2008

REVISED

The Ontario Curriculum
Grades 11 and 12

Science

reach every student

Ontario

BIOLOGY

Biology, Grade 11

University Preparation SBI3U

This course furthers students' understanding of the processes that occur in biological systems. Students will study theory and conduct investigations in the areas of biodiversity; evolution; genetic processes; the structure and function of animals; and the anatomy, growth, and function of plants. The course focuses on the theoretical aspects of the topics under study, and helps students refine skills related to scientific investigation.

Prerequisite: Science, Grade 10, Academic

Big Ideas

Diversity of Living Things

- All living things can be classified according to their anatomical and physiological characteristics.
- Human activities affect the diversity of living things in ecosystems.

Evolution

- Evolution is the process of biological change over time based on the relationships between species and their environments.
- The theory of evolution is a scientific explanation based on a large accumulation of evidence.
- Technology that enables humans to manipulate the development of species has economic and environmental implications.

Genetic Processes

- Genetic and genomic research can have social and environmental implications.
- Variability and diversity of living organisms result from the distribution of genetic materials during the process of meiosis.

Animals: Structure and Function

- Groups of organs with specific structures and functions work together as systems, which interact with other systems in the body.
- The development and uses of technology to maintain human health are based, in part, on the changing needs of society.

Plants: Anatomy, Growth, and Function

- Plants have specialized structures with distinct functions that enable them to respond and adapt to their environment.
- Plant variety is critical to the survival and sustainability of ecosystems.

Fundamental Concepts Covered in This Course (see also page 5)

Fundamental Concepts	Diversity of Living Things	Evolution	Genetic Processes	Animals: Structure and Function	Plants: Anatomy, Growth, and Function
Matter	✓				
Energy	✓			✓	
Systems and Interactions	✓	✓		✓	✓
Structure and Function	✓	✓	✓	✓	✓
Sustainability and Stewardship	✓	✓			✓
Change and Continuity	✓	✓	✓		

A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

OVERALL EXPECTATIONS

Throughout this course, students will:

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

A2. identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields.

SPECIFIC EXPECTATIONS

A1. Scientific Investigation Skills

Throughout this course, students will:

Initiating and Planning [IP]*

A1.1 formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research

A1.2 select appropriate instruments (e.g., sampling instruments, a microscope, a stethoscope, dissection instruments) and materials (e.g., dichotomous keys, computer simulations, plant cuttings), and identify appropriate methods, techniques, and procedures, for each inquiry

A1.3 identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately

A1.4 apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory and biological materials (e.g., preserved specimens); and by using appropriate personal protection

Performing and Recording [PR]*

A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data

A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams

A1.7 select, organize, and record relevant information on research topics from a variety of appropriate sources, including electronic, print, and/or human sources, using suitable formats and an accepted form of academic documentation

Analysing and Interpreting [AI]*

A1.8 synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error

A1.9 analyse the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–F to which the particular area(s) relate (see pp. 20–22 for information on scientific investigation skills).

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge

Communicating [C]*

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

A1.12 use appropriate numeric, symbolic, and graphic modes of representation (e.g., biological diagrams, Punnett squares), and appropriate units of measurement (e.g., SI and imperial units)

A1.13 express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures

A2. Career Exploration

Throughout this course, students will:

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., zoologist, botanist, geneticist, ecologist, pharmacologist, farmer, forester, horticulturalist) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians (e.g., Colin D'Cunha, Louis Bernatchez, Lap-Chee Tsui, Helen Battle, Memory Elvin-Lewis), to the fields under study

B. DIVERSITY OF LIVING THINGS

OVERALL EXPECTATIONS

By the end of this course, students will:

B1. analyse the effects of various human activities on the diversity of living things;

B2. investigate, through laboratory and/or field activities or through simulations, the principles of scientific classification, using appropriate sampling and classification techniques;

B3. demonstrate an understanding of the diversity of living organisms in terms of the principles of taxonomy and phylogeny.

SPECIFIC EXPECTATIONS

B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

B1.1 analyse some of the risks and benefits of human intervention (e.g., tree plantations; monoculture of livestock or agricultural crops; overharvesting of wild plants for medicinal purposes; using pesticides to control pests; suppression of wild fires) to the biodiversity of aquatic or terrestrial ecosystems [AI, C]

Sample issue: Stocking lakes with fish provides recreation for fishing enthusiasts and increases the amount of food available for humans and other animals. However, this practice also increases the competition for food, which could threaten native species and affect the natural biodiversity of the aquatic ecosystem.

Sample questions: What types of conservation efforts have been made to help protect local wetlands from urban developments? In what ways does the planting of native species in a disturbed area help to improve the ecosystem? How and why might some species benefit from human intervention?

B1.2 analyse the impact that climate change might have on the diversity of living things (e.g., rising temperatures can result in habitat loss or expansion; changing rainfall levels can cause drought or flooding of habitats) [AI, C]

Sample issue: Some scientists believe that we are in the early stages of a human-made mass extinction partly caused by rapid climate change. Many species that cannot tolerate the change will become extinct. However, Earth's history has shown that extinction of some species creates opportunities for surviving species to adapt, evolve, and flourish.

Sample questions: Why do higher temperatures affect the survival of some species in freshwater environments? Why would an increase in ocean temperatures endanger many species that depend on coral as a home and food supply? In what ways have longer growing seasons, which may include a second harvest, affected the biodiversity of agricultural lands? How might species such as the Eastern Massasauga rattlesnake be affected by increased water levels in their habitats?

B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

B2.1 use appropriate terminology related to biodiversity, including, but not limited to: *genetic diversity, species diversity, structural diversity, protists, bacteria, fungi, binomial nomenclature,* and *morphology* [C]

B2.2 classify, and draw biological diagrams of, representative organisms from each of the kingdoms according to their unifying and distinguishing anatomical and physiological characteristics (e.g., vertebrate or invertebrate organisms, vascular or nonvascular plants) [PR, AI, C]

B2.3 use proper sampling techniques to collect various organisms from a marsh, pond, field, or other ecosystem, and classify the organisms according to the principles of taxonomy [PR, AI, C]

B2.4 create and apply a dichotomous key to identify and classify organisms from each of the kingdoms [PR, AI, C]

B3. Understanding Basic Concepts

By the end of this course, students will:

B3.1 explain the fundamental principles of taxonomy and phylogeny by defining concepts of taxonomic rank and relationship, such as genus, species, and taxon

B3.2 compare and contrast the structure and function of different types of prokaryotes, eukaryotes, and viruses (e.g., compare and contrast genetic material, metabolism, organelles, and other cell parts)

B3.3 describe unifying and distinguishing anatomical and physiological characteristics (e.g., types of reproduction, habitat, general physical structure) of representative organisms from each of the kingdoms

B3.4 explain key structural and functional changes in organisms as they have evolved over time (e.g., the evolution of eukaryotes from prokaryotes, of plants from unicellular organisms)

B3.5 explain why biodiversity is important to maintaining viable ecosystems (e.g., biodiversity helps increase resilience to stress and resistance to diseases or invading species)

C. EVOLUTION

OVERALL EXPECTATIONS

By the end of this course, students will:

C1. analyse the economic and environmental advantages and disadvantages of an artificial selection technology, and evaluate the impact of environmental changes on natural selection and endangered species;

C2. investigate evolutionary processes, and analyse scientific evidence that supports the theory of evolution;

C3. demonstrate an understanding of the theory of evolution, the evidence that supports it, and some of the mechanisms by which it occurs.

SPECIFIC EXPECTATIONS

C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

C1.1 analyse, on the basis of research, the economic and environmental advantages and disadvantages of an artificial selection technology (e.g., livestock and horticultural breeding) [IP, PR, AI, C]

Sample issue: Selective breeding of agricultural crops can benefit populations in less-developed countries by producing hardier crops, increasing food supplies, and improving the nutritional content of food. However, opponents of artificial selection technology believe that it affects the natural ability of a species to reproduce, which negatively affects biodiversity.

Sample questions: How has selective breeding of specific crops helped to increase the yield of the crop and decrease the need for chemicals in the fields? How has the introduction of genetically engineered species in the horticultural industry affected other species planted in the same areas? In what ways do the characteristics of today's farm animals, such as cattle, pigs, and chickens, differ from those of earlier farm animals? What are the reasons for the differences?

C1.2 evaluate the possible impact of an environmental change on natural selection and on the vulnerability of species (e.g., adaptation to environmental changes can affect reproductive success of an organism) [AI, C]

Sample issue: An increase in forest fires in some areas of North America has affected the reproductive success of some species as their food supplies decrease and they are forced to adapt to adverse habitat conditions. Yet, forest fires also naturally promote changes in plant and animal species over time as the environment becomes more suitable for other species.

