Advanced Biology 11

Guide

NOVA SCOTIA
NOUVELLE-ÉCOSSE

2012

Website References

Website references contained within this document are provided solely as a convenience and do not constitute an endorsement by the Department of Education of the content, policies, or products of the referenced website. The department does not control the referenced websites and subsequent links, and is not responsible for the accuracy, legality, or content of those websites. Referenced website content may change without notice.

Regional Education Centres and educators are required under the Department's Public School Programs Network Access and Use Policy to preview and evaluate sites before recommending them for student use. If an outdated or inappropriate site is found, please report it to <curriculum@novascotia.ca>.

Advanced Biology 11

Prepared by the Department of Education and Early Childhood Development

This is the most recent version of the current curriculum materials as used by teachers in Nova Scotia.

Advanced Biology 11

Draft, May 2012

Acknowledgments

The Nova Scotia Department of Education expresses its indebtedness to biology teachers, university professors, community college instructors, and our educational colleagues for their professional expertise and insights in developing this regional Advanced Biology 11 curriculum guide. In addition, pilot teachers and others who contributed comments and suggestions are to be commended for their commitment to developing exemplary science programs.

Foreword

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12* (1997) provides a framework for standardizing science education across the country. Science curriculum for the Atlantic provinces is described in *Foundation for the Atlantic Canada Science Curriculum* (1998).

This guide is intended to provide teachers with an overview of the outcomes framework for the advanced courses. It also includes some suggestions to assist teachers in designing learning experiences and assessment tasks.

Contents

Introduction

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 that students need in order to develop inquiry, problem-solving, and decision-making abilities; to become lifelong 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 futures.

Advanced science courses offer expanded and extended learning outcomes in both the theoretical and applied aspects of science. The Department of Education has worked with biology teachers, university professors, and other interested parties to establish a set of principles to guide the development of advanced biology courses.

Advanced biology courses build on the curriculum prescribed for academic biology courses and may be offered in discrete classes or in classes together with the academic-level courses. The advanced courses are distinguished by three parts of increased depth in certain parts of the curriculum. These are numerical problem solving, a literature search and report, and an independent study/experiment.

Numerical problem solving is enhanced by the inclusion of more situations presented in variable terms only (no numbers), as well as a selection of more challenging application problems.

Advanced biology courses require students to do an independent study/experiment and to present the results visually, orally, and in written report form. *A Closer Look: Doing Project-Based Science* (Draft, 2010) is a useful resource for this component of the courses. It is important that students be encouraged to investigate the science involved in a topic of personal interest, such as vehicle safety, music and musical instruments, energy for the future, or sports. Project-based learning provides students with an opportunity to demonstrate their initiative and perseverance. These qualities are essential for success in continued study and eventual employment.

This guide is organized as a supplement to *Atlantic Canada Science Curriculum: Biology 11 and Biology 12* (Draft, 2007).

Advanced Biology 11, like other Public School Programs advanced courses, will be available for in-class and online delivery to give more students the opportunity to take advanced courses.

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

- 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
- assessing 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 through 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 in which they engage, 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.

Students in Advanced Biology 11 are expected to meet all of the outcomes that are in Biology 11. The depth of treatment is the major distinction. Advanced biology requires an in-depth treatment of biology concepts, a major literature search and report, and a hands-on investigation of a major physical concept.

Generally, advanced biology should attract students who have a high level of science interest and are strong independent learners. Students will be identified by science teachers or in consultation with administration and counsellors. These students may wish to pursue further study at a post-secondary level and/or careers in science, engineering, or technology.

Writing in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways of learning. Students, at all grade levels, should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students to better record, organize, and understand information from a variety of sources. The process of creating word webs, maps, charts, tables, graphs, drawings, and diagrams to represent data and results helps students learn and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. Through opportunities to talk and write about the concepts they need to learn, students come to better understand both the concepts and related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.

The Three Processes of Scientific Literacy

An individual can be considered scientifically literate when he or 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, analyzing 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 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 classes. 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 students' various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching, they must also actively address cultural and gender stereotyping (e.g., 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 provides 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 analyzing, 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.

