Public District School Board Writing Partnership

Course Profile

Biology

Grade 11
University Preparation
SBI3U

- *for teachers by teachers*

This sample course of study was prepared for teachers to use in meeting local classroom needs, as appropriate. This is not a mandated approach to the teaching of the course. It may be used in its entirety, in part, or adapted.

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Course Overview
Biology, Grade 11, University Preparation, SBI3U

Course Description

This course furthers students' understanding of the processes involved in biological systems. Students study the diversity of living things, cellular functions, the anatomy, growth, and functions of plants, internal systems and regulation, and genetic continuity. Throughout, the course provides cumulative evidence that all life forms, however diverse, are united by a common set of characteristics. The course focuses on the theoretical aspects of the topics under study, and helps students refine skills related to scientific investigation.

This Profile offers one set of suggestions for achieving the Learning Expectations of the SBI3U Curriculum document. Teachers must adapt the Profile to suit their circumstances and to match the students' needs while ensuring that all Learning Expectations of the Guideline are addressed fully.

Course Notes

The Goals of Grade 11 Biology

As in the Grade 1 to 8 Science and Technology curriculum and the Grade 9 and 10 Science courses, SBI3U is directed toward three goals:

- To relate science to technology, society, and the environment;
- To develop skills, strategies, and habits of mind required for scientific inquiry;
- To understand basic concepts of science.

The activities and assessment tasks in this profile reflect the *importance* of the three goals and have been developed around clusters of Specific Expectations that encompass all three goals.

Scientific Literacy for All Students and Preparation for Further Study

The paramount task of science education is to equip all students with scientific literacy – the combination of values, knowledge, and skills that enable them to think creatively, reason logically, evaluate information critically, and communicate effectively. This is an essential base for making productive and ethical decisions, not only about scientific and technological issues but in all areas of life.

This is emphasized in *The Ontario Curriculum, Grades 11 and 12: Science, 2000*: "The newer aspects of the science curriculum – especially those that focus on science, technology, society, and the environment (STSE) – call for students to deal with the impacts of science on society and the environment, which includes both the natural environment and the workplace environment. This requirement brings in issues that relate to human values. Science can therefore not be viewed as merely a matter of "facts"; rather, it is a subject in which students learn to weigh the complex combinations of fact and value that developments in science and technology have given rise to in modern society."

At the same time, SBI3U must adequately prepare those students who will opt for further study of the subject in SBI4U and beyond high school. Knowledge and skills must be learned and assessed at a standard that enables students to realistically assess their aptitude and chances for success in further studies in biology and possible employment in a related field.

Policy Requirements

The curriculum document contains recommendations regarding teaching approaches and curriculum expectations that must be reflected in all courses based on it. Among these are the following statements (pp. 8-10):

- "The expectations in science courses call for an active, experimental approach to learning, and require all students to participate regularly in laboratory activities."
- "Where opportunity allows, students might be required, as part of their laboratory activities, to design and conduct research on a real scientific problem for which the results are unknown."
- "Where possible, concepts should be introduced in the context of real-world problems and issues."
- "In all courses, a list of expectations is given that precedes the strands. These expectations describe skills that are considered to be essential for scientific investigation e.g., skills in research, in the use of materials, and in the use of units of measurement, and skills required for investigating possible careers in the subject area. These skills apply to all areas of course content and must be developed in all strands of the course. Assessment of students' mastery of these skills must be included in the evaluation of students' achievement of the expectations for the course." In this profile, these expectations will be called Science Investigative Skills. For SBI3U, they are found on p. 12 of the curriculum document. These skills serve as a lens through which all Learning Expectations in the profile are interpreted. In addressing the Learning Expectations, the Science Investigative Skills must also be addressed.

Considerations for Planning and Implementing Grade 11 Biology

- SBI3U requires an emphasis on inquiry skills. Through a variety of investigations, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. Direct experience with organisms, materials, and laboratory equipment is necessary to illuminate theoretical concepts and develop skills.
- Learning activities in this profile are set in a context that relates science to technology, society, and the environment.
- A number of activities in this profile have a research focus that requires accessing information beyond the laboratory or field trip. Students should be taught how to use all available sources of information – people, print, online sources and other media, both within the school and in the community. They should also be given opportunities to use those skills, and to experience the challenges that invariably accompany the location and acquisition of valid information. However, care must be taken that *student time is spent primarily on processing information rather than accessing information*, so that the research does not become an end in itself.
- The Expectations are central to all aspects of this profile. The context in which each unit is delivered, the skills and concepts developed, and the assessment tasks used must be interconnected, and linked to the Expectations. The assessment data accumulated throughout the course must be sufficient (in kind and number) to permit teachers to evaluate the *consistent level of performance* for each student in each of the four categories in the Achievement Chart for Science (pp. 174-175)
- Some of the expectations are given special emphasis in learning activities and are often revisited. These are expectations that are taught, assessed, evaluated and where necessary revisited using alternate instructional strategies in a cyclic process that stops only when students have *achieved* them.

- *Each student interprets new information in terms of what he or she already knows*. The student tries to make sense of what is taught by trying to fit it with his or her experience. A key concept is understood when the student examines significant examples that represent the concept, then creates a generalization from those personal experiences. Teachers must be aware of the experiences that students have had prior to Grade 11 and use them as the base for new and more complex concepts. Students may also arrive with misconceptions from prior experience that will interfere with their ability to understand new concepts. Identifying misconceptions and revising them using concrete examples may be required at times.
- *Terminology should be viewed by students as tool for describing observations and communicating ideas, not as an end in itself*. Assessment should focus on the application of terminology to explain concepts and phenomena, not on terms and definitions in isolation. It is essential that students understand the concept before acquiring the vocabulary.
- This profile describes a biology course in which students are encouraged to ask their own questions and, in many cases, find their own answers by inquiry (experiment or research). Fundamental to the skill set of a scientifically literate person/citizen is the ability to ask incisive questions and to interpret the answers critically, including identifying un-stated assumptions.

Rationale for the Unit Sequence of the Course Profile

In this Profile, each Unit is clustered around expectations drawn mainly (but not exclusively) from one strand. This is done to facilitate the implementation of this course. The opening unit, Diversity, introduces concepts and terms that recur throughout the course. The second unit, Cellular Basis of Life, provides a foundation for the study of Plants, Animal Systems and Genetics in the units that follow and so should precede them. Placement of the Genetics unit at the end of the course provides opportunities to reinforce the concept that all organisms share common characteristics that arise from fundamental molecular and cellular similarities.

Units: Titles and Times

Unit 1	Diversity of Living Things	7 hours
Unit 2	Cellular Basis of Life	22 hours
Unit 3	Plants: Anatomy, Growth and Functions	21 hours
Unit4	Internal Systems and Regulation	23.5 hours
* Unit 5	Genetic Continuity	26.5 hours
	Final Assessment	10 hours

* This unit is fully developed in this Course Profile.

Unit Overviews

Key to Abbreviations used in Unit Overview Charts

AC = Achievement Chart	**LS = Learning Skills**
K = Knowledge/Understanding	WI = Works Independently
I = Inquiry	WH = Work Habits/Homework
C = Communication	I = Initiative
MC = Making Connections	O = Organization
	TW = Team Work

Unit 1: Diversity of Living Things

Time: 7 hours

Unit Description

This unit, Diversity of Living Things, provides the introduction to SBI3U. Students focus on the necessity of classification but also consider the arbitrary nature of any classification system. The initial activities introduce the use of different criteria for classification, review prior knowledge of characteristics of life, examine the diversity of living organisms, and provide an opportunity to develop research skills. Biological keys are used to identify specimens. Students research and present information on a member of a kingdom not scheduled for detailed study later in the course. The unit ends with a discussion of diversity, which will continue to thread through the remaining units of the course. Expectations not included in this unit appear in later units, particularly in Unit 5, Genetic Continuity.

Unit Overview Chart

Activity	Time	Expectations	Assessment	
			AC	LS
1.1 The Arbitrary Nature of Classification Systems	2 hours	DLV.01, DL1.01	K	TW, WH, O
1.2 The Five Kingdoms or Is It?	1 hour (plus research time in Library/Resource Centre)	DLV.01, DLV.02, DLV.03, DL1.02, DL1.03, DL1.04, DL2.02, DL3.01	K, I, MC, C	WI, I, O, WH
1.3 Using A Biological Key	2 hours	DLV.02, PAV.01, DL2.01, DL2.03, PA1.04	K, I, MC	WI, I, WH, TW
1.4 The Importance Of Diversity	2 hours	DLV.01, DLV.03, DL1.05, DL3.02	K, MC, C	I, WH, WI

Details of Activities

Act. 1.1.1 Classifying Activity: Each group is given a collection of 15 to 20 items (some share same material, or colour, or function) and asked to organize the items into groups. Students are asked to explain their classification scheme to the rest of the class using a simple dichotomous key and to classify a 'new' item into their groupings. Students reflect on which one of the classification systems presented was better and why.

Act. 1.1.2 What is Life? Students use textbook/Internet resources to review characteristics of life, and the terminology of classification from the Grade 6 course. Alternately, students may participate in a teacher-led discussion.

Act. 1.1.3 Classifying Real Examples: Students attempt to classify different organisms into groups using a set of pictures of animals/plants/fungi that have been downloaded from the Internet or taken from other sources. Again students should see that there are a number of ways to classify.

Assessment: During these activities, student learning skills are assessed.

Act. 1.2.1 Five Kingdoms: Building on Activity 1.1.2, the teacher describes the five Kingdom System with the subdividing of Monera, and the alternative two Super Kingdom System. The position of viruses and prions is also discussed. Students follow-up by using textbook/Internet resources to research characteristics of each kingdom, with particular focus on eubacteria, archeabacteria, fungi, protists and viruses since these are not studied in detail in the subsequent units of this course. Students should focus on modern basis of classification. They reclassify the organisms from Activity 1.1.3 using modern systems of classification. A quiz may be used to evaluate Knowledge Expectations covered up to this point in the course.

Act. 1.2.2 Studying a Member of a Kingdom: Students are introduced to the culminating project for this unit in which each student researches a different example of eubacteria, archeabacteria, fungus, bacteria, or virus, considering the following: digestion, circulation, gas exchange, reproduction and life cycles, habitat, and relationships with humans. This is presented in a visual format such as a poster, pamphlet, or website, and is due at the end of the unit. Information is shared with the entire class.

Assessment: A presentation rubric is used to evaluate inquiry and communication. A class quiz is used to assess knowledge acquired from the presentations.