Sample questions: Why has a decline in the milkweed population, as a result of urbanization and pesticides, affected the migration of monarch butterflies? How has the introduction of bacteria and viruses in inland lakes affected the life cycle of carp? What impact has the loss of bamboo forests to urbanization had on the giant panda's ability to breed and live?

C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

C2.1 use appropriate terminology related to evolution, including, but not limited to: *extinction, natural selection, phylogeny, speciation, niche, mutation, mimicry, adaptation,* and *survival of the fittest* [C]

C2.2 use a research process to investigate some of the key factors that affect the evolutionary process (e.g., genetic mutations, selective pressures, environmental stresses) [IP, PR]

C2.3 analyse, on the basis of research, and report on the contributions of various scientists to modern theories of evolution (e.g., Charles Lyell, Thomas Malthus, Jean-Baptiste Lamarck, Charles Darwin, Stephen Jay Gould, Niles Eldredge) [IP, PR, AI, C]

C2.4 investigate, through a case study or computer simulation, the processes of natural selection and artificial selection (e.g., selective breeding, antibiotic resistance in microorganisms), and analyse the different mechanisms by which they occur [PR, AI, C]

C3. Understanding Basic Concepts

By the end of this course, students will:

C3.1 explain the fundamental theory of evolution, using the evolutionary mechanism of natural selection to illustrate the process of biological change over time

C3.2 explain the process of adaptation of individual organisms to their environment (e.g., some disease-causing bacteria in a bacterial population can survive exposure to antibiotics due to slight genetic variations from the rest of the population, which allows successful surviving bacteria to pass on antibiotic resistance to the next generation)

C3.3 define the concept of speciation, and explain the process by which new species are formed

C3.4 describe some evolutionary mechanisms (e.g., natural selection, artificial selection, sexual selection, genetic variation, genetic drift, biotechnology), and explain how they affect the evolutionary development and extinction of various species (e.g., Darwin's finches, giraffes, pandas)

D. GENETIC PROCESSES

OVERALL EXPECTATIONS

By the end of this course, students will:

D1. evaluate the importance of some recent contributions to our knowledge of genetic processes, and analyse social and ethical implications of genetic and genomic research;

D2. investigate genetic processes, including those that occur during meiosis, and analyse data to solve basic genetics problems involving monohybrid and dihybrid crosses;

D3. demonstrate an understanding of concepts, processes, and technologies related to the transmission of hereditary characteristics.

SPECIFIC EXPECTATIONS

D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

D1.1 analyse, on the basis of research, some of the social and ethical implications of research in genetics and genomics (e.g., genetic screening, gene therapy, in vitro fertilization) [IP, PR, AI, C]

Sample issue: Gene therapy is a promising treatment for some inherited disorders such as cystic fibrosis. However, the technique remains risky and unproven, and there are ethical questions associated with its use and related research.

Sample questions: What are the possible social benefits of applications of stem-cell research? What ethical issues does such research raise? Why is the prospect of using genetically engineered material in human subjects controversial? What are some of the ethical issues related to gene therapy?

D1.2 evaluate, on the basis of research, the importance of some recent contributions to knowledge, techniques, and technologies related to genetic processes (e.g., research into the cystic fibrosis gene; the use of safflowers to produce insulin for human use) [IP, PR, AI, C]

Sample issue: Cancer researchers use bioinformatics and computational biology to study different types of cancer in an attempt to lower the risk of people who have a genetic predisposition to the disease. A risk is that this information could also be used to deny insurance coverage or payment of claims.

Sample questions: How has the human genome project allowed genetic research to move from a wet science to a dry science? How has the study of the copy number alteration of genes, conducted at the Hospital for Sick Children, helped researchers to understand genetic susceptibility to autism spectrum disorders? How has genomic research increased our understanding of human health and diseases?

D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

D2.1 use appropriate terminology related to genetic processes, including, but not limited to: *haploid, diploid, spindle, synapsis, gamete, zygote, heterozygous, homozygous, allele, plasmid, trisomy, non-disjunction,* and *somatic cell* [C]

D2.2 investigate the process of meiosis, using a microscope or similar instrument, or a computer simulation, and draw biological diagrams to help explain the main phases in the process [PR, AI, C]

D2.3 use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, codominance, dihybrid crosses, and sex-linked genes [PR, AI, C]

D2.4 investigate, through laboratory inquiry or computer simulation, monohybrid and dihybrid crosses, and use the Punnett square method and probability rules to analyse the qualitative and quantitative data and determine the parent genotype [PR, AI, C]

D3. Understanding Basic Concepts

By the end of this course, students will:

D3.1 explain the phases in the process of meiosis in terms of cell division, the movement of chromosomes, and crossing over of genetic material

D3.2 explain the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis, and how they account for the transmission of hereditary characteristics according to Mendelian laws of inheritance

D3.3 explain the concepts of genotype, phenotype, dominance, incomplete dominance, codominance, recessiveness, and sex linkage according to Mendelian laws of inheritance

D3.4 describe some genetic disorders caused by chromosomal abnormalities (e.g., non-disjunction of chromosomes during meiosis) or other genetic mutations in terms of chromosomes affected, physical effects, and treatments

D3.5 describe some reproductive technologies (e.g., cloning, artificial insemination, in vitro fertilization, recombinant DNA), and explain how their use can increase the genetic diversity of a species (e.g., farm animals, crops)

E. ANIMALS: STRUCTURE AND FUNCTION

OVERALL EXPECTATIONS

By the end of this course, students will:

E1. analyse the relationships between changing societal needs, technological advances, and our understanding of internal systems of humans;

E2. investigate, through laboratory inquiry or computer simulation, the functional responses of the respiratory and circulatory systems of animals, and the relationships between their respiratory, circulatory, and digestive systems;

E3. demonstrate an understanding of animal anatomy and physiology, and describe disorders of the respiratory, circulatory, and digestive systems.

SPECIFIC EXPECTATIONS

E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

E1.1 evaluate the importance of various technologies, including Canadian contributions, to our understanding of internal body systems (e.g., endoscopes can be used to locate, diagnose, and surgically remove digestive system tumours; lasers can be used during surgery to destroy lung tumours; nuclear magnetic resonance [NMR] imaging can be used to diagnose injuries and cardiovascular disorders, such as aneurysms) [AI, C]

Sample issue: Magnetic resonance imaging (MRI) and computerized tomography (CT) are non-invasive imaging technologies that can produce three-dimensional views of organs, tissues, and bones, providing valuable information on internal body systems. The imaging equipment is expensive to buy, operate, and maintain, so it is usually available only in large urban centres with high demand.

Sample questions: How has the development of the two-photon imaging microscope improved our ability to locate and analyse rare types of cancerous cells? How are nanotechnologies being used in non-invasive exploratory surgeries? What are the benefits of new computer software that allows doctors to view three-dimensional models of organs for surgery and radiation treatments?

E1.2 assess how societal needs (e.g., the need for healthy foods; the need to counteract the effects of sedentary lifestyles) lead to scientific and technological developments related to internal systems (e.g., advances in dietary products and fitness equipment; improved standards for transplanting organs) [AI, C]

Sample issue: Diabetes is becoming a more common medical condition in Canada as a result of increasingly sedentary lifestyles and an aging population. Until recently, people with diabetes had to monitor their blood sugar and self-administer insulin. For many people, this regimen is now being replaced with more convenient and reliable insulin pump therapy.

Sample questions: How has the need to develop safer and faster tests for diagnosing internal diseases led to the development of nanotechnologies? What types of products have resulted from society's demand for multifunctional foods, such as low-calorie junk foods? What types of technologies have been developed in response to the shortage of organs available for transplant?

E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

E2.1 use appropriate terminology related to animal anatomy, including, but not limited to: *systolic, diastolic, diffusion gradient, inhalation, exhalation, coronary, cardiac, ulcer, asthma,* and *constipation* [C]

E2.2 perform a laboratory or computer-simulated dissection of a representative animal, or use a mounted anatomical model, to analyse the relationships between the respiratory, circulatory, and digestive systems [PR, AI]

E2.3 use medical equipment (e.g., a stethoscope, a sphygmomanometer) to monitor the functional responses of the respiratory and circulatory systems to external stimuli (e.g., measure the change in breathing rate and heart rate after exercise) [PR, AI]

E3. Understanding Basic Concepts

By the end of this course, students will:

E3.1 explain the anatomy of the respiratory system and the process of ventilation and gas exchange from the environment to the cell (e.g., the movement of oxygen from the atmosphere to the cell; the roles of ventilation, hemoglobin, and diffusion in gas exchange)

E3.2 explain the anatomy of the digestive system and the importance of digestion in providing nutrients needed for energy and growth (e.g., the body's mechanical and chemical processes digest food, which provides the proteins needed to build muscle, and the fibre, water, vitamins, and minerals needed to regulate body processes)

E3.3 explain the anatomy of the circulatory system (e.g., blood components, blood vessels, the heart) and its function in transporting substances that are vital to health

E3.4 describe some disorders related to the respiratory, digestive, and circulatory systems (e.g., asthma, emphysema, ulcers, colitis, cardiac arrest, arteriosclerosis)

F. PLANTS: ANATOMY, GROWTH, AND FUNCTION

OVERALL EXPECTATIONS

By the end of this course, students will:

F1. evaluate the importance of sustainable use of plants to Canadian society and other cultures;

F2. investigate the structures and functions of plant tissues, and factors affecting plant growth;

F3. demonstrate an understanding of the diversity of vascular plants, including their structures, internal transport systems, and their role in maintaining biodiversity.

