Atlantic Canada
Science Curriculum

Department of Education
English Program Services

CURRICULUM

Biology 11

Implementation Draft
June 2000

Biology 11: Implementation Draft
June 2000

Contents

Foreword

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12*, released in October 1997, will assist in standardizing science education across the country. New science curriculum for the Atlantic Provinces is described in *Foundation for the Atlantic Canada Science Curriculum* (1998). Currently, the Atlantic Provinces Education Foundation (APEF) is developing new science curriculum guidelines for grades 1–10. One of the implications for implementation of the new curriculum is that the Biology 11 course will be significantly different from the existing Biology 11 course. This change also necessitates an edit of the existing biology, chemistry, and physics guides to bring them into alignment with the new Biology 11 course.

Biology 11: Implementation Draft includes the following topics: matter and energy for life, biodiversity, maintaining dynamic equilibrium, and interactions among living things.

This implementation draft guide is intended to provide teachers with the overview of the outcomes framework for the course. It also includes some strategies to assist teachers in designing learning experiences and assessment tasks. The final version of *Biology 11* will provide more details and suggestions for teaching and learning, assessment and evaluation, and resources.

Introduction

Background

The curriculum described in *Foundation for the Atlantic Canada Science Curriculum* and in *Biology 11: Implementation Draft* was planned and developed collaboratively by regional committees. The process for developing the common science curriculum for Atlantic Canada involved regional consultation with the stakeholders in the education system in each Atlantic province. The Atlantic Canada science curriculum is consistent with the science framework described in the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*.

Rationale

The aim of science education in the Atlantic provinces is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become life-long learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, their careers, and their future.

Program Design and Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include the following:

- creating a classroom environment to support the learning and teaching of science
- designing effective learning experiences that help students achieve designated outcomes
- stimulating and managing classroom discourse in support of student learning
- learning about and then using students' motivations, interests, abilities, and learning styles to improve learning and teaching
- analysing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions
- selecting teaching strategies from a wide repertoire

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs not by passive absorption, but rather by actively constructing one's own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students' disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.

The Three Processes of Scientific Literacy

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem-solving, and decision making.

Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and but they also provide a relevant context for engaging in scientific inquiry and/or problem solving.

Meeting the Needs of All Learners

Foundation for the Atlantic Canada Science Curriculum stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware of and make adaptations to accommodate the diverse range of learners in their class. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit them to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching, they also actively address cultural and gender stereotyping about who is interested in and who can succeed in science and mathematics. Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally under-represented in science, and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students' needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.

Assessment and Evaluation

The terms "assessment" and "evaluation" are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in the Atlantic region use these terms for the processes described below.

Assessment is the systematic process of gathering information on student learning.

Evaluation is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

The Atlantic Canada science curriculum is designed to enable students to acquire science-related knowledge, skills, and attitudes and to engage them in the study and analysis of the interrelationships among science, technology, society, and the environment (STSE). It also reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities/skills/actions that are associated with each process of

science learning. Examples of these are illustrated in the following lists. Student learning may be described in terms of ability to perform these tasks.

Inquiry

- define questions related to a topic
- refine descriptors/factors to provide focus for practical and theoretical research
- select an appropriate way to find information
- make direct observations
- perform experiments, record and interpret data, and draw conclusions
- design an experiment that tests relationships and variables
- write lab reports that meet a variety of needs (with limited need to produce) and place emphasis on recorded data
- recognize that both quality of both the process and the product are important

Problem Solving

- clearly define a problem
- produce a range of potential solutions for the problem
- appreciate that several solutions should be considered
- plan and design a product or device intended to solve a problem
- construct a variety of acceptable prototypes; pilot test, evaluate, and refine them to meet a need
- present the refined process/product/device and support why it is "preferred"
- recognize that quality of the process and the product is important

Decision Making

- gather information from a variety of sources
- evaluate the validity of the information source
- evaluate which information is relevant
- identify the different perspectives that influence a decision
- present information to reflect different perspectives
- use information to support a given perspective
- recommend a decision and provide supporting evidence
- communicate a decision and provide a "best" solution

Current Practices in Science Education

Current practices include

- the active involvement of students in constructing and applying scientific explanations and concepts
- scientific inquiry, problem solving, and decision making as a means, as well as a goal, of science education
- effective questioning techniques that promote student interaction

the use of a variety of instructional formats (small group, individual, whole class, exploratory open-ended activities, project work, formal laboratory exercises)