Act. 1.3.1 Introducing the Biological Key: The teacher demonstrates how to use a key for different plants, focussing on monocot and dicot characteristics.

Act. 1.3.2 Putting Into Practice: Students collect specimens such as deciduous tree leaves, coniferous needles, weeds, aquatic flora and fauna. These may be supplemented by specimens provided by the teacher. Working in pairs using user-friendly, pictorial keys, students determine the identities of the specimens.

Assessment: Students are evaluated on their accuracy in using keys. Students can also be assessed/evaluated on their understanding of the use of biological keys by having them design a key for a given group of closely related living things.

Act. 1.4.1 What is Diversity?: Through a class discussion, students review ecological concepts from Grade 10 Science - ecosystems, food chains and webs, monocultures, niche, habitat, etc. and through class discussions link these to the importance of habitat diversity, diversity within a species and the diversity of species within an ecosystem. Sources of genetic variability are briefly noted for later discussion in Unit 5.

Act. 1.4.2 Show and Share: Students display their projects from Activity 1.2.2 for class review. The intent of these displays is to have students appreciate the diversity of organisms by considering examples drawn from several Kingdoms.

Act. 1.4.3 Written Feedback: Students write a journal entry or reflection piece on the importance of diversity within populations and in the environment. This could include a comparison of the diversity uncovered in their research with the relative lack of diversity in the habitats in which they live and work which have been subject to human interference.

Assessment: The journal entry can be evaluated for communication skills as well as making connections using a rubric.

Unit 2: The Cellular Basis of Life

Time: 22 hours

Unit Description

This study of cells, the basic units of life, begins by considering the chemical and structural similarities of all cells. Some of the means by which cells are studied are considered. This leads to a detailed examination of the structure and functions of membranes in the cell; the energy transformations performed by cells; the adaptations of organelles and their interactions as a system. Applications of cell biology in other fields are considered here and throughout the remaining units of this course.

Unit Overview Chart

Activity	Time	Expectations	Assessment AC	Assessment LS
2.1 In what ways are cells the basic units of life?	1 hour	CFV.01	K	
2.2 Cells come in many forms, but all are made of the same basic materials.	4 hours	CFV.01, DLV.01, CF1.02, CF2.02, CF2.03, DL1.02	K, I	T, O
2.3 How do we know about cells?	3 hours	CFV.01, CFV.03, CF2.04	K, I	T, WH
2.4 The cell membrane must select which materials enter and leave the cell.	3.5 hours	CFV.01, CFV.02, CF1.01, CF1.03, CF1.06, CF2.01	K, I, C	WH, O, TW, I
2.5 How do cells obtain energy to fuel the work of living (synthesis of molecules, growth, movement, secretion, reproduction, etc.)?	4 hours	CFV.01, CFV.02, CF1.01, CF1.02, CF1.04, CF1.05, CF2.01	K, I, C	TW, O, WH, I
2.6 Cells operate as systems.	3.5 hours	CFV.01, CF1.01, CF1.06	K, I, C	WI, TW, O, WH, I
2.7 Applying our knowledge of cells and cell systems.	3 hours (plus out of class time)	CFV.03, CFV.01, CFV.02, CF3.01, CF3.02, CF3.03	K, I, MC, C	

Details of Activities

Act. 2.1.1 What is Life? Brief review of Activity 1.1

Act. 2.1.2 Are cells the basic units of life? Teacher-led discussion with examples to establish that:

- cells are the simplest organizations demonstrating all life characteristics (cf. viruses);
- organisms consist of one or more cells and the products of cells; in most multicellular organisms, cells form tissues and organs;
- organisms' functions are performed by cells or result from the actions of cells;
- death and disease result from malfunctions of cells or disruptions of cells by other agents.

Assess students' explanations of how knowledge of cells enables us to understand the nature of life, investigate and control disease, and alter organisms.

Act. 2.2.1 Prokaryotes and Eukaryotes – Students renew their microscope skills and examine prepared slides (and photographs) to compare prokaryotic cells and eukaryotic (plant and animal) cells and tissues. Teacher-led discussion to establish similarities and differences in structure.

Act. 2.2.2 Molecular Composition of Cells – Reading, computer manipulation of 3-D models, lab work and discussion to establish the molecular structure, some properties, occurrence and functions in cells of:

- water, a polar solvent
- carbohydrates (sugars, starches, cellulose)
- lipids, phospholipids
- proteins
- nucleic acids
- dissolved minerals, nutrients, metabolites and wastes.

Assess demonstrated lab techniques; students' explanation of the fundamental similarities of all life forms and the significance of those similarities.

The structure and functions of cells have been discovered in stages as the technologies for studying them have developed.

Act. 2.3.1 Preparation and Staining of Specimens – Students examine prepared slides and make wet mounts of selected cell types with a variety of stains to observe that each stain has different affinities for different materials in cells and reveal different details; that what we know about cell structures is a composite of observations made under varied conditions.

Act. 2.3.2 Microscopes – Brief comparison of light and electron microscopes and resulting images to establish relative advantages/disadvantages of each.
Possible Field Trip: Visit to an electron microscope lab to observe preparation and viewing of specimens. Alternative to Field Trip: Research the history of the microscope; investigate the advantages and disadvantages of different types of microscopes.

Act. 2.3.3 Chemical Analysis – Brief mention of fragmentation, chemical analyses, radioactive tracers, etc. for later reference.

Assess students' explanation with cellular examples of how scientific knowledge develops as tools and techniques develop.

Act. 2.4.1 Fluid Mosaic Model of Cell Membranes – By analysing electron micrographs, observing computer graphics, reading and teacher-led discussion, students will know:

- the molecular components and their fluid arrangement in biological membranes and the chemical properties responsible for that arrangement;
- membrane properties and functions are related to the molecular structure of membranes;
- that variations of this basic structure are found in the membranes of most cells and membranous organelles.

Act. 2.4.2 Passive Transport – Diffusion: cite examples, relate process to particle theory of matter and membrane structure. What is facilitated diffusion? Osmosis: special case of diffusion of water across membranes; implications for cells and organisms.
Laboratory Inquiry: Students set up and observe various demonstrations of diffusion and osmosis using artificial membranes or living cells; students then devise and carry out experiments to investigate factors that may affect the rate of diffusion (such as temperature, particle size, concentration gradients, etc.)

Act. 2.4.3 Active Transport – Which materials are actively transported across cell membranes against concentration gradients? Which cellular and body functions depend on this? How does active transport occur (possible mechanisms and evidence for them; relate to membrane structure)?

Act. 2.4.4 How do cells take in and get rid of molecules and particles that are too big to pass through membranes?

- endocytosis/excocytosis: examples (amoebas, WBCs, digestive endothelium); stages in process (videos, computer graphics);
- secretion: note examples to establish a definition of secretion.

Assess design and execution of experiment; explanation with examples of why cells must mediate intakes/outputs and some of the ways this is accomplished.

Act. 2.5.1 Photosynthesis: How is light energy captured and converted to chemical energy for immediate use or storage for later use?
Laboratory Inquiry: What are the optimal conditions for photosynthesis to occur? Working in groups, students devise experiments to investigate the effect on photosynthesis of different variables. Results are pooled and analysed.
How are chloroplasts adapted to make photosynthesis possible?

Act. 2.5.2 Respiration and Fermentation: Under aerobic conditions, how are molecules (usually glucose) broken down to release energy that can be used by the cell to perform work? How are mitochondria adapted to make this possible?
Under anaerobic conditions, how do muscle cells and yeast continue to release energy from glucose? What are the advantages/disadvantages of these processes compared to aerobic respiration?
Laboratory Inquiry: What are the optimal conditions for fermentation to occur? Working in groups, students devise experiments to measure the rate of fermentation relative to a chosen variable. Results are pooled and analysed.

Assess design and execution of experiment; students' explanations with examples of how cells obtain energy and how this process is essential to life.

Cells have components (organelles) that are adapted for specific functions; the components require each other to function; the components accomplish things by working together that they could not accomplish in isolation.

Act. 2.6.1 The concept of a system can be developed through a brief discussion of familiar examples: a sound system made up of separate components, an assembly line, a football team, etc.

Act. 2.6.2 Working as individuals or small groups, students investigate in detail the structure and functions of a selected organelle. They then identify all the ways that an organelle is dependent on other components in the cell and ways that it supports other cell parts in their functions. Findings are presented by jigsaw or large-group presentations.

Assess demonstration of inquiry skills (information gathering, analysis and organization); students' explanations with examples of structural-functional relationships in cells and how cells operate as systems.

As knowledge of cell structure and function increases, it is used to understand organisms, investigate problems, create solutions and develop new technologies. Ethical, social, economic, and environmental issues often result.

Act. 2.7.1 Inquiry: Students research a topic and prepare a presentation. For example:

- Understanding disease: Students explain how knowledge of cells is used to explain the causes/symptoms of a selected disease, diagnose and/or treat that disease.
- Tissue culture: For a chosen example of tissue culture (medical, agricultural, basic research), students explain the purpose served and use their knowledge of cell biology to explain how it is accomplished.
- Technologies used in recent and current investigations of cells.
- Use of microbes (in Industry, Waste Management), etc.

In each case, the societal implications of the research or application are discussed.

Assessment: Use a rubric to assess the presentations (See Teacher Support Materials, Grade 9 Academic Public Science Profile, pp. x-xviii for examples). A class test is used to assess the content of all presentations.

Unit 3: Plants: Anatomy, Growth and Function

Time: 21 hours

Unit Description

In this unit, students examine the role that plants play in society and the environment. The plant is examined as a system designed specifically for energy capture. Through laboratory and microscopic investigation, students determine the requirements for plant growth and examine how the structure of leaves, stems and roots are adapted to maximize energy capture. Students propose plant science research projects to solve a given problem and make and support individual decisions about which solution is best through a cost/benefit analysis.

Unit Overview Chart

Activity	Time	Expectations	Assessment AC	Assessment LS
3.1 What role do plants play?	2 hours	PAV.01, PAV.02, PA1.01, PA1.06, PA1.07, PA2.04, DL3.02	K, C	O, WI
3.2 What does a plant require for growth?	5 hours	PAV.01, PAV.02, PA1.05, PA2.01, PA2.02	I, C	O, TW, WH
3.3 How does a plant acquire the materials it requires?	9 hours	PAV.01, PAV.02, PA1.01, PA1.02, PA1.03, PA2.03	K, I, C	TW, O, WH
3.4 Which plant research project should be funded?	5 hours	PAV.03, PA3.01, PA3.02, PA3.03, PA3.04	MC, C	O, WH, WI

Details of Activities

Act. 3.1.1 What are the functions of plants? Students brainstorm to create a list of the roles plants play in natural systems (energy capture, habitat structure, food, nutrient mobilization, atmospheric composition, etc.), which of these functions humans depend on and the additional ways that humans make use of plants (commercial products, food supply, medications, etc.). Students complete additional research to add to these lists. Individual students prepare a mind map beginning with a specific plant or group of plants showing all of the uses of this plant, which they post in the classroom.