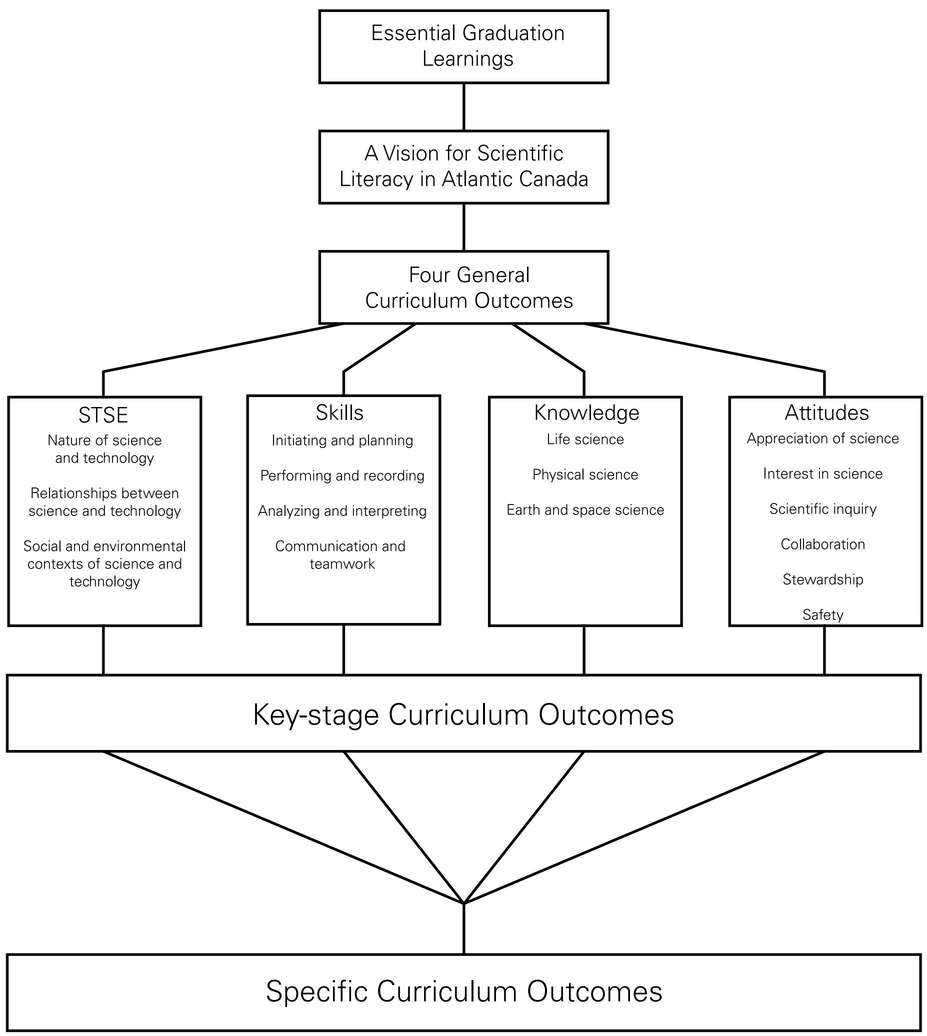
The Atlantic Canada science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities, skills, and actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

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*. The diagram below provides the blueprint of the outcomes framework.

Outcomes Framework



Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries and be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. Provinces may add additional essential graduation learnings as appropriate. The essential graduation learnings are described below.

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) as well as 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, 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 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 will apply these understandings 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 are from the *Common Framework of Science Learning Outcomes K to 12.*

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 framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings.

This curriculum guide outlines specific curriculum outcomes for advanced biology and provides suggestions for learning, teaching, assessment, and resources to support students' achievement of these outcomes. Teachers should consult *Foundation for the Atlantic Canada Science Curriculum* for descriptions of the essential graduation learnings, vision for scientific literacy, general curriculum outcomes, and key-stage curriculum outcomes.

Specific curriculum outcomes are organized in four units. Each unit is organized by topic. Advanced Biology 11 units and topics use Biology 11 outcomes, but the following are done in more depth.

Advanced Biology 11

The following outcomes are from the Biology 11 guide. The topic from the unit and two-page spread are identified with the outcome.