- students asking, and then attempting to answer, their own questions about scientific ideas
- students communicating about scientific ideas orally and in writing
- the establishment and application of the interrelatedness of science concepts and topics
- assessment of learning as an integral and ongoing part of the learning process

Integrating Technology

The integration of computers, graphics calculators, probes, video technology, and other technologies into the biology classroom allows students to

- explore individual or groups of related computations or functions quickly or easily
- create and explore numeric and geometric situations for the purpose of developing conjectures
- perform simulations of situations which would otherwise be impossible to examine
- easily link different representations of the same information
- model situations scientifically
- observe the effects of simple changes in parameters or coefficients
- analyse, organize, and display data

All of these situations enhance discovery learning and problem-solving potential. At the same time, teachers have the opportunity to use technology to communicate with fellow science teachers, to share lessons with experts, and to expose their students to information that would otherwise be inaccessible.

Students will need to learn to make judgments as to when the use of technology is appropriate and when it is not. In all situations, it is imperative that technology be used both as a tool to include, rather than exclude, students and as a means of creating new teaching and learning strategies.

Creating Linkages among Science Disciplines

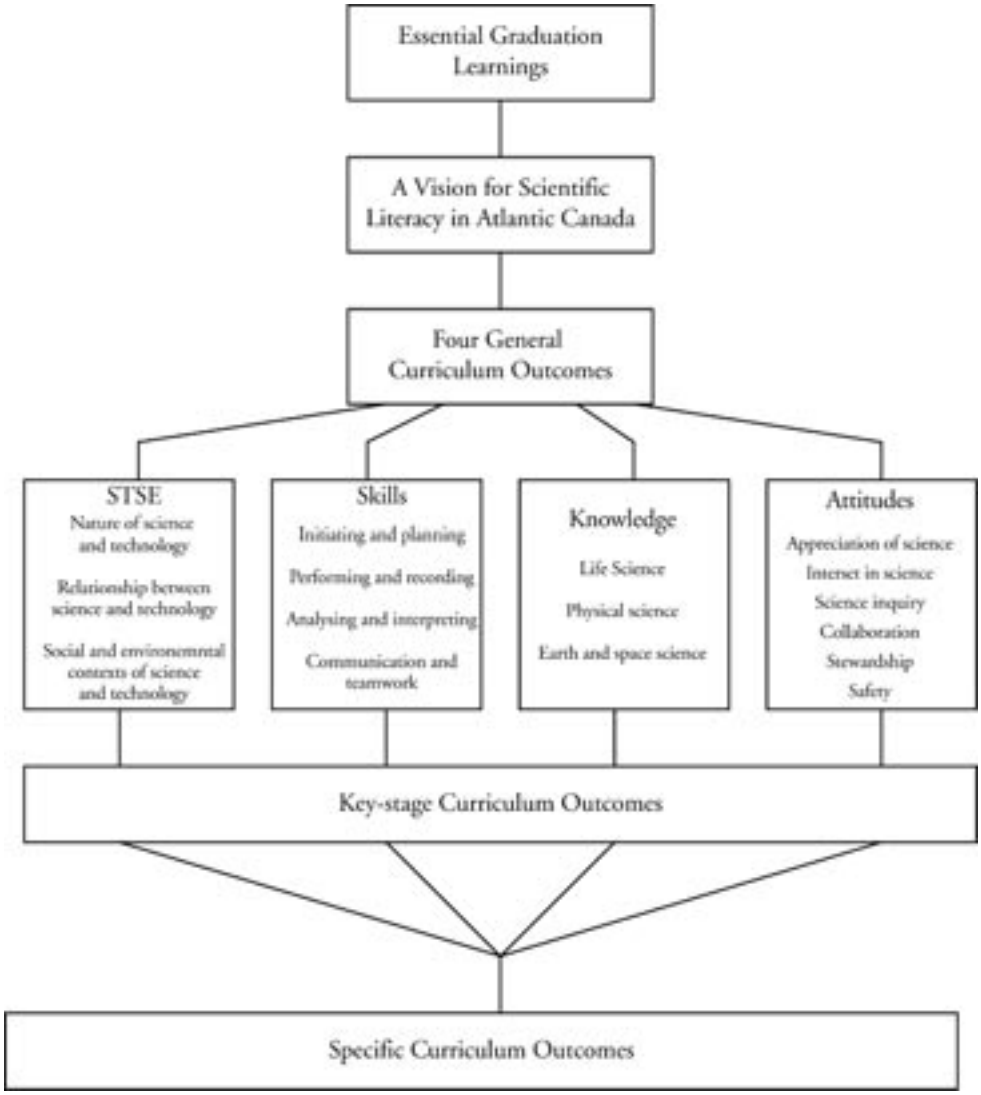
Unifying concepts organize the key ideas that underlie and integrate different scientific disciplines. Unifying concepts are meant to integrate big ideas as a way to provide a context for explaining, organizing, and connecting knowledge. Unifying concepts link the theoretical structures of the various scientific disciplines and apply, for example, to mathematics, technology, and business. The unifying concepts are change, diversity, energy, equilibrium, matter, models, and systems. These concepts are delineated in *Foundation for the Atlantic Canada Science Curriculum*, pages 32–36.