Act. 3.1.2 Why is diversity important? Students participate in a teacher-led discussion about the need for diversity to support all of these uses and the consequences if diversity is reduced or eliminated.

Assess mind-map.

Act. 3.2.1 Using the chloroplast and photosynthesis (from the cell unit) as a starting point, students brainstorm a list of the requirements for plant growth. A discussion of how habitats vary in the provision of these requirements will prepare students for the discussion of succession in 3.3.2.

Act. 3.2.2 Students design and perform a lab on the effects of plant growth regulators.

Act. 3.2.3 Students begin a lab in which each group chooses a different factor to investigate (e.g., light, fertilizer, temperature). This lab will require regularly scheduled time for making observations and recording data. As the final task, students will write a lab report about their group's investigation.

Act. 3.2.4 Homework Question: Using examples, explain why different formulations of commercial fertilizers are used (for example, on immature and mature plants, on flowering and non-flowering plants, on lawns at different seasons).

Assess lab design and lab report.

Act. 3.3.1 Students examine and draw from microscopic slides of various types of leaves from both vascular and non-vascular plants, then explain how the structure of the leaf is adapted to make chloroplasts (and the cells in which they function) as productive as possible.

Act. 3.3.2 Students examine and draw microscopic slides of various types of stems (both monocot and dicot) in order to identify how the structure of the stem is adapted for its functions (supporting the leaf and vascular transport). They participate in a teacher-led discussion about why vascular plants predominate on the planet, and why, through the process of succession, one type of plant replaces another.

Act. 3.3.3 Students examine and draw from microscopic slides of various types of roots (both monocot and dicot) in order to identify how the structure of the root is adapted for its functions (supporting the plant, absorption of water, storage of excess nutrients).

Act. 3.3.4 Students explain, with the aid of a diagram or model, how the entire plant (leaves, stems, roots) works as a system to deliver the required nutrients and store the products of photosynthesis.

Assess microscopic technique and knowledge of how the entire plant works as a system.

Act. 3.4.1 Students work in groups to prepare presentations designed to answer a given problem. For example: Given *x* dollars to spend, propose a plant related project designed to improve the quality of life in a specified location (such as naturalizing the school grounds, building a roof top garden to manage rain runoff and improve heating/cooling, creating a community vegetable garden, etc.). The presentation must include an explanation of how their plan works, why it benefits society, safety considerations, costs, "tradeoffs", and the impact on everyday life and the environment.

Act. 3.4.2 The students participate in a teacher-led discussion about the criteria with which to judge each proposal. Each group presents its proposal to the class.

Act. 3.4.3 Individual students choose one project to support and justify their decision based on the criteria determined during Activity 3.4.2.

Assess presentation and written decision for communication and critical thinking.

Unit 4: Internal Systems and Regulation

Time: 23.5 hours

Unit Description

This unit focuses on the major processes, mechanisms, and systems, including the respiratory system, circulatory system, and digestive system, by which animals maintain their internal environment. The idea that all living things have the same basic requirements for survival is emphasized in a comparative approach to systems. The approach involves revisiting the concept of diversity from Unit 1 and reviewing the plant structures and functions from the previous unit to show clearly how all living things function to solve the same problems. The use of technology, including dissection techniques, for research, diagnosis and treatment of the internal systems will be emphasized throughout the unit. A unit project will focus on lifestyle choices and health impact. Students will collect blood pressure and pulse data on a regular basis over the course of the unit to observe the changes that occur when different factors are manipulated, for example the decreased intake of caffeine or nicotine. This inquiry will be extended to include an analysis of the effects of other lifestyle choices not manipulated in the activity such as special diets and drug use.

Unit Overview Chart

Activity	Time	Expectations	Assessment	
			AC	LS
4.1 Introduction-Your Health	6 hours	ISV.02, ISV.03, IS1.04, IS1.05, IS2.02, IS2.03, IS3.01, IS3.02	K, I, MC, C	TW, O
4.2 Digestive System	4.5 hours	ISV.01, ISV.02, IS1.03, IS2.01, IS3.01, IS3.03, CF1.04, CF1.05, DLV.01, DLV.02, DL1.03, DL2.02	K, I, MC	WH, TW, WI, O, I
4.3 Respiratory System/Gas Exchange	4 hours	ISV.01, ISV.02, ISV.03, IS1.01, IS1.04, IS2.01, IS2.02, IS3.01, IS3.03, DLV.01, DLV.02, DL1.03, DL2.02	K, I, MC, C	TW, WI, WH, O, I
4.4 Circulatory System/Transport System	4 hours	ISV.01, ISV.02, IS1.02, IS2.01, IS2.03, IS3.01, IS3.03, PAV.01, PA1.02, DLV.01, DLV.02, DL1.03, DL2.02	K, I, MC, C	TW, WI, WH, I, O
4.5 End-of-Unit Task	5 hours	ISV.03, IS1.04, IS1.05, IS2.01, IS2.03, IS3.04	K, I, MC, C	TW, WI, O, I, WH

Details of Activities

Act. 4.1.1 Brainstorm*: What do living things need to survive*? Focus the discussion on basic materials (nutrients, gases) needed to live – refer back to last unit and tie plant and animals together in terms of requirements. Use examples to illustrate the widely varied adaptations, from simple to complex, by which organisms obtain the necessities for life (autotrophs, heterotrophs, single-cell animals, multi-cellular organisms) Discuss internal environments in multicellular organisms and the need for regulation and feedback.

Act. 4.1.2 Activity: "Measuring health." Initiate a discussion around a scenario such as a person is found unconscious - what tests are performed to diagnose the nature of the problem. Draw from students' experience or introduce different diagnostic technologies; pulse, blood pressure, respiratory rate, ECG, cat scan. Introduce, demonstrate and practise using stethoscope to monitor heart rate (HR) and sphygmomanometer to monitor blood pressure(BP).

Act. 4.1.3 Project: Nutrition and Lifestyle Choices. Students monitor BP and HR over a short time period (long enough to appreciate the range over which they fluctuate and correlate these with body activities) and research the effects of changing lifestyle habits on these systems (examples: decrease caffeine, sugar, salt, nicotine intake; increase regular exercise). Final Product will include: a scientific rationale for wise lifestyle choices; a research component discussing the effect of a prescription or non-prescription drug on the systems; and an analysis of the impact of a special diet (such as vegetarianism).

Assessment of project includes knowledge of factors and systems, inquiry process, application of information integrated in lifestyle choices rationale and communication of data and analysis. (Rubric, Rating scale, checklists)

Act. 4.2.1 Comparative anatomy of digestive systems in various vertebrate and invertebrate animals (tie back to Unit 1: Diversity - discuss plants).

Act. 4.2.2 Relate the need for carbohydrates in diet to their role in cellular respiration; describe the many uses of proteins (amino acids) and other nutrients. Tie information back to food production in plants from previous unit. Explain how the digestive system is regulated. Investigate one disorder of the digestive system and highlight technologies for diagnosis and treatment. (examples - dietary supplements, endoscope, etc.)

Act. 4.2.3 Activity: Dissection/computer simulated dissection. Working in small groups, students do a simple dissection to develop technique and learn to identify structures (example - view alimentary tract in earthworm).

Assess dissection skill and knowledge of digestive system; structure, requirements and function. (Checklist, Rating scale, Quiz)

Act. 4.3.1 Comparative anatomy of respiratory systems of various vertebrate and invertebrate organisms (tie back to diversity and plants). Use computer simulated dissection, models and/or diagrams to illustrate system structure.

Act. 4.3.2 Discuss the role of the respiratory system. Tie in the system of gas exchange as studied in the plant unit. Discuss one disorder of the respiratory system and technologies for diagnosis and treatment.

Act. 4.3.3 Activity: *Lung Capacity Lab*. Review mechanical process of breathing including specific muscles involved in process. Students use digital or dial spirometer (graduated plastic jugs and water displacement are a cheap but effective alternative) to measure vital capacity. Correlations between age, sex, size, fitness level and smokers can be graphed and should be discussed. Students devise a procedure to record rate and depth of breathing, correlating these with varying degrees of exercise. They account for these correlations by explaining the feedback control of breathing.

Assessment of lab report and lab technique along with general assessment of knowledge of structure, requirements and function of system

Act. 4.4.1 Activity: What is a Circulatory system? Think/Pair/Share is used to develop a list of what circulatory systems carry and what each material contributes to the organism's function. Circulation in organisms of varying complexity is compared, including a comparison of the surface area to volume ratio and transport in single cell organisms.

Act. 4.4.2 Comparative anatomy of circulatory systems in various vertebrate and invertebrate animals (tie back to diversity and plants). Discuss one disorder of the circulatory system and how regulation of this system is carried out. Highlight technologies for diagnosis and treatment.

Act. 4.4.3 Homework Question: Students should look back to the plant unit and create a comparison between veins and arteries in animals and xylem in phloem in plants (example, Venn diagrams or concept maps). Present to class or display on posters.

Act. 4.4.4 Activity: Dissection/computer simulated dissection. Working in small groups, students do a simple dissection to develop technique and learn to identify structures. Use as a review for the structures of all three systems (example-frog).

Assess dissection skill and knowledge of circulatory system; structure, requirements and function (Checklist, Rating scale, Quiz). Assess communication and ability to connect ideas tying plant transport and animal circulation (Peer evaluation, checklists).

Act. 4.5.1 Research: Diseases. Students refer back to the specific diseases discussed in the sections on each system and explain how the other body systems are also disrupted.

Act. 4.5.2 Activity: Dissection Evaluation. A dissection/or simulated dissection of the fetal pig or rat for the purpose of evaluating technique developed throughout the unit. Students are also evaluated on identification of system structures.

Act. 4.5.3 Project: Nutrition and Lifestyle Choices. See first Activity for notes on assignment and evaluation.

Assessment may also include written Knowledge-based test with connections section that incorporates the disease research outlined in Activity 4.5.1.