SPECIFIC EXPECTATIONS

F1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

F1.1 evaluate, on the basis of research, the importance of plants to the growth and development of Canadian society (e.g., as a source of food, pharmaceuticals, Aboriginal medicines, building materials, flood and erosion control; as a resource for recreation and ecotourism) [IP, PR, AI, C]

Sample issue: The agricultural sector holds great economic potential as demand increases for products such as biofuels, biochemicals, and biopharmaceuticals. Bioresources could also support our efforts to produce renewable energy, improve health, and minimize environmental impact. However, critics are concerned about the impact of bioresources on the availability of food crops and the price of food.

Sample questions: In what ways does the local-food movement contribute to community development? How does the re-introduction of native plant species along river banks help to prevent land erosion? What plant species are considered important in sustaining Canada's growth in the agricultural sector? How might the increasing demand for straw-bale housing materials support Canada's agricultural sector and increase the sustainability of other natural resources?

F1.2 evaluate, on the basis of research, ways in which different societies or cultures have used plants to sustain human populations while supporting environmental sustainability (e.g., sustainable agricultural practices in developing countries such as crop rotation and seed saving; traditional Aboriginal corn production practices) [IP, PR, AI, C]

Sample issue: Aboriginal peoples living near Canada's boreal forest rely on forest plants for food and medicine. Plants are harvested by traditional methods to maintain natural habitats and local biodiversity. However, these traditional practices are threatened as more areas are subject to development and commercial resource exploitation.

Sample questions: How are strategies for the conservation and sustainable use of medicinal plants being used by small communities and traditional healers in some developing countries? What effect does the re-establishment of wetland plants in agricultural settings have on the natural balance of the ecosystem? How are plants being used to clean wastewater from fish farms so that the water can go back into local streams?

F2. Developing Skills of Investigation and Communication

By the end of this course, students will:

F2.1 use appropriate terminology related to plants, including, but not limited to: *mesophyll, palisade, aerenchyma, epidermal tissue, stomata, root hair, pistil, stamen, venation, auxin,* and *gibberellin* [C]

F2.2 design and conduct an inquiry to determine the factors that affect plant growth (e.g., the effects on plant growth of the quantity of nutrients, the quantity and quality of light, and factors such as temperature and water retention or percolation rate) [IP, PR, AI]

F2.3 identify, and draw biological diagrams of, the specialized plant tissues in roots, stems, and leaves (e.g., xylem, phloem), using a microscope and models [PR, AI]

F2.4 investigate various techniques of plant propagation (e.g., leaf cutting, stem cutting, root cutting, seed germination) [PR]

F3. Understanding Basic Concepts

By the end of this course, students will:

F3.1 describe the structures of the various types of tissues in vascular plants, and explain the mechanisms of transport involved in the processes by which materials are distributed throughout a plant (e.g., transpiration, translocation, osmosis)

F3.2 compare and contrast monocot and dicot plants in terms of their structures (e.g., seeds, stem, flower, root) and their evolutionary processes (i.e., how one type evolved from the other)

F3.3 explain the reproductive mechanisms of plants in natural reproduction and artificial propagation (e.g., germination of seeds, leaf cuttings, grafting of branches onto a host tree)

F3.4 describe the various factors that affect plant growth (e.g., growth regulators, sunlight, water, nutrients, acidity, tropism)

F3.5 explain the process of ecological succession, including the role of plants in maintaining biodiversity and the survival of organisms after a disturbance to an ecosystem

Biology, Grade 12

University Preparation **SBI4U**

This course provides students with the opportunity for in-depth study of the concepts and processes that occur in biological systems. Students will study theory and conduct investigations in the areas of biochemistry, metabolic processes, molecular genetics, homeostasis, and population dynamics. Emphasis will be placed on the achievement of detailed knowledge and the refinement of skills needed for further study in various branches of the life sciences and related fields.

Prerequisite: Biology, Grade 11, University Preparation

Big Ideas

Biochemistry

- Technological applications that affect biological processes and cellular functions are used in the food, pharmaceutical, and medical industries.
- Biological molecules and their chemical properties affect cellular processes and biochemical reactions.
- Biochemical compounds play important structural and functional roles in cells of all living organisms.

Metabolic Processes

- All metabolic processes involve chemical changes and energy conversions.
- An understanding of metabolic processes enables people to make informed choices with respect to a range of personal, societal, and environmental issues.

Molecular Genetics

- DNA contains all the genetic information for any living organism.
- Proteins control a wide variety of cellular processes.
- Genetic research and biotechnology have social, legal, and ethical implications.

Homeostasis

- Organisms have strict limits on the internal conditions that they can tolerate.
- Systems that maintain homeostasis rely on feedback mechanisms.
- Environmental factors can affect homeostasis.

Population Dynamics

- Population growth follows predictable patterns.
- The increased consumption of resources and production of waste associated with population growth result in specific stresses that affect Earth's sustainability.
- Technological developments can contribute to or help offset the ecological footprint associated with population growth and the consumption of natural resources.

Fundamental Concepts Covered in This Course (see also page 5)

Fundamental Concepts	Biochemistry	Metabolic Processes	Molecular Genetics	Homeostasis	Population Dynamics
Matter	✓	✓			
Energy	✓	✓			
Systems and Interactions				✓	
Structure and Function	✓	✓	✓	✓	
Sustainability and Stewardship					✓
Change and Continuity			✓	✓	✓

A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

OVERALL EXPECTATIONS

Throughout this course, students will:

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

A2. identify and describe careers related to the fields of science under study, and describe contributions of scientists, including Canadians, to those fields.

SPECIFIC EXPECTATIONS

A1. Scientific Investigation Skills

Throughout this course, students will:

Initiating and Planning [IP]*

A1.1 formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research

A1.2 select appropriate instruments (e.g., dialysis tubing, glassware, sphygmomanometer) and materials (e.g., DNA models, plants, plant cuttings, molecular models), and identify appropriate methods, techniques, and procedures, for each inquiry

A1.3 identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately

A1.4 apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory and biological materials (e.g., plants and invertebrates); and by using appropriate personal protection

Performing and Recording [PR]*

A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data

A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams

A1.7 select, organize, and record relevant information on research topics from a variety of appropriate sources, including electronic, print, and/or human sources, using suitable formats and an accepted form of academic documentation

Analysing and Interpreting [AI]*

A1.8 synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error

A1.9 analyse the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–F to which the particular area(s) relate (see pp. 20–22 for information on scientific investigation skills).

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge

Communicating [C]*

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

A1.12 use appropriate numeric, symbolic, and graphic modes of representation (e.g., biological diagrams, three-dimensional molecular models), and appropriate units of measurement (e.g., SI and imperial units)

A1.13 express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures

A2. Career Exploration

Throughout this course, students will:

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., scientific journalist, fisheries and wildlife officer, physician, infectious disease researcher, geneticist) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians (e.g., Evelyn Roden Nelson, Maude Menten, Albert Juan Aguayo, Kimberley J. Fernie, Michael Archer), to the fields under study

B. BIOCHEMISTRY

OVERALL EXPECTATIONS

By the end of this course, students will:

B1. analyse technological applications of enzymes in some industrial processes, and evaluate technological advances in the field of cellular biology;

B2. investigate the chemical structures, functions, and chemical properties of biological molecules involved in some common cellular processes and biochemical reactions;

B3. demonstrate an understanding of the structures and functions of biological molecules, and the biochemical reactions required to maintain normal cellular function.

SPECIFIC EXPECTATIONS

B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

B1.1 analyse technological applications related to enzyme activity in the food and pharmaceutical industries (e.g., the production of dairy products; breadmaking; the use of enzymes to control reaction rates in pharmaceuticals) [AI, C]

Sample issue: Natural enzymes are used in many food production processes to speed up chemical reactions, which reduces water usage and energy consumption. Scientists are now designing and producing synthetic enzymes that will be more efficient catalysts and allow new technological applications in medicine and industry.

Sample questions: Why are there so many different varieties of cheese when the production process is basically the same for all cheeses? What types of food production processes use enzymes to improve production yields? How do they do so? How and why are enzymes used as pharmaceutical supplements to treat digestive system disorders such as celiac disease and lactose intolerance?

