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