Unit 5: Genetic Continuity

Time: 26.5 hours

Unit Description

In this unit, students develop an understanding of meiosis, Mendel's model of inheritance, and forms of inheritance that extend beyond Mendel's model. The students' ability to identify patterns, predict outcomes and solve problems involving monohybrid, dihybrid, incomplete dominance, co-dominance, and sex-linked traits is emphasized. Students also examine some of the technological advances and the contributions of eminent investigators that led to the modern concept of the gene and inheritance.

Unit Overview Chart

Activity	Time	Expectations	Assessment AC	Assessment LS
5.1 Introduction to Variability	1.25 hours	DL3.02	K, I Diagnostic	TW, WH
5.2 Factors Which Carry Variability	2.5 hours	GC1.01, GC3.01, GC1.02	K	WI, O
5.3 Sources of Variability	5 hours	GC1.02, GC1.04, GC2.01, GC2.03, GC3.01, GC3.03, DL1.05, DL3.02, GCV.01	K, I, C	TW, I, O, WH
5.4 Mendelian Genetics	3.75 hours	GC1.03, GC2.04, GC1.02, GCV.01, GCV.02	K, I, C	TW, WH, I, O
5.5 Inheritance of Traits and Patterns of Variability	5 hours	GC1.06, GC1.07, GC2.02, GCV.02	K, I, C	WH, WI, O, TW, I
5.6 Genetic Disorders	4.5 hours	GC1.05, GC2.05, GC3.02, GC3.03, GCV.02	K, I, C	TW, WH, I, O, WI
5.7 End-of-Unit Tasks	4.5 hours	DL3.01, DLV.03, GCV.03	K, I, MC, C	WH, WI, TW, I, O

Final Assessment Tasks

By curriculum policy, the *Final Summative Evaluation* of the course accounts for 30 per cent of the final grade recorded for the course. This summative evaluation is based on an assessment of achievement in all four categories of the Achievement Chart for Science and of expectations from all units of the course.

Time	Assessment Focus		Assessment Activity
	AC	LS	
3 hrs	K MC	WH I WI	**Final Examination**, which includes well-chosen multiple-choice questions (as preparation for university) as well as essay questions. Skills of analysis and application must be tested as well as Knowledge from all strands of the course. An extended response question exploring the broader themes of the course (such as the fundamental unity of all life) can be used to assess skills for Making Connections
7 hrs	I C	TW I C	**Research Project: Biotechnology Symposium** Students apply knowledge and skills gained throughout this course to research an aspect of biotechnology. Findings are presented in an in-class symposium. Possible topics include: genetic modification of food, synthetic production of hormones and drugs, cloning, organ transplantation/rejection, gene therapy, technology used in mapping genomes, genetic screening, etc. In each case, techniques must be explained in enough detail to show the underlying science, environmental and social implications are explored, and costs/benefits are assessed. Inquiry and Communications Skills are assessed.

Teaching/Learning Strategies

Need for Variety and Balance

Since the over-riding aim of this course is to develop scientific literacy in all students, a wide variety of instructional strategies is needed to provide learning opportunities that accommodate a variety of learning styles, interests and ability levels.

In planning activities, make sure that your students have:

- opportunities to work individually, in pairs, in small groups, and in large groups;
- direct-instruction as well as open-ended exploration;
- opportunities to develop concepts themselves from observed data;
- tasks in which they define some of the parameters (such as scope or procedure);
- opportunities to acquire knowledge and apply that knowledge in a variety of contexts;
- opportunities to communicate using standard formats (such as lab reports) as well as opportunities to choose and develop the format.

Skills are Developed through Experience and Refined with Practice

Many of the Learning Expectations describe **Inquiry Skills**. Give students repeated opportunities to carry out genuine inquiries in which they are responsible for defining one or more of the components of the inquiry: the topic or question, the methodology, the mode of presentation, the criteria of success. Students should have multiple opportunities to practise a variety of inquiry styles includes:

- **Research** involves *accessing information* that has already been gathered elsewhere, *selecting* what is needed, and *analysing* that information for patterns and meaning. This will require instruction and practice in techniques for effective use of Library/Resource Centre resources, searching the Internet and interviewing experts.

- **Experimentation** involves *identifying controls and variables, designing the experimental procedure, observing and measuring and analysing* the data for patterns and meaning. This may occur in laboratories or the field. Laboratory techniques and safety procedures must be taught and assessed.

Every inquiry should be driven by a clear *question* that is manageable and has relevance to the students. Students must be given instruction and repeated practice in: identifying and refining good inquiry questions; developing testable hypotheses; setting the parameters of the solutions to be sought; assessing results.

All forms of inquiry as well as other activities throughout the course develop **Communications Skills**. Although the traditional written report is one form of communication, students need to describe what they do and what they learn in other formats - poster presentations, computer presentations, video presentations, oral presentations, music, etc. Through various forms of cooperative learning they discuss, debate and reflect on their own thinking and learning.

In addition to key biological concepts, every Learning Activity should identify a technique or skill that will be taught or reinforced and assessed. Over the length of the course, all skills required to meet the Expectations should be practised repeatedly in a variety of contexts.

Use of Computer Technology

Computer applications should be taught and used whenever they enhance learning by enabling students to do something more efficiently or that they could not otherwise do. A wide variety of software tools should be used to record and display information, including *word-processing* e.g., reports, *spreadsheets*, *graphics,* e.g., flow charts, concept maps, diagrams in place of written reports of investigations *databases*, and *presentation* programs, e.g., an alternative for reporting on investigations, particularly by groups *Probe-ware* should be used to collect data, e.g., to carry out experiments where data must be collected at intervals over several days. *Simulations* may substitute for experiences that would not otherwise be feasible but should not be used to replace direct experiences that are safe, ethical and available. The portability of calculator based laboratory systems makes them useful for work outside the classroom.

Learning Skills

While not evaluated for marks, learning skills - *Works Independently, Teamwork, Organization, Work Habits/Homework, Initiative* - are keys to success in school and beyond. As with other skills, they should be taught, practised, and assessed in the classroom. Variety is essential: individual assignments foster independence and initiative; lab work done in pairs and small-group cooperative learning provide opportunities to develop teamwork. (*Cooperative Small Group Learning (CSGL)* structures are discussed in some detail in Appendix OV-3, beginning on p. 18 of the Overview to the Grade 9 Science, Essential, profile. (http://www.curriculum.org/occ/profiles/9/9essential.htm#science). A summary of CSGL structures has been included as Appendix 1 in the Public profile for Grade 11 Science, SNC3M.)

Making Connections

The knowledge expectations of this course have intrinsic worth as useful information, but they also serve as vehicles for Making Connections.

Connecting biological concepts to social and environmental issues develops the habits of mind for Making Connections.

Applying scientific knowledge to practical problems makes connections to technology; considering how scientific knowledge is acquired brings understanding of the role that technology plays in scientific discovery.

Assessment & Evaluation of Student Achievement

Assessment is a systematic process of collecting information or evidence about student learning. *Evaluation* is the judgment we make about the assessments of student learning based on established criteria.

The purpose of assessment is to improve student learning. This means that judgments of student performance must be *criterion-referenced* so that feedback can be given that includes clearly expressed next steps for improvement. Tools of varying complexity can facilitate this.

- Where completion or non-completion is the issue, a *checklist* is sufficient;
- Where quality of performance is easily identifiable, a *rating scale* can be used;
- For more complex tasks, the criteria may be incorporated into a *rubric* where levels of performance for each criterion are stated in language that can be understood by students. Rubrics describe performance of a generalized skill (such as Inquiry) or can be task-specific.

Checklists, rating scales and rubrics become powerful tools for improving learning when students understand the criteria and levels of performance before they undertake the task. Discussion of the criteria for success should be part of every learning task. Wherever possible, involve your students in the development of the rating scale or rubric (identifying criteria and setting levels of achievement in terms they understand).

Note: The following references are useful in expanding both teacher and student understanding of rubrics as a powerful tool in assessment.

1. The course profile for SCH3U includes Appendix 1: Rubric Development with samples of generic rubrics, which can be adapted for use in science courses across the curriculum. The appendix includes brief suggestions for teacher use of the contents, and the following sample/model rubrics. Each sample relates to a section of the Achievement Chart for Science and to the goals of this science course.
   - Rubric for Declarative Knowledge (Knowledge/Understanding of concepts, generalizations, facts - related to the first goal in this course)
   - Rubric for Procedural Knowledge (Knowledge/Understanding and Inquiry – related to the second goal in this course which focuses on the skills required for performance using manipulative, thinking and reasoning skills.)
   - Rubric for Collaborative Group Work (Learning Skills)
   - Partial Rubric for an Experimental Inquiry
   - Partial Rubric for a Research Inquiry
   - Rubric for a Written Report
2. Task-specific rubrics See TSM 5C: Developing Task-Specific Rubrics, p. 16 of the Teacher Support Materials in the Grade 10 Science, Public Academic Profile.

   Assessment must be embedded within the instructional process throughout each unit rather than being an isolated event at the end. Often, the learning and assessment tasks are the same, with formative assessment provided throughout the activity. In every case, the desired demonstration of learning is articulated at the beginning and the learning activity is planned to make that demonstration possible. When planning learning activities, this process of beginning with the end in mind helps to keep focus on the Expectations and to reduce the inclination to expand what is taught beyond what is required by the guideline.

   *Assessment, Evaluation and Reporting are tied to the **Learning Expectations** and **Achievement Chart for Science*** (pp. 172-175 in *The Ontario Curriculum, Grades 11 and 12: Science, 2000*). Every learning activity and its assessment should collect data for making judgments about performance in one or more of the Achievement Chart categories: Knowledge/Understanding, Inquiry, Communications and Making Connections. Within each unit and across the course, teachers must collect sufficient data (in kind and number) to make valid judgments about each student's performance in all Categories.

In the end, whether the evaluation of the assessment data is expressed as levels of Achievement or as a percentage based on those levels, that judgment must be based on each student's performance based on the criteria, not relative to other students' performances. Final evaluations should reflect the teacher's informed, professional judgment of each student's most consistent level of performance in each category of the Achievement Chart. Report card marks will be expressed in percentages.

A wide and balanced range of assessment strategies is needed to accommodate the varied learning styles of all students, to meet the needs of students with special needs, and to encompass a broadened range of knowledge and skills Expectations. Teachers will consult individual student IEPs for specific direction on accommodation for individuals.