B1.2 evaluate, on the basis of research, some advances in cellular biology and related technological applications (e.g., new treatments for cancer, HIV/AIDS, and hepatitis C; radioisotopic labelling to study the function of internal organs; fluorescence to study genetic material within cells; forensic biological techniques to aid in crime resolution) [IP, PR, AI, C]

Sample issue: In nuclear medicine, radioactive compounds are injected into the body so that images of cells can be scanned to diagnose and treat medical conditions such as cancer and heart disease. Radioisotopes may now be used so routinely and effectively that we have come to rely on them despite concerns about production safety.

Sample questions: How are drugs used to target tumour cells during chemotherapy? How are scientists using bacteria to create antibiotics that fight drug-resistant bacteria strains? What role might nanotechnologies play in replacing current diagnostic and treatment technologies?

B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

B2.1 use appropriate terminology related to biochemistry, including, but not limited to: *active and passive transport, covalent and ionic bond, allosteric site, substrate, substrate-enzyme complex,* and *inhibition* [C]

B2.2 plan and conduct an investigation to demonstrate the movement of substances across a membrane (e.g., the effects of salt water and distilled water on a potato) [IP, PR]

B2.3 construct and draw three-dimensional molecular models of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids [PR, C]

B2.4 conduct biological tests to identify biochemical compounds found in various food samples (e.g., use Benedict's solution to test for carbohydrates in food samples), and compare the biochemical compounds found in each food to those found in the others [PR, AI, C]

B2.5 plan and conduct an investigation related to a cellular process (e.g., factors that affect enzyme activity; factors that affect transport of substances across cell membranes), using appropriate laboratory equipment and techniques, and report the results in an appropriate format [IP, PR, C]

B3. Understanding Basic Concepts

By the end of this course, students will:

B3.1 explain the roles of various organelles, such as lysosomes, vacuoles, mitochondria, internal cell membranes, ribosomes, smooth and rough endoplasmic reticulum, and Golgi bodies, in cellular processes

B3.2 describe the structure of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids, and explain their function within cells

B3.3 identify common functional groups within biological molecules (e.g., hydroxyl, carbonyl, carboxyl, amino, phosphate), and explain how they contribute to the function of each molecule

B3.4 describe the chemical structures and mechanisms of various enzymes

B3.5 identify and describe the four main types of biochemical reactions (oxidation-reduction [redox], hydrolysis, condensation, and neutralization)

B3.6 describe the structure of cell membranes according to the fluid mosaic model, and explain the dynamics of passive transport, facilitated diffusion, and the movement of large particles across the cell membrane by the processes of endocytosis and exocytosis

C. METABOLIC PROCESSES

OVERALL EXPECTATIONS

By the end of this course, students will:

C1. analyse the role of metabolic processes in the functioning of biotic and abiotic systems, and evaluate the importance of an understanding of these processes and related technologies to personal choices made in everyday life;

C2. investigate the products of metabolic processes such as cellular respiration and photosynthesis;

C3. demonstrate an understanding of the chemical changes and energy conversions that occur in metabolic processes.

SPECIFIC EXPECTATIONS

C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

C1.1 analyse the role of metabolic processes in the functioning of and interactions between biotic and abiotic systems (e.g., specialized microbes and enzymes in biotechnological applications to treat wastewater in the pulp and paper industry; microbes and enzymes in bioremediation, such as in the cleanup of oil spills; energy transfer from producers to consumers) [AI, C]

Sample issue: Most restaurants dispose of cooking oil and grease in an environmentally sound way to avoid contaminating municipal sewer systems. One method they can use is bioaugmentation, which uses microorganisms to metabolize oils into bacterial biomass, carbon dioxide, and water. However, this process can create unpleasant odours, which are undesirable in a food service setting.

Sample questions: How do symbiotic bacteria use metabolic processes to produce biohydrogen from food waste? How are microbes used in the bioremediation of contaminated groundwater sites? What is the relationship between the position of a particular species in the food chain and the energy required to maintain that species?

C1.2 assess the relevance, to their personal lives and to the community, of an understanding of cell biology and related technologies (e.g., knowledge of metabolic processes is relevant to personal choices about exercise, diet, and the use of pharmacological substances; knowledge of cellular processes aids in our understanding and treatment of mitochondrial diseases [a group of neuromuscular diseases]) [AI, C]

Sample issue: Some fad weight-loss diets include pills that are believed to speed up the body's metabolism to help a person lose weight quickly. Other diets rely on very low calorie intake for rapid weight loss. However, such methods can lead to destructive metabolic processes in the body, causing organ failure.

Sample questions: How does stem-cell research related to degenerative diseases use technologies to change the metabolic processes of the cells? Why is it important when changing your diet to know how the cells in your body will react to the introduction of new substances or the removal of other substances?

C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

C2.1 use appropriate terminology related to metabolism, including, but not limited to: *energy carriers, glycolysis, Krebs cycle, electron transport chain, ATP synthase, oxidative phosphorylation, chemiosmosis, proton pump, photolysis, Calvin cycle, light and dark reactions,* and *cyclic and noncyclic phosphorylation* [C]

C2.2 conduct a laboratory investigation into the process of cellular respiration to identify the products of the process, interpret the qualitative observations, and display them in an appropriate format [PR, AI, C]

C2.3 conduct a laboratory investigation of the process of photosynthesis to identify the products of the process, interpret the qualitative observations, and display them in an appropriate format [PR, AI, C]

C3. Understanding Basic Concepts

By the end of this course, students will:

C3.1 explain the chemical changes and energy conversions associated with the processes of aerobic and anaerobic cellular respiration (e.g., in aerobic cellular respiration, glucose and oxygen react to produce carbon dioxide, water, and energy in the form of heat and ATP; in anaerobic cellular respiration, yeast reacts with glucose in the absence of oxygen to produce carbon dioxide and ethanol)

C3.2 explain the chemical changes and energy conversions associated with the process of photosynthesis (e.g., carbon dioxide and water react with sunlight to produce oxygen and glucose)

C3.3 use the laws of thermodynamics to explain energy transfer in the cell during the processes of cellular respiration and photosynthesis

C3.4 describe, compare, and illustrate (e.g., using flow charts) the matter and energy transformations that occur during the processes of cellular respiration (aerobic and anaerobic) and photosynthesis, including the roles of oxygen and organelles such as mitochondria and chloroplasts

D. MOLECULAR GENETICS

OVERALL EXPECTATIONS

By the end of this course, students will:

D1. analyse some of the social, ethical, and legal issues associated with genetic research and biotechnology;

D2. investigate, through laboratory activities, the structures of cell components and their roles in processes that occur within the cell;

D3. demonstrate an understanding of concepts related to molecular genetics, and how genetic modification is applied in industry and agriculture.

SPECIFIC EXPECTATIONS

D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

D1.1 analyse, on the basis of research, some of the social, ethical, and legal implications of biotechnology (e.g., the bioengineering of animal species, especially those intended for human consumption; the cultivation of transgenic crops; the patenting of life forms; cloning) [IP, PR, AI, C]

Sample issue: Corporations that have patented genetically modified (GM) seeds legally require farmers to buy new seeds from them each planting season. Corporations that find GM crops on a farm that did not purchase their seed can take the farmer to court. However, natural processes such as cross-pollination can result in the migration of GM crops to neighbouring farms.

Sample questions: Should private companies be able to patent life forms, including genetic material? Why or why not? Who owns and controls our personal genetic information? Who should have access to our personal genetic information and decide how it will be used? What are the ethical implications of reproductive technologies that allow postmenopausal women to conceive?

D1.2 analyse, on the basis of research, some key aspects of Canadian regulations pertaining to biotechnology (e.g., current or potential legislation for mandatory DNA fingerprinting, human cloning, ownership of a genome, patenting of genetically modified organisms), and compare them to regulations from another jurisdiction [IP, PR, AI, C]

Sample issue: Modern biotechnologies, such as selective breeding, are regulated under Health Canada's Food and Drugs Act and the Canadian Environmental Protection Act. It is an ongoing challenge to ensure that our regulations keep up with advances in scientific knowledge and technologies, as well as with developments in other countries.

Sample questions: What is the role of the Canadian Food Inspection Agency with respect to biotechnology? What role does the Canadian Environmental Protection Act play in regulating biotechnology? Why was bovine growth hormone approved for use in dairy cattle in the United States but not in Canada? Why does Mexico have laws to limit the cultivation of genetically modified corn? What countries have banned human cloning? What is Canada's position on this issue?