Curriculum Outcomes Framework

Overview

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. Figure 1 provides the blueprint of the outcomes framework.

Figure 1: Conceptual Map



Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Essential graduation learnings are cross-curricular in nature and comprise six areas of learning: *aesthetic expression*, *citizenship*, *communication*, *personal development*, *problem solving*, and *technological competence*.

Aesthetic Expression: *Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.*

Citizenship: *Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.*

Communication: *Graduates will be able to use the listening, viewing, speaking, reading and writing modes of language(s) and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.*

Personal Development: *Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.*

Problem Solving: *Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts*

Technological Competence: *Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.*

General Curriculum Outcomes

The general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered as interrelated and mutually supportive.

Science, Technology, Society, and the Environment (STSE)

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

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.

Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understanding to interpret, integrate, and extend their knowledge.

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.

Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science.

The key-stage curriculum outcomes presented in the following pages were taken from the Pan-Canadian document, *Common Framework of Science Learning Outcomes K–12*. The number attached to each outcomes links the statement to both the Pan-Canadian framework and to specific curriculum outcomes described in curriculum guides. The numbering system is not meant to imply order of importance.

STSE

By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to

- describe and explain disciplinary and interdisciplinary processes used to enable us to understand natural phenomena and develop technological solutions (114)
- distinguish between science and technology in terms of their respective goals, products, and values and describe the development of scientific theories and technologies over time (115)
- analyse and explain how science and technology interact with and advance one another (116)
- analyse how individuals, society, and the environment are interdependent with scientific and technological endeavours (117)
- evaluate social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages for sustainability, considering a variety of perspectives (118)

Skills

By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to

- ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues (212)
- 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 (213)

- analyse data and apply mathematical and conceptual models to develop and assess possible explanations (214)
- work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results (215)

Knowledge

By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to

- compare and contrast the reproduction and the development of representative organisms (313)
- determine how cells use matter and energy to maintain organization necessary for life (314)
- analyse the patterns and products of evolution (316)
- compare and contrast mechanisms used by organisms to maintain homeostasis (317)
- evaluate relationships that affect the biodiversity and sustainability of life within the biosphere (318)

Attitudes

By the end of grade 12, students will have achieved the outcomes for entry–grade 9 and will also be expected to

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not (436)
- appreciate that the applications of science and technology can raise ethical dilemmas (437)
- value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds (438)
- show a continuing and more informed curiosity and interest in science and science-related issues (439)
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research (440)
- consider further studies and careers in science and technology-related fields (441)
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations (442)
- use factual information and rational explanations when analysing and evaluating (443)
- value the processes for drawing conclusions (444)
- work collaboratively in planning and carrying out investigations, as well as generating and evaluating ideas (445)
- have a sense of personal and shared responsibility for maintaining a sustainable environment (446)
- project the personal, social, and environmental consequences of a proposed action (447)
- want to take action for maintaining a sustainable environment (448)

- show concern for safety and accept the need for rules and regulations (449)
- be aware of the direct and indirect consequences of their actions (450)

Specific Curriculum Outcomes

Specific curriculum outcome statements describe what students are expected to know and be able to do at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a reasonable framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings.

Specific curriculum outcomes are organized in four units for each grade level with the exception of Chemistry 11 which has three. Each unit is organized by topic. Biology 11 units and topics follow.

GCO Science, Technology, Society, and the Environment (STSE): Students will develop an understanding of the nature of science and technology, of the relationship between science and technology, and of the social and environmental contexts of science and technology.