There must be opportunities for students to demonstrate learning at all levels of the Achievement Chart. Strategies include:

- diagnostic, formative and summative assessments;
- performance tasks and pencil-and-paper instruments. Both are needed to assess the full range of Expectations;
- both teacher assessment and student (self- and peer) assessment. With clearly articulated criteria, students become partners in the assessment process;
- both individual and group assessment. When students are engaged in group tasks it is appropriate to consider group interaction as an indicator of each student's learning skills. However, assessment must focus primarily on each student's individual demonstration of the Learning Expectations.

Accommodations

Students with special needs, whether identified formally or not, need additional supports to succeed in Grade 11 Biology. For each identified student, read the Individual Education Plan (IEP) for information about specific accommodations designed to compensate for specific disabilities. The following are examples of accommodations and aids that may be helpful for students with special needs:

- Ensure that peer helpers are available when students are working in small groups.
- Provide handout sheets with sample calculations and specific skill instructions.
- Help students create data charts into which they record information.
- Advise special education staff in advance when students are working on major assignments.
- Record key words on the board when students are expected to make their own notes.
- Allow students to report verbally to a scribe (teacher or student) who can then help in note making.
- Permit students a wide range of options for recording and reporting their work to utilize student strengths, e.g., drawings, diagrams, flow charts, concept maps.
- Timelines may need to be extended to give students more time to process language and put their thoughts into words.
- Where an activity requires reading, give it in advance to students or provide a selection of materials at different reading levels.

Students in English as a Second Language/English Literacy Development programs may require additional supports:

- Have students keep a science dictionary of terms using pictures and first language words.
- Where an activity requires reading, give it in advance to students.
- Permit the use of a translation dictionary on assessments.
- Provide additional time on assessments for dictionary use and processing language.
- Have the teacher-librarian identify resources with appropriate reading level when research is required.
- Advise ESL/ESD staff in advance when significant written work is required.

Resources

Instruction and Assessment

Armstrong, Thomas. *Multiple Intelligences in the Classroom*. Alexandria, VA: Association for Supervision and Curriculum Development. 1994. ISBN 0-87120-230-1

Brown, John L. *Observing Dimensions of Learning in Classrooms and Schools*. Alexandria, VA: Association for Supervision and Curriculum Development. 1995. ISBN 0-87120-255-7

Burke, Kay. *How to Assess Thoughtful Outcomes*. Palatine, Illinois: IRI/Skylight Publishing, Inc., 1993. ISBN 0-932935-58-3 (1-800-348-4474)

Herman, Aschbacher and Winters. *A Practical Guide to Alternative Assessment*. Association for Supervision and Curriculum Development. 1992. ISBN 0-87120-197-6

McDonald, Joseph P. et al. *Graduation by Exhibition: Assessing Genuine Achievement*. Alexandria, VA: Association for Supervision and Curriculum Development. 1993. ISBN 0-87120-204-2

Zemelman, Daniels and Hyde. *Best Practice: New Standards for Teaching and Learning in America's Schools*. Portsmouth, NH: Heinemann. 1993. ISBN 0-435-08788-6

Internet Resources

Note: The URLs for the websites have been verified by the writers prior to publication. Given the frequency with which these designations change, teachers should always verify the websites prior to assigning them for student use.

Schools should develop and maintain web sites on which selected resources are listed, particularly those that have links to other science references. One excellent site with very extensive links is The Internet Public Library http://www.ipl.org

See also the *Crucible*, Vol. 32 No. 3 January 2001, STAO Hot Websites: Biology Resources for Teachers and Students, p.12

Other general science sites include:

American Association for the Advancement of Science
http://www.aaas.org/

Association for Supervision and Curriculum Development -- variety of high quality publications and videos on a wide variety of topics – many principals and superintendents have memberships and can purchase materials at reduced rates. Also the home of Educational Leadership magazine. –
http://www.ascd.org/

Canadian government and research sites related to science and engineering –
http://www.nserc.ca/relate.htm

CBC Educational Resources – http://www.cbc.ca/insidecbc/educational/

Education Network of Ontario – http://www.enoreo.on.ca/

Education resources on the web (Canadian site) –
http://www.educ.uvic.ca/depts/snsc/pages/weblinks/weblinks.htm

EDU Web Index – to find anything on the Ministry's web site. –
http://www.edu.gov.on.ca/eng/webmap.html

Gateway to Educational Materials – http://www.thegateway.org/

Great Canadian Scientists: http://www.science.ca/reference.html – brief biographies of over 100 Canadian scientists and inventors

Kathy Schrock's Guide for Educators. – http://discoveryschool.com/schrockguide/

Midwest Mathematics and Science Consortium (MSC) – http://www.ncrel.org/msc/msc.htm

National Science Foundation (USA) – http://www.nsf.gov/

National Staff Development Council – issues of implementation – http://www.nsdc.org/

Online Resources for Assessment – http://www.rmcdenver.com/useguide/assessme/online.htm

Ontario Ministry of Education (EDU) – curriculum documents page – http://www.edu.gov.on.ca/eng/document/curricul/curricul.html

Regional Education Laboratories in the USA – focus on educational research – http://www.sedl.org/RELs.html

Science Museum, London, England – http://www.nmsi.ac.uk/science_museum_fr.htm

Science Museum, Munich, Germany (Deutsches Museum) – http://www.deutsches-museum.de/e_index.htm

Science Teachers Association of Ontario (STAO) links to science sites – http://www.stao.org/hotlinks.htm

STAR Centre for Academic Renewal (Texas) – http://www.starcenter.org/

USA National Academy of Sciences – http://www.nas.edu/

OSS Policy Considerations

Students can apply and refine the skills, knowledge and habits of mind they acquire in SBI3U through Cooperative Education, work experience and service placements within the community. They also have the opportunity to explore various science-related careers related to the course and consider them when they are developing their Annual Education Plan (AEP).

- A work site placement must be directly connected to the Expectations of SBI3U if it is to contribute to a student's perspective of future careers or educational opportunities. The wording in the document *Cooperative Education and Other forms of Experiential Learning* (*Ontario, Ministry of Education, 2000*) provides clear direction, and should be the focus of the personalized learning plans for students. "[T]he personalized learning plan **must** include the following: "the curriculum expectations of the related course that describe the knowledge and skills the student will **extend and refine** through application and practice at the workplace" (p. 23, emphasis added). The placement is not intended to introduce the student to the Expectations, but should connect closely enough that significant Expectations are clearly extended and refined in a workplace setting. Both workplace and community experiences may offer unique opportunities for students to achieve the goal of SBI3U "To relate science to technology, society, and the environment" and to gain experience in the Science Investigative Skills defined at the beginning of the course description in the guideline. The personalized placement-learning plan of a student who has an Individual Education Plan (IEP) must be developed with direct reference to the IEP.
- Students are required to complete 40 hours of community involvement activities prior to graduation. Volunteer work in hospitals, retirement residences and nursing homes, conservation authorities, humane societies, etc. would provide connections to the goals of SBI3U while supporting the intent of the service to encourage students to develop awareness and understanding of civic responsibility and the role they can play in supporting and strengthening their communities.
- Students graduating from Ontario schools must be technologically literate. Through the study of this science course students must come to understand and apply technological concepts, use computers in various applications, and analyse the implications of technology on individuals and society.

Coded Expectations, Biology, Grade 11, University Preparation, SBI3U

Scientific Investigation Skills

SIS.01 · demonstrate an understanding of safety practices consistent with Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., use proper techniques in preparing, using, and disposing of bacterial cultures);

SIS.02 · select appropriate instruments and use them effectively and accurately in collecting observations and data (e.g., microscope, laboratory glassware, stethoscope, dissection instruments);

SIS.03 · demonstrate the skills required to plan and carry out investigations, using laboratory equipment safely, effectively, and accurately (e.g., conduct an experiment to determine the effects of quantity and quality of light on photosynthesis);

SIS.04 · select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results (e.g., use characteristics of organisms and the principles and nomenclature of taxonomy to classify organisms; use proper terminology related to organs and tissues);

SIS.05 · locate, select, analyse, and integrate information on topics under study, working independently and as part of a team, and using appropriate library and electronic research tools, including Internet sites;

SIS.06 · compile, organize, and interpret data, using appropriate formats and treatments, including tables, flow charts, graphs, and diagrams;

SIS.07 · communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., report on an experimental investigation of the movement of materials across a cell membrane);

SIS.08 · express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures;

SIS.09 · select and use appropriate SI units (units of measurement of the *Système international d'unités*, or International System of Units);

SIS.10 · identify and describe science- and technology-based careers related to the subject area under study (e.g., biochemist, forester, geneticist, physiotherapist, oncologist, horticulturist).

Cellular Functions

Overall Expectations

CFV.01 · demonstrate an understanding of cell structure and function and the processes of metabolism and membrane transport;

CFV.02 · investigate the fundamental molecular principles and mechanisms that govern energy-transforming activities in all living matter, whether it be animal, plant, or microbial;

CFV.03 · demonstrate an understanding of the relationship between cell functions and their technological and environmental applications.

Specific Expectations

Understanding Basic Concepts

CF1.01 – describe how organelles and other cell components carry out various cell processes (e.g., digestion, transportation, gas exchange, excretion) and explain how these processes are related to the function of organs;

CF1.02 – identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids;

CF1.03 – describe the fluid mosaic structure of cell membranes, and explain the dynamics of passive transport (facilitated diffusion) and the processes of endocytosis and exocytosis of large particles;
CF1.04 – explain the flow of energy between photosynthesis and respiration;
CF1.05 – compare anaerobic respiration (including fermentation) and aerobic respiration and state the advantages and disadvantages for an organism or tissue of using either process;
CF1.06 – illustrate and explain important cellular processes (e.g., protein synthesis, respiration, lysosomal digestion), including their function in the cell, the ways in which they are interrelated, and the fact that they occur in all living cells.

Developing Skills of Inquiry and Communication

CF2.01 – design and carry out an investigation on cellular function, controlling the major variables (e.g., examine the movement of substances across a membrane; measure a metabolic process such as fermentation);
CF2.02 – view and manipulate computer-generated, three-dimensional molecular models of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids;
CF2.03 – identify new questions and problems stemming from the study of metabolism in plant and animal cells (e.g., What is the relationship between chloroplasts and mitochondria in plant cells?);
CF2.04 – carry out, in a safe and accurate manner, biological tests for macromolecules found in living organisms (e.g., use iodine and Benedict's solution to test for carbohydrates; use Sudan IV to test for the presence of lipids).