D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

D2.1 use appropriate terminology related to molecular genetics, including, but not limited to: *polymerase I, II, and III, DNA ligase, helicase, Okazaki fragment, mRNA, rRNA, tRNA, codon, anticodon, translation, transcription,* and *ribosome subunits* [C]

D2.2 analyse a simulated strand of DNA to determine the genetic code and base pairing of DNA (e.g., determine base sequences of DNA for a protein; analyse base sequences in DNA to recognize an anomaly) [AI]

D2.3 conduct an investigation to extract DNA from a specimen of plant or animal protein [PR]

D2.4 investigate and analyse the cell components involved in the process of protein synthesis, using appropriate laboratory equipment and techniques, or a computer simulation [PR, AI]

D3. Understanding Basic Concepts

By the end of this course, students will:

D3.1 explain the current model of DNA replication, and describe the different repair mechanisms that can correct mistakes in DNA sequencing

D3.2 compare the structures and functions of RNA and DNA, and explain their roles in the process of protein synthesis

D3.3 explain the steps involved in the process of protein synthesis and how genetic expression is controlled in prokaryotes and eukaryotes by regulatory proteins (e.g., the role of operons in prokaryotic cells; the mechanism of gene expression in eukaryotic cells)

D3.4 explain how mutagens, such as radiation and chemicals, can cause mutations by changing the genetic material in cells (e.g., the mechanisms and effects of point mutations and frameshift mutations)

D3.5 describe some examples of genetic modification, and explain how it is applied in industry and agriculture (e.g., the processes involved in cloning, or in the sequencing of DNA bases; the processes involved in the manipulation of genetic material and protein synthesis; the development and mechanisms of the polymerization chain reaction)

D3.6 describe the functions of some of the cell components used in biotechnology (e.g., the roles of plasmids, restriction enzymes, recombinant DNA, and vectors in genetic engineering)

D3.7 describe, on the basis of research, some of the historical scientific contributions that have advanced our understanding of molecular genetics (e.g., discoveries made by Frederick Griffith, Watson and Crick, Hershey and Chase)

E. HOMEOSTASIS

OVERALL EXPECTATIONS

By the end of this course, students will:

E1. evaluate the impact on the human body of selected chemical substances and of environmental factors related to human activity;

E2. investigate the feedback mechanisms that maintain homeostasis in living organisms;

E3. demonstrate an understanding of the anatomy and physiology of human body systems, and explain the mechanisms that enable the body to maintain homeostasis.

SPECIFIC EXPECTATIONS

E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

E1.1 assess, on the basis of findings from a case study, the effects on the human body of taking chemical substances to enhance performance or improve health (e.g., the risks and benefits of taking large quantities of vitamins or amino acids; the effects on the human body of substances that people use to cope with stress) [PR, AI, C]

Sample issue: Steroids are a class of drugs that can be used for healing and building of tissues under proper medical supervision. However, if used for the wrong purpose, such as athletic performance enhancement, or if they are taken incorrectly, steroids can be dangerous and result in negative long-term effects on many body systems.

Sample questions: How do certain classes of drugs help with neurotransmission in the brain? What effects does aloe vera have on the human body? How do common antidepressants work? Why should people, especially young people, be carefully monitored when on such medications? What are the possible side effects of statin drugs used to lower cholesterol? Why has the federal government proposed legislation to regulate natural health products?

E1.2 evaluate, on the basis of research, some of the human health issues that arise from the impact of human activities on the environment (e.g., the effects of synthetic estrogen compounds released into our water systems; the effects of leaching of compounds from plastic products into soil and water) [IP, PR, AI, C]

Sample issue: Human-produced biosolids are a low-cost source of nutrient-rich organic matter that is often spread on agricultural land rather than being sent for incineration or landfill disposal. Opponents of land application of biosolids are concerned about the potential health impact of heavy metals, bacteria, and drugs that may remain in the biosolids.

Sample questions: In what ways have mining, forestry, and hydroelectric developments affected the health of Aboriginal people in Northern Ontario? What are the links between air pollution and respiratory diseases such as asthma? What types of human activity have led to the thinning of the ozone? What human health conditions are related to this phenomenon? How can the dumping of chemicals down sinks and into storm sewers affect the incidence of skin conditions among swimmers at local beaches?

E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

E2.1 use appropriate terminology related to homeostasis, including, but not limited to: *insulin, testosterone, estrogen, nephron, dialysis, pituitary, synapse,* and *acetylcholine* [C]

E2.2 plan and construct a model to illustrate the essential components of the homeostatic process (e.g., create a flow chart that illustrates representative feedback mechanisms in living things) [IP, AI, C]

E2.3 plan and conduct an investigation to study a feedback system (e.g., stimulus response loop) [IP, PR, AI]

E2.4 plan and conduct an investigation to study the response mechanism of an invertebrate to external stimuli (e.g., the instinctive behaviour of an invertebrate in response to a stimulus such as light), using appropriate laboratory equipment and techniques [IP, PR, AI]

E3. Understanding Basic Concepts

By the end of this course, students will:

E3.1 describe the anatomy and physiology of the endocrine, excretory, and nervous systems, and explain how these systems interact to maintain homeostasis

E3.2 explain how reproductive hormones act in human feedback mechanisms to maintain homeostasis (e.g., the actions of male and female reproductive hormones on their respective body systems)

E3.3 describe the homeostatic processes involved in maintaining water, ionic, thermal, and acid–base equilibrium, and explain how these processes help body systems respond to both a change in environment and the effects of medical treatments (e.g., the role of feedback mechanisms in water balance or thermoregulation; how the buffering system of blood maintains the body's pH balance; the effect of medical treatments on the endocrine system; the effects of chemotherapy on homeostasis)

F. POPULATION DYNAMICS

OVERALL EXPECTATIONS

By the end of this course, students will:

F1. analyse the relationships between population growth, personal consumption, technological development, and our ecological footprint, and assess the effectiveness of some Canadian initiatives intended to assist expanding populations;

F2. investigate the characteristics of population growth, and use models to calculate the growth of populations within an ecosystem;

F3. demonstrate an understanding of concepts related to population growth, and explain the factors that affect the growth of various populations of species.

SPECIFIC EXPECTATIONS

F1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

F1.1 analyse the effects of human population growth, personal consumption, and technological development on our ecological footprint (e.g., the deforestation resulting from expanding development and demand for wood products causes the destruction of habitats that support biological diversity; the acidification of lakes associated with some industrial processes causes a decrease in fish populations) [AI, C]

Sample issue: Every day, millions of Canadians drive their vehicles to work, school, or entertainment venues, which creates greenhouse gases and consumes non-renewable resources. These behaviours, and many other consumption habits, all contribute to our ecological footprint. Many experts believe that we are consuming more resources each year than Earth can produce.

Sample questions: How does the Living Planet Index (LPI) help a nation to assess its ecological footprint and sustain its population? How does the planned obsolescence of electronic devices and appliances contribute to our ecological footprint? What impact has rapid population growth into the suburbs had on the local environment? What is the environmental impact of using packaged infant formula instead of breastfeeding a baby for the first six months of life?

F1.2 assess, on the basis of research, the effectiveness of some Canadian technologies and projects intended to nourish expanding populations (e.g., the risks and benefits of growing genetically modified canola; some of the sustainable development projects funded by the Canadian International Development Agency [CIDA]) [IP, PR, AI, C]

Sample issue: Every year, millions of children in developing nations die from diseases and malnutrition related to micronutrient deficiencies. The Canada-based Micronutrient Initiative develops, implements, and monitors programs aimed at eliminating vitamin and mineral deficiencies in expanding populations. The main challenge of such an initiative is to create sustainable solutions that will reach all those who need help.

Sample questions: How are Canadian programs helping to reverse the effects of land degradation and promote sustainable farming in semi-arid and dry sub-humid areas? What is Canada's role in the Flour Fortification Initiative, and how effectively does this initiative meet its goal of nourishing expanding populations?

F2. Developing Skills of Investigation and Communication

By the end of this course, students will:

F2.1 use appropriate terminology related to population dynamics, including, but not limited to: *carrying capacity*, *population growth*, *population cycle*, *fecundity*, and *mortality* [C]

F2.2 use conceptual and mathematical population growth models to calculate the growth of populations of various species in an ecosystem (e.g., use the concepts of exponential, sigmoid, and sinusoidal growth to estimate the sizes of various populations) [PR, AI, C]

F2.3 determine, through laboratory inquiry or using computer simulations, the characteristics of population growth of two different populations (e.g., the different population cycles of a predator and its prey; the population cycles of two populations that compete for food; the increase of Aboriginal compared to non-Aboriginal populations and the significant difference in average age between the two groups) [PR, AI, C]

F3. Understanding Basic Concepts

By the end of this course, students will:

F3.1 explain the concepts of interaction (e.g., competition, predation, defence mechanism, symbiotic relationship, parasitic relationship) between different species

F3.2 describe the characteristics of a given population, such as its growth, density (e.g., fecundity, mortality), distribution, and minimum viable size

F3.3 explain factors such as carrying capacity, fecundity, density, and predation that cause fluctuation in populations, and analyse the fluctuation in the population of a species of plant, wild animal, or microorganism

F3.4 explain the concept of energy transfer in a human population in terms of the flow of food energy in the production, distribution, and use of food resources

F3.5 explain how a change in one population in an aquatic or terrestrial ecosystem can affect the entire hierarchy of living things in that system (e.g., how the disappearance of crayfish from a lake causes a decrease in the bass population of the lake; how the disappearance of beaver from an ecosystem causes a decrease in the wolf population in that ecosystem)

ENVIRONMENTAL SCIENCE

Environmental Science, Grade 11

University/College Preparation **SVN3M**

This course provides students with the fundamental knowledge of and skills relating to environmental science that will help them succeed in life after secondary school. Students will explore a range of topics, including the role of science in addressing contemporary environmental challenges; the impact of the environment on human health; sustainable agriculture and forestry; the reduction and management of waste; and the conservation of energy. Students will increase their scientific and environmental literacy and examine the interrelationships between science, the environment, and society in a variety of areas.