Key-stage Curriculum Outcomes (KSCO)	Specific Curriculum Outcomes (SCO)
• describe and explain disciplinary and interdisciplinary processes used to enable us to understand natural phenomena and develop technological solutions (114)	114-1 explain how a paradigm shift can change scientific world views 114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge 114-4 identify various constraints that result in tradeoffs during the development and improvement to technologies 114-5 describe the importance of peer review in the development of scientific knowledge 114-9 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions
• distinguish between science and technology in terms of their respective goals, products, and values and describe the development of scientific theories and technologies over time (115)	115-1 distinguish between scientific questions and technological problems 115-5 analyse why and how a particular technology was developed 115-7 explain how scientific knowledge evolves as new evidence comes to light and laws and theories are tested and subsequently restricted, revised, or replaced
• analyse and explain how science and technology interact with an advance one another (116)	116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology 116-4 analyse and describe examples where technologies were developed based on scientific understanding 116-7 analyse natural and technological systems to interpret and explain their structure and dynamics
• analyse how individuals, society, and the environment are interdependent with scientific and technological endeavours (117)	117-2 analyse society's influence on scientific and technological endeavours 117-4 debate the merits of funding specific scientific or technological endeavours and not others 117-5 provide examples of how science and technology are an integral part of their lives and their community
• evaluate social issues related to the applications and limitations of science and technology, and explain decision in terms of advantages and disadvantages for sustainability, considering a variety of perspectives (118)	118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives 118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot 118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspective, including that of sustainability

GCO 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.

Key-stage Curriculum Outcomes (KSCO)	Specific Curriculum Outcomes (SCO)
• ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues (212)	212-1 identify questions to investigate that arise from practical problems and issues 221-2 define and delimit problems to facilitate investigation 212-6 design an experiment and identify specific variables 212-7 formulate operational definitions of major variables
• 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 (213)	213-2 carry out procedures controlling the major variables and adapting or extending procedures where required 213-3 use in instruments effectively and accurately for collecting data 213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data 213-6 use library and electronic research tools to collect information on a given topic 213-8 select and use apparatus and materials safely
• analyse data and apply mathematical and conceptual models to develop and assess possible explanations (214)	214-1 describe and apply classification systems and nomenclatures used in the sciences 214-2 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies 214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots 214-5 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables 214-7 compare theoretical and empirical values and account for discrepancies 214-8 evaluate the relevance, reliability, and adequacy of data nd data collection methods 214-9 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information 214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty 214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion 214-15 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan

	214-17 identify new questions or problems that arise for what was learned
• work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results (215)	215-1 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others 215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results 215-3 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information 215-6 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise 215-7 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task

GCO Knowledge: Students will construct knowledge and understanding of concepts in life science, physical science, and Earth and space science, and apply these understanding to interpret, integrate, and extend their knowledge.

Key-stage Curriculum Outcomes (KSCO)	Specific Curriculum Outcomes (SCO)
• compare and contrast the reproduction and the development of representative organisms (313)	313-1 analyse and explain the life cycle of a representative organism from each kingdom, including a representative virus
• determine how cells use matter and energy to maintain organization necessary for life (314)	314-1 identify chemical elements and compounds that are commonly found in living systems 314-2 identify the role of some compounds, such as water, glucose, and ATP, commonly found in living systems 314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids 314-5 explain the cell theory 314-6 describe cell organelles visible with the light and electron microscopes 314-7 compare and contrast different types of procaryotic and eucaryotic cells 314-8 describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion 314-9 compare and contrast matter and energy transformations associated with the processes of photosynthesis and aerobic respiration
• analyse the patterns and products of evolution (316)	316-5 use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy 316-6 describe the anatomy and physiology of a representative organism from each kingdom, including a representative virus
• compare and contrast mechanisms used by organisms to maintain homeostasis (317)	*Grade 11 will require the study of the immune system including the study of HIV/AIDS and a minimum of one of the following systems:* – *Circulatory* – *Respiratory* – *Digestive* – *Excretory* *Grade 12 will include chemical and electrochemical systems.* 317-1 explain how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis

	317-3 explain the importance of nutrition and fitness to the maintenance of homeostasis
	317-4 evaluate the impact of viral, bacterial, genetic, and environmental diseases on an organism's homeostasis
	317-5 evaluate, considering ethical issues, the consequences of medical treatments such as radiation therapy, cosmetic surgery, and chemotherapy
	317-6 predict the impact of environmental factors such as allergens on homeostasis within an organism
	317-8 explain how behaviours such as tropisms, instinct, and learned behaviour help to maintain homeostasis
• evaluate relationships that affect the biodiversity and sustainability of life within the biosphere (318)	318-7 compare Canadian biomes in terms of climate, vegetation, physical geography, and location
	318-8 describe population growth and explain factors that influence population growth
	318-9 analyse interactions within and between populations
	318-10 evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources
	318-11 use the concept of the energy pyramid to explain the production, distribution, and use of food resources

Attitude Outcomes

It is expected that the entry to grade 12 science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the *Elaborations—Strategies for Learning and Teaching* sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcomes statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcomes statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

GCO Attitude: 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.