Relating Science to Technology, Society, and the Environment

CF3.01 – present informed opinions on advances in cellular biology and possible applications through related technology (e.g., new treatments for cancer; the possibility of producing ethanol as a fuel; the uses of radioactive labelling, fluorescence of genetic material, or simulations of three-dimensional molecular structure);
CF3.02 – explain how scientific knowledge of cellular processes is used in technological applications (e.g., how knowledge of a particular microbe is used in biotechnological applications in the pulp and paper industry or in the clean-up of oil spills);
CF3.03 – analyse ways in which societal needs have led to technological advances related to cellular processes (e.g., document, using newspaper articles, the impact of public awareness on research to detect and treat diseases such as AIDS and hepatitis C).

Genetic Continuity

Overall Expectations

GCV.01 · demonstrate an understanding of the necessity of meiosis and describe the importance of genes in transmitting hereditary characteristics according to Mendel's model of inheritance;
GCV.02 · perform laboratory studies of meiosis and analyse the results of genetic research related to the laws of heredity;
GCV.03 · outline the scientific findings and some of the technological advances that led to the modern concept of the gene and to genetic technology, and demonstrate an awareness of some of the social and political issues raised by genetic research and reproductive technology.

Specific Expectations

Understanding Basic Concepts

GC1.01 – demonstrate an understanding of the process and importance of mitosis (e.g., cell division and the phases of mitosis);

GC1.02 – explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation (e.g., explain how the sex of an individual can be determined genetically; demonstrate an understanding that the expression of a genetic disorder linked to the sex chromosomes is more common in males than in females);

GC1.03 – describe and explain the process of discovery (e.g., the sequence of studies and the knowledge gained) that led Mendel to formulate his laws of heredity;

GC1.04 – explain the process of meiosis in terms of the replication and movement of chromosomes;

GC1.05 – describe genetic disorders (e.g., Down syndrome, cystic fibrosis, muscular dystrophy, fragile X syndrome) in terms of the chromosomes affected, physical effects, and treatment;

GC1.06 – explain, using Mendelian genetics, the concepts of dominance, co-dominance, incomplete dominance, recessiveness, and sex-linkage;

GC1.07 – predict the outcome of various genetic crosses.

Developing Skills of Inquiry and Communication

GC2.01 – explain the process of meiosis, with reference to a computer simulation or to their own investigations with a microscope (e.g., using slides of grasshopper testis, explain what happens in the first and second stages of prophase and metaphase and anaphase 2 in meiosis);

GC2.02 – solve basic genetic problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes using the Punnett method;

GC2.03 – organize data (e.g., in a table) that illustrate the number of chromosomes in haploid cells and diploid cells, and the number of pairs of chromosomes in diploid cells, that occur in various organisms before, during, and as a result of meiosis;

GC2.04 – compile qualitative and quantitative data from a laboratory investigation on monohybrid and dihybrid crosses, and present the results, either by hand or computer (e.g., record observations using a "Virtual Fly" laboratory software package);

GC2.05 – research genetic technologies using sources from print and electronic media, and synthesize the information gained (e.g., describe the Human Genome Project, transgenics, or the process of genetic screening; list the advantages and disadvantages of cloning or the genetic manipulation of plants).

Relating Science to Technology, Society, and the Environment

GC3.01 – summarize the main scientific discoveries of the nineteenth and twentieth centuries that led to the modern concept of the gene (e.g., the discoveries of Hugo de Vries, W.S. Sutton, Thomas Morgan, J. Muller, Barbara McClintock, Rosalind Franklin, James Watson, and Francis Crick);

GC3.02 – describe and analyse examples of genetic technologies that were developed on the basis of scientific understanding (e.g., the improvement of an experimental procedure to extract DNA from bacterial or plant cells);

GC3.03 – identify and describe examples of Canadian contributions to knowledge about genetic processes (e.g., research into cystic fibrosis) and to technologies and techniques related to genetic processes (e.g., the invention of nuclear magnetic resonance [NMR]).

Internal Systems and Regulation

Overall Expectations

ISV.01 · describe and explain the major processes, mechanisms, and systems, including the respiratory, circulatory, and digestive systems, by which plants and animals maintain their internal environment;

ISV.02 · illustrate and explain, through laboratory investigations, the contribution of various types of systems and processes to internal regulation in plant and animal systems;

ISV.03 · evaluate the impact of personal lifestyle decisions on the health of humans, and analyse how societal concern for maintaining human health has advanced the development of technologies related to the regulation of internal systems.

Specific Expectations

Understanding Basic Concepts

IS1.01 – describe the process of ventilation and gas exchange from the environment to the cell (e.g., describe the pathway of oxygen from the atmosphere to the cell, and the roles of ventilation, haemoglobin, and diffusion in this process);

IS1.02 – explain the role of transport or circulatory systems in the transport of substances in an organism (e.g., explain how nutrients, respiratory gases, end products of metabolism, and hormones or regulatory chemicals are transported from one area in an organism to another);

IS1.03 – describe the importance of nutrients and digestion in providing substances needed for energy and growth (e.g., relate the need for carbohydrates in the diet to their role in cellular respiration; describe the many uses of proteins; describe how plants use nutrients);

IS1.04 – demonstrate an understanding of how fitness level is related to the efficiency of metabolism and of the cardiovascular and respiratory systems;

IS1.05 – describe how the use of prescription and non-prescription drugs can disrupt or help maintain homeostasis (e.g., describe the effects of acetylsalicylic acid, or ASA, on human systems).

Developing Skills of Inquiry and Communication

IS2.01 – compare the anatomy of different organisms – vertebrate and/or invertebrate (e.g., carry out a dissection, or use a computer-simulated dissection, of a mammal or a fish to examine the heart, the pulmonary circulation system, the aorta, and other main arteries and veins, and compare the functions of the arteries and veins to those of xylem and phloem in plants);

IS2.02 – design and carry out, in a safe and accurate manner, an experiment on feedback mechanisms, identifying specific variables (e.g., investigate feedback controls by comparing resting rates of heartbeat and breathing with those after exercise, and then again after rest);

IS2.03 – select and integrate information about internal systems from various print and electronic sources, or from several parts of the same source (e.g., present information about special diets, such as those for vegans and diabetics; develop a pamphlet on how to treat the accidental ingestion of poisons).

Relating Science to Technology, Society, and the Environment

IS3.01 – identify examples of technologies that have enhanced scientific understanding of internal systems (e.g., instruments used to monitor biological systems, such as the computer axial tomography [CAT] scanner or the stethoscope, and products used to alter or augment them, such as pharmaceuticals, prosthetics, and pacemakers; the use of radio-isotopes to identify and combat diseases);

IS3.02 – provide examples of Canadian contributions to the development of technology for examining internal systems (e.g., devices used in nuclear medicine);

IS3.03 – analyse and explain how societal needs have led to scientific and technological developments related to internal systems (e.g., explain how the need to maintain wellness in humans led to the development of dietary products and fitness equipment; analyse how social awareness of the importance of organ donation has led to improved techniques for transplanting organs, such as the liver);

IS3.04 – present informed opinions about how scientific knowledge of internal systems influences personal choices concerning nutrition and lifestyle (e.g., explain the advantages and disadvantages of taking steroids or amino acid supplements; explain the scientific reasons for committing personal time to exercise).

Diversity of Living Things

Overall Expectations

DLV.01 · demonstrate an understanding of the diversity of living organisms through applying the concepts of phylogeny and taxonomy to the kingdoms of life (including Eubacteria and Archeabacteria) and viruses;

DLV.02 · use techniques of sampling and classification to illustrate the fundamental principles of taxonomy;

DLV.03 · relate the role of common characteristics and diversity within the kingdoms of life (including Eubacteria and Archeabacteria) to the importance of maintaining biodiversity within natural ecosystems, and explain the use of micro-organisms in biotechnology.

Specific Expectations

Understanding Basic Concepts

DL1.01 – define the fundamental principles of taxonomy and phylogeny (e.g., provide definitions of concepts such as genus, species, and taxon, and explain how species are categorized and named according to structure and/or evolutionary history);

DL1.02 – compare and contrast the structure and function of different types of prokaryotic and eukaryotic cells (e.g., compare prokaryotic and eukaryotic cells in terms of genetic material, metabolism, and organelles/cell parts);

DL1.03 – describe selected anatomical and physiological characteristics of representative organisms from each life kingdom and a representative virus (e.g., describe gas exchange mechanisms and structures, or reproductive processes and components);

DL1.04 – compare and contrast the life cycles of representative organisms from each life kingdom and a representative virus (e.g., draw and label the life cycles of representative organisms, and make a chart comparing the features of the life cycles);

DL1.05 – explain the importance of sexual reproduction (including the process of meiosis) to variability within a population.

Developing Skills of Inquiry and Communication

DL2.01 – demonstrate, through applying classification techniques and terminology, the usefulness of the system of scientific nomenclature in the field of taxonomy;

DL2.02 – classify representative organisms from each of the kingdoms (e.g., classify organisms according to their nutritional pattern, type of reproduction, habitat, and general structures);

DL2.03 – use appropriate sampling procedures to collect various organisms in a marsh, pond, or other ecosystem, and classify them following the principles of taxonomy.

Relating Science to Technology, Society, and the Environment

DL3.01 – explain the relevance of current studies of viruses and bacteria to the field of biotechnology (e.g., give examples of how viruses and bacteria are used in biotechnology);

DL3.02 – demonstrate an understanding of the connection between biodiversity and species survival (e.g., state the advantages to a population of having genetic variations between individuals – such as the resistance to infection by "new" micro-organisms, the resistance of insects to pesticides, or the resistance of bacteria to antibiotics; explain why some species and not others survive an environmental stress).

Plants: Anatomy, Growth, and Functions

Overall Expectations

PAV.01 · describe the major processes and mechanisms by which plants grow, develop, and supply various products, including energy and nutrition, needed by other organisms;

PAV.02 · demonstrate an understanding, based in part on their own investigations, of the connections among the factors that affect the growth of plants, the uses of plants, and the ways in which plants adapt to their environment;

PAV.03 · evaluate how the energy and nutritional needs of a population influence the development and use of plant science and technology.