Prerequisite: Grade 10 Science, Applied or Academic

Big Ideas

Scientific Solutions to Contemporary Environmental Challenges

- Current environmental issues are complex, and may involve conflicting interests or ideas.
- Scientific knowledge enables people to make informed decisions about effective ways to address environmental challenges.

Human Health and the Environment

- Environmental factors can have negative effects on human health.
- It is possible to minimize some of the negative health effects of environmental factors by making informed lifestyle choices and taking other precautions.

Sustainable Agriculture and Forestry

- Modern agricultural and forestry practices can have positive and negative consequences for the economy, human health, and the sustainability of ecosystems, both local and global.

Reducing and Managing Waste

- Well-thought-out waste management plans help to sustain ecosystems, locally and globally.
- By making informed choices, consumers can reduce the amount or alter the nature of the waste they produce.

Conservation of Energy

- The impact of energy production and consumption on environmental sustainability depends on which resources and energy production methods are used.

Fundamental Concepts Covered in This Course (see also page 5)

Fundamental Concepts	Scientific Solutions to Contemporary Environmental Challenges	Human Health and the Environment	Sustainable Agriculture and Forestry	Reducing and Managing Waste	Conservation of Energy
Matter	✓	✓	✓	✓	
Energy	✓	✓	✓	✓	✓
Systems and Interactions	✓	✓		✓	
Structure and Function		✓		✓	✓
Sustainability and Stewardship	✓	✓	✓	✓	✓
Change and Continuity	✓				

A. SCIENTIFIC INVESTIGATION SKILLS AND CAREER EXPLORATION

OVERALL EXPECTATIONS

Throughout this course, students will:

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

A2. identify and describe careers related to the fields of science under study, and describe the contributions of scientists, including Canadians, to those fields.

SPECIFIC EXPECTATIONS

A1. Scientific Investigation Skills

Throughout this course, students will:

Initiating and Planning [IP]*

A1.1 formulate relevant scientific questions about observed relationships, ideas, problems, or issues, make informed predictions, and/or formulate educated hypotheses to focus inquiries or research

A1.2 select appropriate instruments (e.g., probes, moisture meters, rain gauges), and materials (e.g., water-sampling kits, soil-testing kits), and identify appropriate methods, techniques, and procedures, for each inquiry

A1.3 identify and locate a variety of print and electronic sources that enable them to address research topics fully and appropriately

A1.4 apply knowledge and understanding of safe laboratory practices and procedures when planning investigations by correctly interpreting Workplace Hazardous Materials Information System (WHMIS) symbols; by using appropriate techniques for handling and storing laboratory equipment and materials and disposing of laboratory materials; and by using appropriate personal protection

Performing and Recording [PR]*

A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data

A1.6 compile accurate data from laboratory and other sources, and organize and record the data, using appropriate formats, including tables, flow charts, graphs, and/or diagrams

A1.7 select, organize, and record relevant information on research topics from a variety of appropriate sources, including electronic, print, and/or human sources, using suitable formats and an accepted form of academic documentation

Analysing and Interpreting [AI]*

A1.8 synthesize, analyse, interpret, and evaluate qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis and whether it is consistent with scientific theory; identify sources of bias and/or error; and suggest improvements to the inquiry to reduce the likelihood of error

A1.9 analyse the information gathered from research sources for logic, accuracy, reliability, adequacy, and bias

* The abbreviation(s) for the broad area(s) of investigation skills – IP, PR, AI, and/or C – are provided in square brackets at the end of the expectations in strands B–F to which the particular area(s) relate (see pp. 20–22 for information on scientific investigation skills).

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions with reference to scientific knowledge

Communicating [C]*

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

A1.12 use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement (e.g., SI and imperial units)

A1.13 express the results of any calculations involving data accurately and precisely, to the appropriate number of decimal places or significant figures

A2. Career Exploration

Throughout this course, students will:

A2.1 identify and describe a variety of careers related to the fields of science under study (e.g., organic chemist, landscaper, conservationist, air quality technician, personal support worker, environmental lawyer) and the education and training necessary for these careers

A2.2 describe the contributions of scientists, including Canadians (e.g., Pierre Dansereau, Margaret Newton, Johan F. Dormaar, Sheila Watt-Cloutier, Severn Cullis-Suzuki), to the fields under study

B. SCIENTIFIC SOLUTIONS TO CONTEMPORARY ENVIRONMENTAL CHALLENGES

OVERALL EXPECTATIONS

By the end of this course, students will:

B1. analyse social and economic issues related to an environmental challenge, and how societal needs influence scientific endeavours related to the environment;

B2. investigate a range of perspectives that have contributed to scientific knowledge about the environment, and how scientific knowledge and procedures are applied to address contemporary environmental problems;

B3. demonstrate an understanding of major contemporary environmental challenges and how we acquire knowledge about them.

SPECIFIC EXPECTATIONS

B1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

B1.1 analyse, on the basis of research, social and economic issues related to a particular environmental challenge (e.g., overfishing, deforestation, acid rain, melting of the polar ice cap) and to efforts to address it [IP, PR, AI, C]

Sample issue: Greenhouse gas emissions from motor vehicles are a major contributor to global warming. The use of ethanol and other biofuels in motor vehicles reduces these emissions. However, diverting crops from food production to fuel production can increase prices and decrease the supply of food.

Sample questions: What are some of the social and economic challenges associated with cleaning up and conserving fresh water supplies? What are some alternative energy sources? What social and economic challenges are associated with their development? In what ways can consuming locally grown foods help the local economy, society, and the environment?

B1.2 analyse ways in which societal needs or demands have influenced scientific endeavours related to the environment (e.g., the development of drought- and pest-resistant crops to address the rising global need for food; research into alternative energy sources in response to demands to address the impact on climate change of burning fossil fuels) [AI, C]

Sample issue: Because of unstable oil prices and the environmental damage caused by motor vehicle emissions, many consumers have been demanding more environmentally friendly vehicles. As a result, car companies are devoting greater resources towards the development of more fuel-efficient engines, hybrid vehicles, and cars powered by electricity or other types of energy.

Sample questions: How and why do demands by environmentally conscious consumers affect the types of products developed by corporations? What impact have the energy needs of remote communities had on innovations in the development of off-grid energy sources? What types of products have been developed in response to the health threats resulting from ozone depletion?

B2. Developing Skills of Investigation and Communication

By the end of this course, students will:

B2.1 use appropriate terminology related to the application of scientific knowledge and procedures to environmental issues, including, but not limited to: *fact, inference, paradigm, objectivity,* and *causality* [C]

B2.2 plan and conduct a laboratory inquiry to test a scientific procedure used to address a contemporary environmental problem (e.g., an oil spill, acid precipitation) [IP, PR, AI]

B2.3 investigate, through research or using case studies or computer simulation, how scientific knowledge and procedures are applied to address a particular contemporary environmental issue (e.g., scientific data on the needs and habits of endangered species are used to develop plans to protect threatened species; life-cycle assessments are conducted to determine the total environmental impact of a consumer product) [PR, AI]

B2.4 use a research process to investigate how evidence, theories, and paradigms reflecting a range of perspectives have contributed to our scientific knowledge about the environment (e.g., with respect to debates about climate change; regarding the relationship between the cod moratorium and seal populations in Atlantic Canada), and communicate their findings [IP, PR, AI, C]

B2.5 use a research process to locate a media report on a contemporary environmental issue (e.g., climate change, melting of the polar ice cap, deforestation), summarize its arguments, and assess their validity from a scientific perspective [IP, PR, AI, C]

B3. Understanding Basic Concepts

By the end of this course, students will:

B3.1 identify some major contemporary environmental challenges (e.g., global warming, acid precipitation), and explain their causes (e.g., deforestation, carbon and sulfur emissions) and effects (e.g., desertification, the creation of environmental refugees, the destruction of aquatic and terrestrial habitats)

B3.2 describe how scientists use a variety of processes (e.g., environmental impact assessments, environmental scans) to solve problems and answer questions related to the environment

B3.3 explain how new evidence affects scientific knowledge about the environment and leads to modifications of theory and/or shifts in paradigms (e.g., the impact of evidence of the effects of carbon dioxide emissions on theories of global warming)

B3.4 explain how an environmental challenge has led to advances in science or technology (e.g., scrubbers on smokestacks to decrease sulfur dioxide emissions, hybrid cars)

B3.5 describe a variety of human activities that have led to environmental problems (e.g., burning fossil fuels for transportation or power generation; waste disposal) and/or contributed to their solution (e.g., the development of renewable sources of energy; programs to reduce, reuse, and recycle)

C. HUMAN HEALTH AND THE ENVIRONMENT

OVERALL EXPECTATIONS

By the end of this course, students will:

C1. analyse initiatives, both governmental and non-governmental, that are intended to reduce the impact of environmental factors on human health;

C2. investigate environmental factors that can affect human health, and analyse related data;

C3. demonstrate an understanding of various environmental factors that can affect human health, and explain how the impact of these factors can be reduced.