•

Matter and Energy for Life

Students will be expected to

Historical Development Cell Theory

- explain how a paradigm shift can change scientific world views (114-1)
- explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions (114-9)
- describe the importance of peer review in the development of scientific knowledge (114-5)
- explain the role of evidence, theories, and paradigms in the development of cell theory (114-2)
- explain the cell theory (314-5)
- analyze and describe how scientific understanding was enhanced or revised as a result of the invention of the microscope (116-2)

Introduction to the Microscope

- select and use apparatus and materials safely (213-8)
- use instruments effectively and accurately for collecting data (213-3)
- compile and display using line diagrams and/or digital imagery, evidence and information collected through the use of the microscope (214-3)

Interaction of Cell Structures

- describe cell organelles visible with the light and electron microscopes (314-6)
- compare and contrast different types of procaryotic and eucaryotic cells (314-7)
- analyze why and how a particular technology was developed and improved over time (115-5)
- describe and evaluate the design of microscope technologies and the way they function (116-6)

- describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion (314-8)
- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- formulate operational definitions of major variables (212-7)
- carry out procedures controlling the major variables and adapting or extending procedures where required (213-2)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion (214-11)

Photosynthesis and Respiration

- compare and contrast matter and energy transformations associated with the processes of photosynthesis and aerobic respiration (314-9)
- compile and organize experimental data to investigate photosynthesis and/or respiration, and present the results (213-2)

Biodiversity

Students will be expected to

Classifying Living Things

- explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced (115-7)
- use organisms found in a local or regional ecosystem to demonstrate an understanding of the fundamental principles of taxonomy (316-5)
- identify limitations of a biological classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
- describe and apply classification systems and nomenclatures used in the biological sciences (214-1)
- use library and electronic research tools to collect information on modern techniques used in the classification process (213-6)
- analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)

Diversity among Living Things

- construct arguments to support a decision or judgement, 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)
- analyze and explain the life cycle of a representative organism from each kingdom, including a representative virus (313-1)

Maintaining Dynamic Equilibrium I

Students will be expected to

Homeostatis

- explain the concept of homeostasis and its critical nature to living things (317-1)
- explain the importance of maintaining homeostasis (317-3)
- explain how tropisms help maintain homeostasis (317-8)

Circulatory System

- explain how different plant and animal circulatory systems help maintain homeostasis (317-1)
- design an experiment to relate blood pressure and physical activity and identify the specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- identify, in general terms, the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism (317-4)
- analyze why and how a particular technology related to the treatment of circulatory disorders was developed and improved over time (115-5)

Respiratory System

- explain, using the respiratory system, how different animal systems, including the vascular and nervous systems, help maintain homeostasis (317-1)
- design an experiment to collect data on respiratory function and identify the specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- identify, in general terms, the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism (317-4)
- predict the impact of environmental factors such as allergens on homeostasis within an organism (317-6)

Digestive System

- identify chemical elements and compounds that are commonly found in living systems (314-1)
- identify the role of some compounds involved in digestion such as water, glucose, and enzymes (314-2)
- explain, using the digestive system, how animal systems help maintain homeostasis (317-1)
- identify and describe the structure and function of the important biochemical compounds, carbohydrates, proteins, and lipids (314-3)
- design an experiment to investigate the effect of specified variables on the effectiveness of an enzyme (212-6)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- identify, in general terms, the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism (317-4)

- 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 (214-15)
- identify multiple perspectives that influence a science-related decision or issue (215-4)

Excretory System

- explain how different animal systems help maintain homeostasis (317-1)
- identify, in general terms, the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism (317-4)
- analyze and describe examples where technologies were developed based on scientific understanding (116-4)
- analyze natural and technological systems to interpret and explain their structure and dynamics (116-7)
- debate the merits of funding specific scientific or technological endeavours and not others (117-4)

Immune System

- predict the impact of environmental factors such as allergens on homeostasis within an organism (317-6)
- explain how different animal systems, including the immune system, help maintain homeostasis (317-1)

Interactions among Living Things

Students will be expected to

Canadian Ecology

- describe and apply classification systems and nomenclature used in the study of ecology (214-1)
- analyze natural and technological systems to interpret and explain their 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 and synthesize relevant information on the features of the Canadian biomes (213-6)

Population Dynamics

- analyze interactions within and between populations (318-9)
- using the concept of the energy pyramid to explain the energy flow in 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, taking into account an array of perspectives, including that of sustainability (118-10)

Population Change

- 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)

- synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)
- interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables (214-5)
- compare theoretical and empirical population values and account for discrepancies (214-7)

Global Resources

- evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources (318-10)
- propose courses of action on the social issue of global population control, taking into account an array of perspectives, including that of sustainability (118-10)

Attitudes Outcomes

It is expected that the Atlantic Canada 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 section 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 readiness for responsible application of what students learn.