The following pages present the attitude outcomes from the pan-Canadian *Common Framework of Science Learning Outcomes K to 12* for the end of grade 12.

Attitude Outcome Statements

By the end of grade 12, students will be expected to . . .

Appreciation of Science	Interest in Science	Scientific Inquiry
436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not **437** appreciate that the applications of science and technology can raise ethical dilemmas **438** value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds **Evident when students, for example,** • consider the social and cultural contexts in which a theory developed • use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on STSE issues • recognize the usefulness of being skilled in mathematics and problem solving • recognize how scientific problem solving and the development of new technologies are related • recognize the contribution of science and technology to the progress of civilizations • carefully research and openly discuss ethical dilemmas associated with the applications of science and technology • show support for the development of information technologies and science as they relate to human needs • recognize that western approaches to science are not the only ways of viewing the universe • consider the research of both men and women	**439** show a continuing and more informed curiosity and interest in science and science-related issues **440** acquire, with interest and confidence, additional science knowledge and skills using a variety of resources and methods, including formal research **441** consider further studies and careers in science- and explore where further science- and technology-related fields **Evident when students, for example,** • conduct research to answer their own questions • recognize that part-time jobs require science- and technology-related knowledge and skills • maintain interest in or pursue further studies in science • recognize the importance of making connections between various science disciplines • explore and use a variety of methods and resources to increase their own knowledge and skills • are interested in science and technology topics not directly related to their formal studies • explore where further science- and technology-related studies can be pursued • are critical and constructive when considering new theories • and techniques use scientific vocabulary and principles in everyday discussions • readily investigate STSE issues	**442** confidently evaluate evidence and consider alternative perspectives, ideas, and explanations **443** use factual information and rational explanations when analysing and evaluating **444** value the processes for drawing conclusions **Evident when students, for example,** • insist on evidence before accepting a new idea or explanation ask questions and conduct research to confirm and extend their understanding • criticize arguments based on the faulty, incomplete, or misleading use of numbers • recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen • expend the effort and time needed to make valid inferences • critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation • critically assess their opinion of the value of science and its applications • criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist • insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged • seek new models, explanations, and theories when confronted with discrepant events or evidence

Attitude Outcome Statements

By the end of grade 12, students will be expected to . . .

Collaboration	Stewardship	Safety
445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas **Evident when students, for example,** • willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics • assume a variety of roles within a group, as required • accept responsibility for any task that helps the group complete an activity • give the same attention and energy to the group's product as they would to a personal assignment • are attentive when others speak • are capable of suspending personal views when evaluating suggestions made by a group • seek the points of view of others and consider diverse perspectives and accept constructive criticism when sharing their ideas or points of view • criticize the ideas of their peers without criticizing the persons • evaluate the ideas of others objectively • encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making • contribute to peaceful conflict resolution encourage the use of a variety of communication strategies during group work • share the responsibility for errors made or difficulties encountered by the group	**446** have a sense of personal and shared responsibility for maintaining a sustainable environment **447** project the personal, social, and environmental consequences of proposed action **448** want to take action for maintaining a sustainable environment **Evident when students, for example,** • willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation • 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 • participate in social and political systems that influence environmental policy in their community examine/recognize both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans • willingly 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 • are critical-minded regarding the short- and long-term consequences of sustainability	**449** show concern for safety and accept the need for rules and regulations **450** be aware of the direct and indirect consequences of their actions **Evident when students, for example,** • read the label on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood • criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment • consider safety a positive limiting factor in scientific and technological endeavours • carefully manipulate materials, cognizant of the risks and potential consequences of their actions • write into a laboratory procedure safety and waste-disposal concerns • evaluate the long-term impact of safety and waste disposal on theenvironment and the quality of life of living organisms • use safety and waste disposal as criteria for evaluating an experiment • assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place • seek assistance immediately for any first aid concerns like cuts, burns, or unusual reactions • keep the work station uncluttered, with only appropriate lab materials present

Program Overview

Introduction

The Biology 11 and Biology 12 programs emphasize the unifying concepts: *change, diversity, energy, equilibrium, matter, systems* and *models* as they relate to biology. Unifying concepts provide connections among units of study in both courses and provide a framework to show how individual sections of these programs relate to the big ideas of science. Both programs enable students to become aware of the tremendous impact of biology and technology upon society. A suggested sequence is presented within each course but individuals are free to alter this sequence as they see fit.