SPECIFIC EXPECTATIONS

C1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

C1.1 analyse grassroots initiatives that are intended to reduce the impact of environmental factors on human health (e.g., community cleanup of local aquatic or terrestrial environments; class action lawsuits against major polluters) [AI, C]

Sample issue: People from the Grassy Narrows Reserve in Northern Ontario were experiencing chronic health problems. They commissioned a study, which found that many animals and fish that were part of a traditional diet were contaminated with mercury and heavy metals. Guidelines were proposed to limit consumption of the affected animals, and thereby improve people's health.

Sample questions: Are there any grassroots groups in your community concerned with the state of the environment and its impact on human health? What types of actions do they take? What action has been taken by the Bulkley Valley and Lakes District Airshed Management Society to help reduce the impact of particulate matter in air on the health of local people? What is the Yellow Fish Road program, and how does it try to reduce the number of contaminants in local water sources?

C1.2 evaluate the effectiveness of government initiatives that are intended to reduce the impact of environmental factors on human health (e.g., Ontario Ministry of the Environment smog advisories; provincial laws regulating drinking water; WHMIS regulations on hazardous material) [AI, C]

Sample issue: To protect the health of people who live on the street, the City of Toronto issues heat and cold alerts, opening cooling centres or heated shelters where people can escape extreme weather conditions. However, not everyone is aware of these services, and there are not always enough spaces to meet needs.

Sample questions: Why does the Ontario Ministry of the Environment issue smog advisories? Why are there concerns about the water quality in many First Nations communities in Canada? Why did the water treatment plant in Kashechewan, in Northern Ontario, fail to protect the community from contaminated water?

C2. Developing Skills of Investigation and Communication

By the end of this course, students will:

C2.1 use appropriate terminology related to human health and the environment, including, but not limited to: *contaminants, heavy metals, air pollution,* and *pesticide* [C]

C2.2 analyse longitudinal data to determine the impact of various environmental factors that affect human health (e.g., air temperature, atmospheric greenhouse gases, contaminants in drinking water) [AI]

C2.3 investigate, through laboratory inquiry or field study, water samples from natural and disturbed environments (e.g., tap water; pond, river, or lake water from disturbed and undisturbed areas; water from an outdoor pool), and analyse the resulting data [PR, AI]

C2.4 analyse, on the basis of a laboratory inquiry, computer simulation, or field study, particulate matter in air (e.g., an air sample from an exhaust pipe or air vent, particles in a filter that cigarette smoke has passed through, particles caught on sticky paper set up in an open area) [PR, AI]

C2.5 investigate health standards for buildings and methods to retrofit or otherwise improve structures to reduce their negative impact on human health (e.g., the use of materials that do not contain volatile organic compounds, the use of biological air and water filters), and communicate their findings [PR, C]

C3. Understanding Basic Concepts

By the end of this course, students will:

C3.1 identify the main pollutants and environmental contaminants that can affect human health (e.g., air pollutants such as sulfur dioxide, nitrous oxide, and particulates; noise pollution; heavy metals such as lead and mercury; DDT; PCBs; mould; volatile organic compounds such as acetone and chlorinated solvents)

C3.2 describe the effects of a variety of environmental factors on human health (e.g., air pollutants are associated with disorders such as asthma; consumption of fish products from contaminated water may lead to increased levels of heavy metals in the human body; the thinning of the ozone layer may lead to increased incidence of skin cancer; noise pollution may impair hearing)

C3.3 describe ways in which a variety of environmental contaminants (e.g., volatile organic compounds in paints, carpets, and cleaning products; mercury in fish; E. coli in the water at public beaches) can enter the human body (e.g., inhalation, ingestion, absorption)

C3.4 describe measures that can reduce exposure to environmental contaminants (e.g., wearing protective clothing or sunscreen, or remaining indoors during peak UV hours, to prevent exposure to ultraviolet rays; avoiding the use of paints, solvents, and cleaning agents that contain volatile organic compounds)

C3.5 identify a variety of populations who are particularly vulnerable to the effects of environmental factors, and explain why these populations are vulnerable (e.g., seniors are vulnerable to extreme temperatures because the ability to regulate body temperature diminishes as people age; Inuit who follow a traditional diet are vulnerable to contaminants that accumulate in the fatty tissue of sea mammals because these animals are their main food source)

D. SUSTAINABLE AGRICULTURE AND FORESTRY

OVERALL EXPECTATIONS

By the end of this course, students will:

D1. evaluate the impact of agricultural and forestry practices on human health, the economy, and the environment;

D2. investigate conditions necessary for plant growth, including the soil components most suitable for various species, and various environmentally sustainable methods that can be used to promote growth;

D3. demonstrate an understanding of conditions required for plant growth and of a variety of environmentally sustainable practices that can be used to promote growth.

SPECIFIC EXPECTATIONS

D1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

D1.1 evaluate, on the basis of research, a variety of agricultural and forestry practices (e.g., companion planting, biological pest control, the use of genetically modified seed, forest fire control) with respect to their impact on the economy and the environment (e.g., the use of nematodes eliminates crop damage from grubs, thus contributing to better harvests, while reducing the use of toxic chemical pesticides; under some circumstances, forest thinning can help prevent or reduce the seriousness of forest fire, and its economic and environmental consequences) [IP, PR, AI, C]

Sample issue: The recycling of animal waste as fertilizer is economical and is generally considered an environmentally sustainable practice. However, care must be taken that the manure does not run off into water sources, as it can contaminate them with E. coli and other bacteria.

Sample questions: What are the economic and environmental pros and cons of growing crops that are genetically modified to be herbicide resistant? Why is organic produce more expensive than conventionally grown produce? What are the economic advantages of monoculture, both on farms and in forestry operations? How can monocultural practices lead to environmental degradation? What types of forestry practices can be implemented to maintain features of old-growth ecosystems while harvesting trees?

D1.2 evaluate, on the basis of research, the impact, including the long-term impact, of agricultural and forestry practices on human health (e.g., the use of chemical fertilizers and pesticides; the use of growth hormones and antibiotics in livestock; the use of feed containing animal by-products; the clear-cutting of forests) [IP, PR, AI, C]

Sample issue: The toxins in pesticides can accumulate in the human body over the years. Although the immediate effects of exposure to pesticide may be unnoticeable, the chemicals build up in body fat and organs and can lead to a variety of cancers.

Sample questions: What was the source of contamination of well water in Walkerton, Ontario, in 2000? What are the immediate and long-term health effects of exposure to E. coli? What is known about the long-term effects of consuming genetically modified food? What impact could the spraying of forest canopies to prevent gypsy moth infestations have on human health?

D2. Developing Skills of Investigation and Communication

By the end of this course, students will:

D2.1 use appropriate terminology related to sustainable agriculture and forestry, including, but not limited to: *bioremediation, crop rotation, companion planting, organic product, humus, compost, mulch, silviculture,* and *naturalization* [C]

D2.2 test samples of a variety of types of soil (e.g., clay, loam, commercial potting soil) to determine their nutrients and composition (e.g., pH; the percentage of nitrogen, phosphorus, and potassium; porosity; moisture) [PR, AI]

D2.3 use an inquiry process to investigate the nutrients in and composition of a variety of compost samples (e.g., nutrients such as nitrogen, phosphorous, potassium; composition with respect to pH, porosity), and analyse the findings to determine appropriate uses for each sample [IP, PR, AI]

D2.4 prepare a soil mixture (e.g., using compost, manure, vermiculite, black earth, top soil, peat moss, loam, and/or sand) for a selected plant species, based on analysis of the criteria for optimal growth for that species (e.g., cactus, tomato plants, wheat, jack pine) [PR, AI]

D2.5 use a research process to investigate environmentally sustainable methods of managing and maintaining healthy and productive agricultural zones and forests (e.g., companion planting, crop rotation, selective tree-harvesting, planting a diverse canopy) [IP, PR]