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

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.

Key-Stage Curriculum Outcomes: Attitudes

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 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

Key-Stage Curriculum Outcomes: Attitudes

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, 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 the environment 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

Learning and Teaching Advanced Biology
In-depth Treatment: Cellular Biology

Advanced Biology 11 will cover the in-depth treatment of cellular biology.

Students will be expected to

- identify chemical elements and compounds that are commonly found in living systems (314-1)
- identify and describe the structure and function of the important biochemical compounds, carbohydrates, proteins, and lipids (314-3)

The molecules that make up living things can be grouped into five classes: water, carbohydrates, lipids, proteins, and nucleic acids. An understanding of the structure and function of these molecules is necessary to many branches of biology, especially biochemistry, physiology, and molecular genetics.

As water is the single most abundant compound in most living things and provides an environment in which metabolic reactions can occur, the biological significance of each property of water should be researched, (polarity, density, surface tension, viscosity, high light transmission, cohesion, universal solvent, specific heat capacity, latent heat of fusion and vaporization)

The four major groups of organic molecules encountered in biology are carbohydrates, lipids, proteins and nucleic acids. The first three are most relevant to a more detailed approach to cell transport, interaction of cellular structures, energy transformations, and the processes that maintain dynamic equilibrium. Nucleic acids, although introduced here, will be treated more thoroughly in Biology 12. Using molecular model kits and electronic and text resources, students will investigate the chemical structure, shapes, and functions of these macromolecules as well as dehydration synthesis and hydrolysis.

- work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- carry out procedures controlling the major variables and adapting or extending procedures where required (213-2)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)

- In advanced biology, students should be given the opportunity to design their own experiment. An investigation into the factors that affect the rate of enzyme activity gives them the opportunity to do so. The importance of protein structure relating to its function as well as conditions that result in denaturation of proteins can be reinforced with a fairly simple experiment. Students can formulate hypothesis, make predictions, design, and conduct a controlled experiment to examine how environmental factors such as pH or temperature affect the activity of an enzyme.

Membranes function as a living boundary around cells. The structure of the cell membrane results in selective permeability. Membrane structure as well as the principles of membrane transport also applies to the many varieties of internal membranes that compartmentalize the cell.

- describe how organelles manage various cell processes such as ingestion, digestion, transportation, and excretion (314-8)

Cell membrane structure may be studied in more detail here, looking at membrane fluidity as a function of the hydrocarbon tails of the phospholipids and cholesterol content, and membrane proteins and their functions in transport, as enzymes, in signal transduction, cell junctions, cell-to-cell recognition, and attachment points for the ECM and cytoskeleton. Students often are left with the impression that membrane proteins are blobs embedded in the membrane. It is important to relate the protein structure studied earlier to the integral and peripheral proteins.

The processes of diffusion, osmosis, and the effect of solute concentration on water potential as it relates to living plant tissues can be investigated using a model membrane system. Using a lab such as Lab One: Diffusion and Osmosis from the AP Biology Lab Manual, students are able to calculate the water potential from the experimental data that they collect. Molarity (a chemistry connection), graphing skills, percent change and understanding and using a formula (math connections) can be reinforced. Since careless or variable procedures can dramatically affect the results, students are expected to be attentive to detail.

Osmoregulation (demonstrated with paramecium when observing the behaviours of live protists in the biodiversity section), sodium-potassium pumps as an example of active transport and chemiosmosis can be introduced here but discussed in context with photosynthesis and respiration.

In-depth Treatment: Literature Search and Report on Mental Health

A literature search and report is a required part of advanced biology. This can take many forms and can be reported in a variety of ways. Students, like scientists, need to be able to effectively communicate their knowledge and findings to a variety of audiences in order to compare results, ask for funding, and/or write proposals and articles.