Biology 11

The purpose of the Biology 11 program is to explore the unity and diversity of living things. The underlying concepts provide connections between units of study, fostering an awareness of the tremendous impact of biology and technology upon society.

Biology 11 consists of the following four units of study:

Unit 1: Matter and Energy for Life

Cells are introduced as the basic units of life. This unit investigates the role of cell structures in matter exchange and energy flow and recognizes the impact of technology on our understanding of cell structure and processes.

Unit 2: Biodiversity

The vast diversity of living things necessitates an organized system for their classification and study. This unit provides a thorough investigation and overview of life's unity and diversity within the biosphere.

Unit 3: Maintaining Dynamic Equilibrium I

All living things struggle to maintain an internal balance in response to the constant pressure of external phenomena. This unit investigates the role of various systems and the influence of behaviour in the regulation of homeostasis.

Unit 4: Interactions among Living Things

Ecosystems involve complex interactions between biotic and abiotic factors. This unit investigates the role of these factors on population dynamics and the flow of energy within ecological systems.

Biology 12

The purpose of the Biology 12 program is to explore life from a molecular perspective. The underlying concepts provide connections between units of study, demonstrating the molecular basis of regulation and evolutionary change. The design is intended to foster an awareness of the tremendous impact of biology and technology upon society.

Biology 12 consists of the following four units of study:

Unit 1: Maintaining Dynamic Equilibrium II

All living organisms struggle to maintain an internal balance in response to the constant pressure of external phenomena. This unit investigates the role of chemical and electrochemical systems in the regulation of homeostasis. The impact of disease, medical technology and drugs will also be explored.

Unit 2: Reproduction and Development

Reproduction is essential for the continuity of a species. This unit investigates the reproductive process at the cellular and multicellular levels. The influence of reproductive technologies will also be explored.

Unit 3: Genetic Continuity

Much of the structure and function of organisms is determined by their genetic material. This unit investigates the structure and replication of DNA, its transcription to RNA and translation into proteins. A discussion of how genes flow from one generation to the next serves as an introduction to basic genetics. The effects of mutation, genetic disease and genetic engineering will also be explored.

Unit 4: Evolution, Change and Diversity

Science attempts to provide an explanation for the origin and evolution of life on earth. This unit investigates evidence that supports the theory of evolution and offers an analysis of evolutionary mechanisms.

Biology 11 Topics

Matter and Energy for Life

- Introductory experiences illustrate the development of the cell theory
- Introduction to laboratory work
- Basic cellular structures function together within the cell
- Membranes function as a living boundary around cells
- What is the importance of photosynthesis and respiration to living things

Biodiversity

- How are living things organized into groups for ease of study
- Introduction to the diversity present among living things

Maintaining Dynamic Equilibrium I

- Maintaining a balance within living things
- Circulatory systems transport energy and nutrients to maintain equilibrium within an organism
- The gas exchange in respiratory systems helps to maintain homeostasis
- Matter and energy exchange within digestive systems help to maintain homeostasis
- Excretory systems are responsible for maintaining internal homeostasis
- Immune systems act to maintain homeostasis

Interactions Among Living Things

- An understanding of Canadian ecology and geography promotes national awareness and good decision-making
- Ecosystems do not exist in isolation from each other
- Population change over time can be expressed in quantitative terms
- Human population growth places demands on global resources

Biology 11 Sequential Specific Curriculum Outcomes

Matter and Energy for Life

Introductory experiences illustrate the development of the cell theory

- explain the importance of communicating the results of the development of the cell theory, using appropriate language (114-9)
- explain the cell theory (314-5)
- analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)

Introduction to laboratory work

- select and microscopes effectively, safely, and accurately for collecting data (213-3, 213-8)
- compile, organize, and display evidence to facilitate the interpretation of data (213-5, 214-3)

Basic cellular structures function together within the cell

- compare and contrast different types of procaryotic and eucaryotic cells (314-7)
- describe and apply classification systems and nomenclature used for the basis of cell grouping systems (214-1)
- describe cell organelles visible with the light and electron microscopes (314-6)

- describe how organelles manage various cell processes such as ingestion, digestion, transportation and excretion (314-8)
- analyse and describe examples where the microscope enhanced or revised scientific understanding of cells (115-5, 116-6)

Membranes function as a living boundary around cells

- describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion (314-8)
- working co-operatively with team members, formulate definitions, carry out procedures and provide a statement that addresses the major variables and their link between data and the conclusion (212-7, 213-2, 214-11, 215-6)