Specific Expectations

Understanding Basic Concepts

PA1.01 – illustrate the process of succession and the role of plants in the maintenance of diversity and the survival of organisms;

PA1.02 – describe the structure and function of the components of each of the leaf, the stem, and the root of a representative vascular plant (e.g., describe the path of water from the soil through the plant);

PA1.03 – explain how non-vascular plants (e.g., multicellular algae, bryophytes) function without a specialized vascular system;

PA1.04 – differentiate between monocot and dicot plants by observing and comparing the structure of their seeds and identifying vascular differences between plants;

PA1.05 – describe the effects of growth regulators (e.g., auxins, gibberellins, cytokinins);

PA1.06 – describe and explain some of the food and industrial processes that depend on plants;

PA1.07 – describe and explain some of the uses of plant extracts in food and therapeutic products.

Developing Skills of Inquiry and Communication

PA2.01 – design and carry out an experiment to determine the factors that affect the growth of a population of plants, identifying and controlling major variables (e.g., examine the effect on plant growth of the quantity of nutrients, or the quantity and quality of light, or temperature, or salinity);

PA2.02 – describe the nutrients required for the development of plants (e.g., describe the uses of nitrogen, phosphorus, and potassium in the plant, and relate them to fertilizer content; consider different stages in the growth of plants, from germination through growth, flowering, and fruit production, and indicate the appropriate fertilizer to be used at each stage);

PA2.03 – identify, using a microscope and models, the plant tissues in roots, stems, and leaves (e.g., use a microscope to identify tissues such as xylem and phloem throughout the plant);

PA2.04 – compile information about the chemical products derived from plants and, either by hand or computer, display the information in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots (e.g., make a chart of plants and their related products).

Relating Science to Technology, Society, and the Environment

PA3.01 – identify various factors that result in trade-offs in the development of food technologies (e.g., explain why vegetable growers might prefer varieties that "travel well" – that is, don't spoil easily – over those with the most flavour or nutritional value);

PA3.02 – describe and explain ways in which society supports and influences plant science and technology (e.g., analyse the influence on food production technologies of the constant demand for fresh fruit at affordable prices);

PA3.03 – express opinions supported by their own research about the case for funding certain projects in plant science or technology rather than others (e.g., evaluate the relative merits, for funding purposes, of research projects on genetic manipulation of plants over projects related to the development of organic products);

PA3.04 – describe how a technology related to plants functions (e.g., long-term use of pesticides, including herbicides), and evaluate it on the basis of identified criteria such as safety, cost, availability, and impact on everyday life and the environment.

Unit 5: Genetic Continuity

Time: 26.5 hours

Unit Description

In this unit, students develop an understanding of variability, meiosis, Mendel's model of inheritance, and forms of inheritance that extend beyond Mendel's model. The students' ability to identify patterns, predict outcomes and solve problems involving monohybrid, dihybrid, incomplete dominance, co-dominance and sex-linked traits is emphasized through the collection and examination of raw data in place of the traditional word problem approach. Students also examine some of the technological advances and the contributions of eminent investigators that led to the modern concept of the gene and inheritance. As a final task, students participate in a debate about a current genetics issue.

Unit Synopsis Chart

Activity	Time	Expectations	Assessment	Task/Focus
5.1 Introduction to Variability	75 min	DL3.02	Diagnostic K, I	Small group brainstorming and reporting; teacher-led discussion; data gathering and organizing
5.2 Factors Which Carry Variability	150 min	GC1.01, GC1.02, GC3.01	K	Teacher directed lesson; students work with models; review of student understanding of mitosis
5.3 Sources of Variability	300 min	GCV.01, GC1.02, GC1.04, GC2.01, GC2.03, GC3.01, GC3.03, DL1.05, DL3.02	K, I, C	Teacher led-class discussion; student problem-solving laboratory activity; role play of process of meiosis
5.4 Mendelian Genetics	225 min	GCV.01, GCV.02, GC1.02, GC1.03, GC2.04	K, I, C	Student investigation; teacher-led discussion; students design and perform laboratory investigation, pool class data and propose models to explain
5.5 Inheritance of Traits and Patterns of Variability	300 min	GCV.01, GC1.06, GC1.07, GC2.02	K, I, C	Students use their data and teacher-supplied data to define terms and use Punnet Squares to solve problems
5.6 Genetic Disorders	270 min	GCV.02, GC1.05, GC2.05, GC3.02, GC3.03	K, I, C	Teacher pre-lab; cooperative small group activity; reporting of results for class recording of information; students perform pedigree analysis and discuss implications
5.7 End-of-Unit Tasks	270 min	GCV.03, DLV.03, DL3.01	K, I, MC, C	Research and small group formal debates; fact-based opinion writing assignment using debate information and research

Unit Planning Notes

- Germinate plants required for Activity 5.4.3 in sufficient time so that they are ready for analysis in Activity 5.4.3.
- Introduce tasks and assign topics for Activity 5.7 early in the unit so that students can gather information throughout the unit.
- Collect recombination data from a variety of sources.
- Book access to the computer lab as required.
- Be aware of current information in the field of genetics, as the content in this area is changing rapidly.

Unit Resources

The following sites are good general resources, which include a variety of links to other genetics sites.

Genetics Education Centre – www.kumc.edu/gec/lessons.html
The Gene School – http://library.advanced.org/28599
Mendel Web – www.netspace.org/MendelWeb/

Activity 5.1: Introduction to Variability

Time: 75 minutes

Description

The first activity introduces students to the variability that is present around them. By brainstorming examples of characteristics that make each of them unique, students collect evidence of this variability. Students then have the opportunity to "measure" their degree of variability and compare it to their classmates. The teacher can clear misconceptions and enhance prior knowledge. During this time, students should be introduced to the end-of-unit tasks involving a debate and piece of reflective writing (refer to Activity 5.7). These tasks allow students the opportunity to describe the connection between the study of genetics and its influence on society. This connection will form the basis for one area of the Final Assessment Task (Biotechnology Symposium) occurring towards the end of the course.

Strand(s) & Learning Expectations

Strand(s): Diversity of Living Things

Learning Expectations

DL3.02 - demonstrate an understanding of the connection between biodiversity and species survival.

Prior Knowledge & Skills

- The knowledge and skills developed in Unit 1: Diversity of Living Things.
- Apart from content from SNC1D Reproduction Strand, no prior genetics knowledge is required.

Planning Notes

- Teachers may wish to supply large chart paper and markers for brainstorming sessions.
- Allow time for the introduction of Activity 5.7 (debate and the "opinion piece" of the end-of-unit task), including the formation of groups and the introduction of the rules of debating.
- Make yourself and your class aware of the presence of certain sensitive issues regarding heredity (e.g., deceased parent, blended families, adopted children, victims of disease in the family).

Teaching/Learning Strategies

5.1.1 Student Activity: In small groups, students brainstorm answers to the following question: What characteristics or traits do we possess which make us unique/variable when compared to another person? and Why is variability beneficial in a group/population? Students use large chart paper and markers provided to record their ideas. Group answers are presented to the class.

Teacher Facilitation: Begin by asking students Who IS in your class after all (not by name)? Set the stage for the brainstorming activity by helping students to identify different types of anatomical and physiological variability that may exist between students for example, coloration, blood type, chemical sensitivity, etc. Then students have the option of attempting to categorize the traits. Recall the Diversity unit previously studied in this course to focus on the importance of variability to the success of a group/population and the relationship between genetic variation and diversity. The end-of-unit task (Activity 5.7) should be introduced at this time so that students can conduct their research throughout the Unit.

5.1.2 Student Activity: Given a tool ("genetics wheel" or numbering system) for organizing variability, students quantify their degree of variability for a particular list of traits. The final number is called the Variation Number. Students compare their Variation Number with other students to assess the level of variation. Class data collection and discussion of the results follows. Students may wish to repeat the exercise with their family members, or through a school survey of students and teachers, and compare the degrees of variability within and between groups.

Teacher Facilitation: Choose 6 -10 physical traits for analysis. Discontinuous traits such as tongue-rolling, handedness, ear-lobe attachment and thumb cross will present few problems. However, polygenic traits (eye colour, hair colour) can also be used and re-investigated in Activity 5.5. Class discussion surrounding results should include: any repeats of Variation Number (twins?); effect of sample size and population size; link to diversity. A Genetics Wheel is a common resource available in most Biology textbooks. If a Genetics Wheel is not available, an alternative suggestion is to choose an easily measured trait (such as height), measure the trait in class, and prepare a histogram to illustrate variability.

Assessment & Evaluation of Student Achievement

No formal assessment is required. A diagnostic assessment of knowledge and skills with respect to preparedness for Activity 5.2 can be performed. Students can continue to look for evidence of variation in the world around them (e.g., in other animals, in plants).

Accommodations

- Be aware and sensitive to a student's personal experience with a particular genetic disease/disorder.

Resources

The Gene School – http:/library.advanced.org/19037 – an excellent source of experiments, tutorials, quizzes on all genetics topics

@Genetics – www.atgenetics.com – a collection of search engines for genetics topics

http://library.thinkquest.org/19037/teach_links.html -a collection of genetics activities

http://chroma.mbt.washington.edu/outreach/WHO.html – a game which introduces concepts of traits and diversity.

Activity 5.2: Factors Which Carry Variability

Time: 150 minutes

Description

In this activity, students explore the relationship between DNA, genes, alleles and chromosomes. They review the process of mitosis as a means for producing genetically identical cells and identify that another mechanism must be present to allow for the variability identified in Activity 5.1.

Strand(s) & Learning Expectations

Strand(s): Genetic Continuity

Learning Expectations

GC1.01 - demonstrate an understanding of the process and importance of mitosis;
GC3.01 - summarize the main scientific discoveries of the nineteenth and twentieth centuries that led to the modern concept of the gene;
GC1.02 - explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation.

Prior Knowledge & Skills

- An understanding of mitosis from the SNC1D Reproduction Unit.

Planning Notes

- Prepare diagrams and models in advance to help illustrate the relationship between the terms.

Teaching/Learning Strategies

5.2.1 Student Activity: Students participate in a teacher-directed lesson about the mechanism for transfer of information, structural and functional relationship between DNA, genes, alleles and chromosomes, DNA replication, and cytoplasmic inheritance. Students build models of chromosomes and use the models to simulate the replication process.

Teacher Facilitation: Use a variety of teaching aids including diagrams and models to explain the role of DNA in the transfer of information. The relationship between DNA, genes, alleles, and chromosomes should be emphasized. Identify misconceptions about the structure of genes and use this as a focus for the lesson. Introduce the contributions of scientists such as Watson, Crick and Rosalind Franklin to our understanding of the structure of DNA.