Students will be expected to

- collect information on how the brain functions with respect to the biology of mental health and mental illness compared with other diseases (AB-1)
- define mental health and mental illness, giving the causes and strategies to address them (AB-2)
- examine society's expectations about positive mental health and mental illness (AB-3)
- report on mental health and mental illness from a medical or societal perspective (AB-4)

Students are studying body systems in biology. Your brain controls your body. This unit examines how the brain functions with respect to mental health and mental illness. This vital organ is sometimes neglected as to how it affects how the body works, physically and mentally. Brain research has given much information about how the brain works and how its functions can cause changes in behaviour that last different times. The teacher should explain that the students will be looking at mental health and mental illness with respect to how the brain functions, types of illnesses, and positive supports.

Everyone has physical health and mental health. Discuss the similarities and differences to physical and mental health and illness. Students may brainstorm ideas about each and then a brief discussion may occur. Everyone has mental health, and tips for mental health may be explored.

Students should view pictures and/or video of how the brain functions and take personal notes. The teacher should review the materials beforehand so that they may be prepared to discuss the information when questions occur.

What is mental health? What is mental illness? Students should research definitions of these. Everyone has mental health. Teachers may provide definitions (Health Education Authority, UK, 1997, and www.cmha.ca) and have a class discussion about these. By careful questioning and explanations, students and teachers should know that there is nothing to be guilty about for having any mental illnesses. Stigmas linked with mental illness might be discussed. The similarities and differences between health and illness should be noted. Teachers may invite a mental health expert in to talk about the various types of mental health and mental illness.

Students should look at what happens when the brain gets sick. Information on specific mental illnesses may be looked at as a class or in groups and then presented to the class. These should include the following: anxiety, attention deficit hyperactivity disorder, bipolar mood disorder, depression, eating disorders, and schizophrenia. Students should answer the following questions about each: What is it? Who gets it? What are the symptoms? What causes it? How can it be treated? What supports are available?

Students will be able to recognize that mental illness is associated with brain activity and understand the symptoms, causes, treatments, and supports.

Students might do a survey or look at surveys that exist about attitudes towards mental health and mental illness. Students could explore the myths, stigmas, realities, and discriminations on mental health and mental illness. Respect about this topic must happen.

Investigation: An Independent Study/Experiment

Students will be expected to

- do problem and/or project-based research on plants (AB-5)

Students will do an independent research project on an aspect of plants. The teacher should do a project at the same time as the students to model the behaviour and the teacher should report his or her findings. Refer to *A Closer Look: Project-Based Science* (Draft 2010) for examples of timelines, plans, and reports. A project about local plants, plants around their school, plants for a garden, and plants needed for various species maybe explored. Some topics may include and are not limited to the following:

- Effects of sound on plants
- Effects of light on plants
- Effects of colour on plants
- Experiments with hydroponics
- Using seedlings started from seeds to produce food
- Producing mushrooms
- Transpiration rated for plants
- Sugar levels in plant sap
- Plant nutrients
- Factors affecting seed germination
- Effects of phosphates on plants (land and water)
- Effects of water impurities on plants
- Factors affecting flowering of plants
- Using dishwasher water to keep bugs off plants
- Comparing how different plants are able to add humus to soil
- Using plant cuttings to make roots for planting
- Using household materials to help plant health
- Using electric fields on plants
- Effect of music on plants
- Effects of organic fertilizers on plants
- Effects of landscaping on plants
- Study of insect behaviour on plants

Introduction

A key component of the curriculum for advanced biology courses is the completion of a major culminating project that includes an extensive biology analysis.

The project creates an opportunity for students to explore biology from their own perspective. Through project-based science, teachers free their students to explore biology in ways that can incorporate in their research their backgrounds, skill sets, and interests. It allows students to become *real* scientists and truly learn about biology in the world around them.

Biology and Problem/Project-Based Science

Problem/project-based science, often referred to as *real science*, is a science instruction method that has students and teachers completing projects in a fashion similar to the research methods of *real* scientists. Through individual and collaborative research, students are provided with the opportunity to construct science knowledge through hands-on, minds-on, self-directed experiences.
The problem/project-based method encourages teachers and students to explore and examine a variety of different activities and situations that address different learning styles and cognitive strengths. Through this process, a number of science curriculum outcomes are easily addressed, as well as outcomes from other curriculum programs.