What is the importance of photosynthesis and respiration to living things

- compare and contrast matter and energy transformations associated with the process of photosynthesis and aerobic respiration (314-9)
- compile, organize data, and provide a statement using laboratory experiments, to facilitate interpretation of photosynthesis and/or respiration (213-2, 213-5, 214-11)

Biodiversity

How are living things organized into groups for ease of study

- describe peer review and explain how classification systems developed as new evidence concerning living things emerged (114-5, 115-7, 116-2)
- use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy (316-5)
- identify questions, limitations, and alternatives inherent in a classification system (214-2, 214-7, 212-1)
- describe and apply classification systems and nomenclatures used in species (214-1)
- use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy (316-5)
- use library and electronic tools to collect and communicate information on techniques used in the classification process (213-6, 215-1)

Introduction to the diversity present among living things

- construct arguments to support a decision on characteristics shared by living things, using examples and evidence and recognizing various perspectives (118-6)
- describe the anatomy and physiology of a representative organism from each kingdom, including a representative virus (316-6)
- analyse and explain the life cycle of a representative organism from each kingdom, including a representative virus (313-1)

Maintaining Dynamic Equilibrium I

Grade 11 will require a minimum of two of the following systems:

- *Circulatory*
- *Respiratory*
- *Digestive*
- *Excretory*
- *Immune*

Grade 12 will include chemical and electrochemical systems.

Maintaining a balance within living things

- analyse and describe examples where technologies were developed based on scientific understanding (116-4)
- distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot (118-8)
- explain the importance of nutrition and fitness to the maintenance of homeostasis (317-3)
- explain how behaviours such as tropisms, instinct, and learned behaviour help to maintain homeostasis (317-8)

Circulatory systems transport energy and nutrients to maintain equilibrium within an organism

- explain, using circulatory systems, how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- analyse natural and technological systems related to the circulatory system, to interpret and explain their structure and dynamics (116-7)
- design, compile and organize data, and identify and apply criteria for an experiment with appropriate data treatment, evidence and sources of information, and variables (212-6, 213-5, 214-9)
- identify, in general terms, the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism linking this to the circulatory system (317-4)

- predict the impact of environmental factors such as allergens on homeostasis within an organism linking this to the circulatory system (317-6)

The gas exchange in respiratory systems helps to maintain homeostasis

- explain, using respiratory systems, how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- analyse natural and technological systems related to the respiratory system, to interpret and explain their structure and dynamics (116-7)
- estimate quantities and use appropriate representation to communicate your results on respiration (215-2, 213-4)
- design, compile and organize data, and identify and apply criteria for an experiment with appropriate data treatment, evidence and sources of information, and variables (212-6, 213-5, 214-9)
- describe disorders linked to the respiratory system and their effect on the homeostasis of the system and the organism as a whole (317-4)
- evaluate the physiological and ethical consequences of medical treatments such as radiation therapy, chemotherapy, and cosmetic surgery (317-5)
- predict the impact of environmental factors such as allergens on homeostasis within an organism linking this to the respiratory system (317-6)

Matter and energy exchange within digestive systems help to maintain homeostasis

- explain, using digestive systems, how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- analyse natural and technological systems related to the digestive system, to interpret and explain their structure and dynamics (116-7)
- design an experiment, compile and organize data, and demonstrate a knowledge of WHMIS to investigate the effect of specified variables on the effectiveness of an enzyme (212-6, 213-5, 213-9)
- identify disorders linked to the digestive system and their effect on the homeostasis of the system and the organism as a whole (317-4)

Excretory systems are responsible for maintaining internal homeostasis

- explain, using excretory systems, how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- analyse natural and technological systems related to the excretory system, to interpret and explain their structure and dynamics (116-7)
- describe disorders linked to the excretory system and their effect on the homeostasis of the system and the organism as a whole (317-4)
- predict the impact of environmental factors such as allergens on homeostasis within an organism linking this to the excretory system (317-6)
- identify, analyse and describe kidney dialysis technology and propose alternate solution(s), identifying the potential strengths and weaknesses (116-4, 214-15, 114-4, 115-5)
- analyse and debate society's influence on organ transplant therapy (117-2, 117-4)

Immune systems act to maintain homeostasis

- describe disorders linked to the immune system and their effect on the homeostasis of the system and the organism as a whole (317-4)
- predict the impact of environmental factors such as allergens on homeostasis within an organism linking this to the immune system (317-6)
- explain, using the immune system, how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- analyse natural and technological systems related to the immune system, to interpret and explain their structure and dynamics (116-7)