D2.6 design a landscaping project for their local area (e.g., a rooftop garden, a plot in a community garden, a riparian restoration), taking into account local conditions (e.g., zone hardiness, soil composition, amount of sunlight and rainfall), and propose a course of action to ensure the sustainability of the project and its healthy interaction with the surrounding environment (e.g., companion gardening, the use of compost to fertilize the soil, the use of native plants, the inclusion of plants that attract birds or butterflies) [IP, PR, AI]

D3. Understanding Basic Concepts

By the end of this course, students will:

D3.1 explain the basic principles of various agricultural and forestry practices (e.g., Integrated Pest Management), and identify regulations and regulatory bodies associated with these practices (e.g., Health Canada's Pest Management Regulatory Agency [PMRA], the Pest Control Products Act)

D3.2 describe the basic requirements for plant growth (e.g., growing medium, light, moisture, nutrients)

D3.3 describe the soil components (e.g., pH, moisture, the percentage of humus, porosity with respect to water and air) needed by a variety of plants for optimal growth

D3.4 explain different ecologically sound practices for improving and maintaining soil structure and fertility (e.g., crop rotation, fallowing, adding compost or manure, inter-seeding grains and legumes, mulching, tree harvesting using a shelterwood system)

D3.5 explain agricultural techniques and forestry practices that aim to maintain both biodiversity and long-term productivity (e.g., growing a variety of species, inter-planting crops, planting native and heritage varietals instead of hybrids or transgenic species, saving seeds, maintaining some older trees and snags for animal habitat)

D3.6 describe sustainable water-management practices in agricultural and forestry settings (e.g., regulating the frequency of watering, planting species suited to local precipitation levels, limiting run-off and erosion)

E. REDUCING AND MANAGING WASTE

OVERALL EXPECTATIONS

By the end of this course, students will:

E1. analyse economic, political, and environmental considerations affecting waste management strategies;

E2. investigate the effectiveness of various waste management practices;

E3. demonstrate an understanding of the nature and types of waste and strategies for its management.

SPECIFIC EXPECTATIONS

E1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

E1.1 analyse, on the basis of research, the impact of economic and political considerations on the development of waste management practices or strategies (e.g., incineration of hazardous waste; biological filtration and reuse of greywater; user fees for garbage disposal; vermicomposting) [IP, PR, AI, C]

Sample issue: The use of landfill sites has been a long-time strategy for disposal of garbage. As local sites fill up, some municipalities are shipping their garbage to distant sites. This strategy is often politically unpopular and, with high fuel prices, is increasingly expensive, so local politicians are under pressure to implement new strategies.

Sample questions: What are the costs of recycling compared to the costs of using landfill sites or incinerating garbage? Why is garbage incineration a controversial political issue? Why do municipal recycling programs recycle only a limited number of items?

E1.2 evaluate the short- and long-term impact on the environment of a specific type of waste (e.g., waste products from animal farming; plastic shopping bags; tailings from mines) [AI, C]

Sample issue: Non-rechargeable batteries can be convenient, but their disposal presents problems. Batteries contain heavy metals and corrosive substances that can contaminate landfill sites and leach into surrounding soil or water. Ontario municipalities designate batteries as hazardous waste, yet some people continue to throw them in the garbage.

Sample questions: What impact do disposable diapers have on the environment? What effects does the dumping of solid waste into lakes, rivers, or oceans have on aquatic life? How long does it take polystyrene, widely used to make food and drink containers, to break down? What environmental challenges are associated with nuclear waste?

E2. Developing Skills of Investigation and Communication

By the end of this course, students will:

E2.1 use appropriate terminology related to waste management, including, but not limited to: *solid, liquid, and gaseous waste; toxic waste; heavy metal; chlorinated hydrocarbons;* and *polychlorinated biphenyls (PCBs)* [C]

E2.2 plan and conduct an inquiry in a micro-environment to treat a solid, liquid, or gaseous waste (e.g., reduce the acidity in a closed bog system in an aquarium; use a vermicomposter to recycle solid organic matter) [IP, PR]

E2.3 use a research process to investigate the waste generated throughout the life cycle of a product (e.g., the waste associated with all the materials and energy that go into the development and disposal of a computer or a running shoe) [IP, PR]

E2.4 plan and conduct a waste audit within their school, and propose a plan of action for waste reduction based on their findings (e.g., review the school's policy regarding paper and plastic recycling, monitor actual practices, and propose strategies to improve them) [IP, PR, AI, C]

E2.5 investigate a local, regional, national, or global waste management practice (e.g., local practices such as recycling or charging for residential and/or commercial garbage bags; shipping garbage to landfill sites in another region; disposal of nuclear waste; dumping raw sewage into rivers, lakes, oceans), and communicate their findings [PR, C]

E3. Understanding Basic Concepts

By the end of this course, students will:

E3.1 describe different categories of waste (e.g., biodegradable, recyclable, toxic, organic, inorganic)

E3.2 explain some current waste remediation practices used with substances or products that are not environmentally friendly (e.g., "Toxic Taxi" for pick-up of household hazardous waste; the recycling of plastic to make furniture and "lumber")

E3.3 describe the scientific principles involved in processing solid, liquid, and gaseous waste (e.g., combustion, decomposition, pyrolysis)

E3.4 explain common strategies and technologies used in the collection and storage of waste (e.g., strategies such as recycling, composting, dumping in landfill sites; technologies such as compacters, enzyme digesters, flocculation tanks)

E3.5 explain how scientific knowledge and technological processes have been applied in the development of environmentally sound waste management strategies (e.g., accelerated waste aeration, bioremediation)

F. CONSERVATION OF ENERGY

OVERALL EXPECTATIONS

By the end of this course, students will:

F1. assess the impact on society and the environment of the use of various renewable and non-renewable energy sources, and propose a plan to reduce energy consumption;

F2. investigate various methods of conserving energy and improving energy efficiency;

F3. demonstrate an understanding of energy production, consumption, and conservation with respect to a variety of renewable and non-renewable sources.

SPECIFIC EXPECTATIONS

F1. Relating Science to Technology, Society, and the Environment

By the end of this course, students will:

F1.1 evaluate the impact on the environment of renewable and non-renewable energy sources, and propose an environmentally friendly solution to reduce non-renewable energy consumption (e.g., a plan for broader use of hybrid cars or solar panels) [AI, C]

Sample issue: In some remote areas that are off the electrical grid, generators that run on fossil fuels are used to generate electricity. However, these devices are inefficient, and they produce carbon dioxide, which contributes to global warming, and noise pollution.

Sample questions: What impact can hydroelectric dams and generating stations have on the local environment? What effects do coal mining and the use of coal-burning power plants have on the local, regional, and global environment? How can the use of ethanol reduce the amount of petroleum needed to run cars?

F1.2 assess the costs and benefits to society of the use of renewable and non-renewable energy sources, using a variety of criteria (e.g., associated health concerns, reliability, ability to meet demand, start-up and production costs) [AI, C]

Sample issue: The extraction, processing, and burning of fossil fuels damage the environment. However, some fossil fuels, such as coal, are plentiful and therefore a reliable source of energy. Some alternative energy sources, such as wind and solar power, are less reliable, and their unit costs are much higher.

Sample questions: How do the costs of coal and geothermal power compare? Do these costs change when environmental costs and benefits of the two sources are factored in? What are the health concerns associated with nuclear power? Why are wind and solar power less reliable than fossil fuel sources? How could that change?

F2. Developing Skills of Investigation and Communication

By the end of this course, students will:

F2.1 use appropriate terminology related to energy conservation, including, but not limited to: *renewable resource, non-renewable resource,* and *R-value*

F2.2 investigate energy consumption and costs in their household over a given period of time, and suggest ways in which their household could conserve energy [PR, AI, C]

F2.3 plan and conduct an energy audit of a home or business, and propose ways to improve its energy efficiency [IP, PR, AI, C]

F2.4 design and construct a working model of a device that uses an alternative energy source (e.g., a wind generator, a solar-powered car, a "fan boat") [IP, PR]

F2.5 plan and conduct an inquiry to evaluate the effectiveness of various insulation materials and/or techniques (e.g., straw, foam, fibreglass, blown cellulose) [IP, PR, AI]

F3. Understanding Basic Concepts

By the end of this course, students will:

F3.1 explain the historical significance of a variety of energy sources (e.g., whale oil, coal), and describe their long-term impact on the environment

F3.2 describe the characteristics of a sustainable energy system (e.g., equitable access to the source, long-term availability, limited environmental impact)

F3.3 explain the basic principles and characteristics of various types of renewable (e.g., tidal, geothermal, solar, wind) and non-renewable (e.g., coal, oil, gas) energy production and their impact on the environment

F3.4 describe methods of energy production and conservation intended to reduce greenhouse gas emissions (e.g., energy production methods at the Prince Edward Island Wind-Hydrogen Village; charging higher prices for energy used during peak hours)

F3.5 describe technological advances aimed at reducing energy consumption (e.g., programmable thermostats, improved R-value in insulation, compact fluorescent light bulbs, rechargeable batteries, "smart meters")

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