A problem/project-based science activity can be designed to fit any science classroom. It can be a small activity that covers a few class periods to a full-course investigation that results in a project to be celebrated in a variety of ways. Whatever the end result, problem/project-based science activities all include a number of common components. These are:

- *A focus question:* When students create a focus question they become the key figure(s) in a project from the beginning. A clear focus question allows organization of the method that will be used to direct the research. The question is key here and is one of the most difficult parts of the process. The focus question also provides a reference point for reflection throughout the study. The question may be revised throughout the course of study as directed by the research.
- *Investigation:* In project-based science the focus question leads directly to authentic problem solving through textual and online research, experimental design and operation, data collection and analysis, estimation, discussion and debate, group interaction, summarizing and drawing conclusions, and the refining and examination of the original question.
- *Artifacts:* Throughout the duration of a project, artifacts will be produced such as a number of reports, devices, and displays that show a true understanding of the focus question.
- *Collaboration:* Whether working alone or in groups, collaboration will occur throughout a project-based exercise. Working in class, sharing new discoveries, questioning others' conclusions, and participation in classroom presentations allow students and teachers to explore avenues in their research that they may not follow on their own, and further expand the study of the focus question.
- *Technology and Telecommunications:* Modern technology allows exploration science in a wide variety of ways. Communication with professional scientists, discussions with other students from around the region or the world, and the accessibility of vast amounts of information allow students and teachers to completely

explore the answers to their questions and share the information that they have collected.

How to Use Project-Based Science

Project-based science can be used to cover virtually any topic in the science classroom. It allows the teacher to cover a variety of skills and social outcomes that are not always reached by traditional methods of science instruction. Project-based science should be used to bring the process of science (inquiry, problem-solving, and decision-making) to students. A project should include a discussion to establish focus questions, a specific timeline for research, and time for investigation. Creating a timeline and a bank of resources will make projects run smoothly. A well-planned project that is presented with enthusiasm will be sure to cover a number of science outcomes.

Finding a Focus Question

The focus question is the most important part of a student and teacher project. Spending time on developing the focus question will help organize the project ideas better and will help give better project results for your students. When creating a focus question, students should consider the following:

- Is the question interesting?
- Can the focus question be answered with the resources available for research?
- Does the focus question fit within the parameters set out for the project?
- Is the focus question clearly posed?
- Does the focus question clearly direct research?
- Can the focus question be completely investigated within the time line of the research?

A student or teacher should answer yes to all of the questions above. The focus question will be the driving force of research, so should be considered carefully.

The benefit to students of a clear focus question is the fact that it directs research along one specific pathway. Many students find long-term projects difficult because they find the amount of information available to be immense. If a clear focus question is developed before the start of in-depth research, the student will have less difficulty with the massive amounts of information available on any topic. The focus question allows students to quickly sort through useful and non-useful information.

Sample Teacher Project

The teacher project provides a teacher with a unique opportunity to guide student efforts without controlling the direction or methodology of student research. The teacher is always one step ahead of the student and uses the project to highlight where a student should be with their research as time passes. The teacher project also provides teachers an opportunity to look into a specific aspect of the curriculum that may not otherwise be explored.

Benefits of Project-Based Learning

Project-based science provides a number of unique learning opportunities. Treating students like young scientists turns the table on science learning and makes the student the constructor of knowledge. Some of the many benefits of a project-based approach to science instruction are:

- the development of problem-solving and questioning skills in students
- the opportunity to enhance research skills and develop critical-thinking and evaluation skills in students
- the opportunity for students to collect and share knowledge in a number of formats addressing a variety of intelligences
- the achievement of a number of STSE and science skills outcomes
- the achievement of a number of language arts outcomes with respect to writing
- the achievement of a number of mathematics outcomes
- the development of authentic learning and assessment practices
- the transfer of knowledge development from teacher to student
- the opportunity for teachers to become the students and develop project skills along with students
- the correlation of knowledge from biology, chemistry, and other branches of science
- the introduction of students to science practices
- the opportunity for teachers in different curriculum areas to work collaboratively on a project
- the ability to modify and adapt an individual's project in order to accommodate their strengths and avoid weaknesses
- the chance to showcase student work to the school, to parents, and to the general public