Interactions Among Living Things

An understanding of Canadian ecology and geography promotes national awareness and good decision-making

- describe and apply classification systems and nomenclatures used in the ecological hierarchy of an organization of living systems (214-1)
- analyse the biosphere to interpret and explain its structure and dynamics (116-7)
- compare Canadian biomes in terms of climate, vegetation, physical geography, and location (318-7)
- use library and electronic research tools to collect, evaluate, and synthesis information on the features of the Canadian biomes (213-6, 214-8, 215-3)

Ecosystems do not exist in isolation from each other

- analyse interactions within and between populations (318-9)
- use the concept of the energy pyramid to explain the production, distribution, and use of food resources (318-11)
- propose and evaluate courses of action on social issues related to the natural balance of ecosystems (118-10)

Population change over time can be expressed in quantitative terms

- describe population growth and explain factors that influence population growth (318-8)
- use library and electronic tools to collect information on the limiting factors that work to influence population growth (213-6)
- compare theoretical and empirical values and account for discrepancies for population growth (214-7)

Human population growth places demands on global resources

- evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources (318-10)
- provide examples of how science and technology are an integral part of their lives and community (117-5)

Unit Organization

The order in which the four units of a grade appear in the guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the year. That is, one unit may introduce a concept that is then extended in a subsequent unit. Likewise, one unit may focus on a skill or context that will be built upon later in the year.

Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world. In some cases, a unit may require an extended time frame to collect data on weather patterns, plant growth, etc. These cases may warrant starting the activity early and overlapping it with the existing unit. In all cases, the intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful and socially and culturally relevant contexts.

Unit Overview

Each unit begins with a two-page synopsis. On the first page, introductory paragraphs provide an unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills addressed in other grades so teachers will understand how the unit fits with the students' progress through the complete science program.

Figure 2: Organization of the Unit Overview

Unit Title	
Introduction	Synopsis of the unit
Focus and context	Focus: Inquiry, Decision Making, or Problem Solving (Possible contexts suggested)
Science Curriculum Links	Links to concepts and skills studied addressed elsewhere

The second page of the two-page overview provides a table of the outcomes from the *Common Framework of Science Learning Outcomes K to 12* that the unit will address. The numbering system used is the one in the pan-Canadian document as follows:

- 100s—Science-Technology-Society-Environment (STSE) outcomes
- 200s—Skills outcomes
- 300s—Knowledge outcomes
- 400s—Attitude outcomes (see pages 20–22)

These code numbers appear in brackets after each specific curriculum outcome (SCO).

Figure 3: Organization of the Curriculum Outcomes Overview

Curriculum Outcomes Overview		
STSE	**Skills**	**Knowledge**
(**outcome number**) Science-Technology-Society-Environment outcomes from *Common Framework of Science Learning Outcomes K to 12*	(**outcome number**) Skills outcomes from *Common Framework of Science Learning Outcomes K to 12*	(**outcome number**) Knowledge outcomes from *Common Framework of Science Learning Outcomes K to 12*

The Four-Column Spread

All units comprise a two-page layout of four columns as illustrated in Figure 2. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

Figure 4: The Four-Column Spread

Topic (suggested instructional hours)			
Outcomes	**Elaborations–Strategies for Learning and Teaching**	**Tasks for Instruction and/or Assessment**	**Notes**
• **Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)** • **Specific curriculum outcome based on the pan-Canadian outcomes (outcome number)**	Suggested activities and elaborations of outcome Suggested activities and elaborations of outcome	*Informal/Formal Observation* *Performance* • sample assessment item (outcome number) *Journal* *Interview* • sample assessment item (outcome number) *Paper/Pencil* *Presentation* *Portfolio*	Authorized and other recommended resources that address outcomes

Column One: Outcomes

The first column lists a group of specific curriculum outcome statements. These are based on the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appears in parenthesis after the outcome statement. Some STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column Two: Elaborations—Strategies for Learning and Teaching

The second column describes the learning environment and experiences that will support students' achievement of the outcomes listed in the first column. Elaborations of the outcomes may also be included in this column, as well as background information.

The suggestions in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

Column Three: Tasks for Instruction and/or Assessment

The third column provides suggestions for ways that students' achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journals, paper and pencil, and presentations. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

Column Four: Notes

This column contains a variety of information related to the items in the other columns, including suggested resources, elaboration or strategies, successes, cautions, and definitions.