on the Hardy-Weinberg principle in problem-solving exercises **(AI–NS6) [ICT C6–4.1]**.

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

- use appropriate notation and significant digits to show gene frequency and changes in gene frequency over time **(CT–NS2)**.

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 the interaction of individuals in a population with one another and with members of other populations.

Specific Outcomes for Knowledge

Students will:

30–D2.1k describe the basis of species interactions and symbiotic relationships and describe the influence of these interactions on population changes; i.e.,
- predator-prey and producer-consumer relationships
- symbiotic relationships: commensalism, mutualism and parasitism
- interspecific and intraspecific competition

30–D2.2k explain the role of defence mechanisms in predation and competition; *e.g., mimicry, protective coloration, toxins, behaviour*

30–D2.3k explain how mixtures of populations that define communities may change over time or remain as a climax community; i.e., primary succession, secondary succession.

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

Students will:

30–D2.1sts explain why Canadian society supports scientific research and technological development to facilitate a sustainable society, economy and environment **(SEC4a) [ICT F2–4.2, F2–4.8]**
- *discuss public support for scientific work done on predator-prey relationships as part of wildlife management in national and provincial parks, such as the introduction of wolves*
- *identify examples of wildlife management techniques used by Aboriginal peoples*
- *assess the long-term implications of fire control and prevention on population and ecosystem stability, diversity and productivity*
- *assess the impact of parasites on populations and how this impact could be reduced, considering examples such as liver flukes in elk and lungworms in bighorn sheep.*

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 the interaction of individuals in a population with one another and with members of other populations.

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
- *plan an investigation of species interaction in a national park or wilderness area* **(IP–NS2, IP–NS3)**.

Performing and Recording

Students will:

30–D2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information
- design and perform an experiment or a simulation to demonstrate interspecific and intraspecific competition **(IP–NS2, IP–NS3, IP–NS4, PR–NS3, PR–NS4, PR–NS5)**
- design and perform an experiment to demonstrate succession in a micro-environment and record the pattern of succession over time; *e.g., hay infusion* **(IP–NS2, IP–NS3, IP–NS4, PR–NS3, PR–NS4, PR–NS5)**
- perform simulations to investigate relationships between predators and their prey; *e.g., computer simulation, role-playing* **(PR–NS2, PR–NS3, PR–NS4)**.

Analyzing and Interpreting

Students will:

30–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions
- summarize and evaluate a symbiotic relationship **(PR–NS1, AI–NS6)**
- *research and analyze the effects of clearcutting versus selective logging practices on ecosystems* **(PR–SEC1, AI–SEC2)**.

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
- *research and present practical solutions for reducing the impact of highway fencing on animals in Banff and Jasper National Parks* **(CT–SEC1, CT–SEC2) [ICT C1–4.4]**
- *develop, present and defend a position on whether organisms should be deliberately introduced into new environments* **(CT–SEC1, CT–SEC2) [ICT C1–4.4, C7–4.2]**
- *research and present characteristics of interrelationships between organisms for analysis by classmates* **(CT–SEC1, CT–SEC2) [ICT C1–4.4, C7–4.2]**.

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 explain, in quantitative terms, the change in populations over time.

Specific Outcomes for Knowledge

Students will:

30–D3.1k describe and explain, quantitatively, factors that influence population growth; i.e.,
- mortality, natality, immigration, emigration
- change in population size, ΔN = [natality + immigration] – [mortality + emigration]

30–D3.2k describe the growth of populations in terms of the mathematical relationship among carrying capacity, biotic potential, environmental resistance and the number of individuals in the population; i.e.,
- growth rate, $gr = \frac{\Delta N}{\Delta t}$, where ΔN is the change in number of individuals in a population and Δt is change in time
- per capita growth rate, $cgr = \frac{\Delta N}{N}$, where ΔN is the change in number of individuals in a population relative to N, the original number of individuals
- population density, $D_p = \frac{N}{A}$, or $D_p = \frac{N}{V}$, where N is the number of individuals in a given space, A is the area, and V is the volume

30–D3.3k explain the different population growth patterns; i.e.,
- logistic growth pattern (S-shaped curve) and exponential growth pattern (J-shaped curve)
- open and closed populations

30–D3.4k describe the characteristics and reproductive strategies of *r*-selected and *K*-selected organisms.

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

Students will:

30–D3.1sts explain how concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**
- *develop appropriate investigative strategies, such as a risk-benefit analysis or cost-benefit analysis, for analyzing biological issues*
- *compare the growth of the human population with that of populations of other 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 explain, in quantitative terms, the change in populations over time.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

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

- *identify questions about factors that affect population growth rates* **(IP–NS1)**.

Performing and Recording

Students will:

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

- design and perform an experiment or a computer simulation to demonstrate the effect of environmental factors on population growth rate **(IP–NS2, IP–NS3, IP–NS4, PR–NS3, PR–NS4) [ICT C6–4.4, F1–4.2]**
- *monitor a paramecium population over time, using a microscope and a grid slide* **(PR–NS2, PR–NS3, PR–NS4, PR–NS5)**
- *research zebra mussel population growth in the Great Lakes* **(PR–NS1, PR–NS4)**
- *research the impact of introduced trout species on populations of native bull trout (Salvelinus confluentus) in Alberta's lakes and streams* **(PR–NS1)**.

Analyzing and Interpreting

Students will:

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

- graph and interpret population growth of *r*-selected and *K*-selected organisms **(AI–NS2) [ICT C7–4.2]**
- calculate and interpret change in population size, growth rate, per capita growth rate and population density **(AI–NS2, AI–NS3, AI–NS4)**
- *compare and evaluate human population growth rates in various countries* **(AI–NS2**) [**ICT C7–4.2]**
- *demonstrate and assess the effect of environmental factors (biotic potential and environmental resistance) on population growth curves* **(AI–NS2, AI–NS6)**
- *calculate population growth rate under ideal conditions, given specific parameters* **(AI–NS3, AI–NS4)**
- *state a generalization based on data for the growth of a closed population* **(AI–NS2, AI–NS6)**
- *explain limitations in identifying changes in populations and explain how traditional knowledge can contribute to knowledge about changes* **(AI–NS4)**.

Communication and Teamwork

Students will:

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

- *develop, present and defend a position on Earth's carrying capacity of Homo sapiens* **(CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, C7–4.2]**.

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.

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

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