5.2.2 Student Activity: Students use the models previously built to demonstrate the need for the duplication of chromosomes to produce new cells with identical genetic composition. They review the concept of mitosis as a mechanism for the creation of new cells. Students identify that the cells produced by mitosis are genetically identical to the original cell and identify situations where the production of such cells is required. Using the results of Activity 5.1, students discuss the need for another mechanism to account for the variation seen within the class.

Teacher Facilitation: Use this opportunity for a diagnostic assessment of students' understanding of mitosis which was covered in SNC1D. The emphasis of this section should be on the use of mitosis as a process to create new cells, not a detailed study of the stages of mitosis.

Assessment & Evaluation of Student Achievement

- Assess the knowledge and understanding of the relationships between genes, chromosomes and DNA using a quiz.

Resources
Genetics Science Learning Centre – http://gslc.genetics.utah.edu/basic/index.html
– a tutorial about genes, DNA and chromosomes.

Activity 5.3: Sources of Variability
Time: 300 minutes

Description
The purpose of this activity is to identify the factors that contribute to variability in an individual and in a population/group. The introduction in Activity 5.1 to types of variation in individuals can be recalled as a lead into its inherent causes. Lab activities will be conducted to illustrate recombination. The significant events of meiosis (reduction in chromosome number, recombination) are highlighted. A role-playing exercise will be performed to reinforce the principles of meiosis.

Strand(s) & Learning Expectations
Strand(s): Genetic Continuity and Diversity of Living Things

Learning Expectations
GC1.02 - explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation;
GC1.04 - explain the process of meiosis in terms of the replication and movement of chromosomes;
GC2.01 - explain the process of meiosis, with reference to a computer simulation or to their own investigations with a microscope;
GC2.03 - organize data that illustrate the number of chromosomes in haploid cells and diploid cells, and the number of pairs of chromosomes in diploid cells, that occur in various organisms before, during, and as a result of meiosis;
GC3.01 - summarize the main scientific discoveries of the nineteenth and twentieth centuries that led to the modern concept of the gene;
GC3.03 - identify and describe examples of Canadian contributions to knowledge about genetic processes and to technologies and techniques related to genetic processes;
GCV.01 - demonstrate an understanding of the necessity of meiosis and describe the importance of genes in transmitting hereditary characteristics according to Mendel's model of inheritance;
DL1.05 - explain the importance of sexual reproduction to variability within a population;
DL3.02 - demonstrate an understanding of the connection between biodiversity and species survival.

Prior Knowledge & Skills
- Knowledge and skills as studied in the Reproduction Unit of SNC1D.

Planning Notes
- Models and/or posters of meiosis may be useful to visual learners.
- For the recombination lab (Activity 5.3.3), read and collect all required materials.
- A large clear space in the classroom or an alternate area is required for the role-playing exercise.

Teaching/Learning Strategies
5.3.1 Student Activity: Students participate in a class discussion to identify the processes which contribute to variation. This discussion provides the knowledge to support the skills of problem solving in the activities to follow.

Teacher Facilitation: Lead the class discussion so that students create a list of the processes/events which contribute to variability. These include: genetic recombination (Activity 5.3.3); random fertilization between gametes (SNC1D); gamete production itself (Activity 5.3.2); and mutation. Identify the fact that gender is actually a simple form of variability through a discussion of gender determination. Introduction of the terms genotype and phenotype will illustrate the need for a method to classify the variation. For Canadian contributions to the study of genetics, the identification of the Barr Body by Dr. Murray Barr for use in nuclear sexing can be included. Emphasize the importance of all types of variation to biodiversity and species survival.

5.3.2 Student Activity: Students participate in a class discussion on the process of meiosis and its role in sexual reproduction in enough detail to describe how each of the following occurs: chromosome number is reduced by half; crossing-over occurs; and, most importantly, how these events contribute to genetic variation in offspring. Students compare the number of chromosomes and chromosome pairs in haploid and diploid cells before, during, and as a result of meiosis by organizing data from a variety of organisms.

Teacher Facilitation: Lead a class discussion which emphasizes the significant outcomes/events of meiosis without concentrating on the phase names and details of less significant events in each phase. The phases, after all, are but snapshots of a dynamic process and should be treated as such. Add a further contributor to variation to the list compiled in Activity 5.3.1. That is, the effects of the random independent assortment of homologues on the equatorial plate. Introduce the terms homologous chromosomes and recall the terms gene and allele from Activity 5.2.1. See Resources for computer simulation. Alternatively, students could use prepared slides of the stages of meiosis to reinforce their understanding of the significant outcomes/events of meiosis. Provide data on haploid and diploid cells from a variety of organisms before, during and after meiosis for students to organize.

5.3.3 Student Activity: In pairs, students perform a problem-solving lab activity involving the recombination of traits by "building" offspring from a given set of parents. Parental alleles are provided along with a key of phenotypes and corresponding genotypes. Potential offspring are produced and the phenotype of each trait is constructed. Class results are compiled so that the effect of recombination can be illustrated.

Teacher Facilitation: Provide the student groups with a key of phenotypes and corresponding genotypes. Everyday objects can be used to allow students to "build" the offspring (e.g., Bb - legs made of 2 marshmallows, TT - antennae made of 2 toothpicks, gg - 3 body marshmallow segments, Gg - 2 body marshmallow segments). The point of this activity is to illustrate that hundreds of possible combinations and permutations will result for as few as 8-10 traits. See Resources listed below for detailed instructions.

5.3.4 Student Activity: Students role-play the events of meiosis (as in spematogenesis with no polar body production) by arranging into teams of four. Each student represents a chromosome (thus each group is a tetrad or replicated homologous pair) and coloured bands on the arms and legs represent alleles. Students "perform" meiosis by walking through the process. Recombination and reduction in chromosome number should result.

Teacher Facilitation: Provide the students with coloured fabric or bands to indicate the alleles of several traits on several different chromosome pairs (discuss the merit of using a limited number of chromosomes and traits). During crossing-over, the bands are exchanged and new combinations result. Upon the end of meiosis, students will form four gamete "cells" one in each corner of the room and the uniqueness of each gamete will be evident. Random independent assortment of homologues can be demonstrated more visually here than through a diagram. (Briefly describe the fate of polar bodies in oogenesis).

Assessment & Evaluation of Student Achievement

- Traditional knowledge-based quiz of the sources of variation and the significant events of meiosis will be conducted.
- Successful construction of recombined offspring in Activity 5.3.3 will be assessed through the use of a checklist and/or self-and peer assessment.
- A performance assessment of the role-playing is optional.

Accommodations

- Include students with mobility challenges by assigning roles such as the "variability referees" (responsible for "randomly" announcing the times and locations of recombination in the role-playing activity), etc.
- For enrichment, students can design their own legend of traits for the recombination lab.
- For enrichment, consider the relationship between the distance between two genes on a chromosome and linkage of corresponding phenotypes.

Resources

The Gene School – http://library.advanced.org/28599/ – A large overview of the genetics field.

http://esd.iu5.org/LessonPlans/reebop/reebopmain.htm – provides instructions for the recombination lab (Activity 5.3.3)

www.accessexcellence.org/AE/AEC/AEF/1996/meyer_chromsome.html – provides instructions for the role-play of meiosis

Meiosis Tutorial and animation – http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html

Great Canadian Scientists: http://www.science.ca/reference.html – brief biographies of over 100 Canadian scientists and inventors

Activity 5.4: Mendelian Genetics

Time: 225 minutes

Description

Beginning with an activity to illustrate the laws of probability, students examine Mendel's laws of heredity. They examine Mendel's pea plant experiments and explore the role of mathematical analysis in his work. Students design and perform a lab in which they collect and analyse data resulting from the cross between two individuals. The focus of this activity is analysis of ratios collected from lab data.

Strand(s) & Learning Expectations

Strand(s): Genetic Continuity

Learning Expectations

GC1.02 - explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation;
GC1.03 - describe and explain the process of discovery that led Mendel to formulate his laws of heredity;
GC2.04 - compile qualitative and quantitative data from a laboratory investigation on monohybrid and dihybrid crosses, and present the results, either by hand or computer;
GCV.01 - demonstrate an understanding of the necessity of meiosis and describe the importance of genes in transmitting hereditary characteristics according to Mendel's model of inheritance;
GCV.02 - perform laboratory studies of meiosis and analyse the results of genetic research related to the laws of heredity.

Prior Knowledge & Skills

- Laws of probability from studies in Mathematics (The Ontario Curriculum, Grade 8)
- Design and execution of laboratory activities.

Planning Notes

- Use *Wisconsin Fast Growing Plants* or radish seedlings.
- Plants must be germinated prior to this activity.
- Consult with students and others to determine what preliminary work or bookings will need to be done if graphing calculators or computers are to be used in Activity 5.4.3.

Teaching/Learning Strategies

5.4.1 Student Activity: Students perform a coin-toss exercise to illustrate the laws of probability and in turn apply these to Mendel's laws of heredity.

Teacher Facilitation*:* Divide students into pairs and assigns each pair to toss two coins 10 times, record the data and identify patterns. Two pairs pool their data and identify patterns. The entire class pools its data and identifies patterns. Lead a discussion about the laws of probability, the importance of sample size, and use these concepts to introduce Mendel's laws of heredity and his use of probability and sample size in his research.

5.4.2 Student Activity: Students participate in a teacher-led discussion about Mendel's pea plant experiments and his use of mathematical analysis.

Teacher Facilitation: Provide the background about Mendel's experiments and lead a discussion about his use of mathematical analysis. His choice of discontinuous traits and his use of a large sample size should be emphasised as well as the intuitive brilliance of his hypothesis.

5.4.3 Student Activity: Students design and perform a lab to germinate and grow Wisconsin fast-growing plants or radish seedlings. The purpose of the lab is to analyse genotypic ratios in F1 generation seedlings resulting from seeds produced by a known cross between two heterozygous individuals (for example two green radish plants which produce offspring with different appearances such as green and albino radish seedlings). The emphasis is on the collection of data and a search for a model to explain the data. Students could use graphing calculators to identify trends in the data and develop models.

Teacher Facilitation: Assist students in the design and execution of the lab as required. It should be noted that the focus of this activity is on the ratios produced, not on the methods for predicting the outcomes (Punnett Squares). Class pooling of data is recommended to reinforce the importance of a large sample size in determining the ratios. Be cautious that misconceptions are not compounded by this data. Alternatively, a computer simulation of Mendel's experiment can be completed (see Resources). If graphing calculators are to be used, review procedures for finding "best fit" curves and lines.

Assessment & Evaluation of Student Achievement

- Assess knowledge of Mendel's contributions and laws of heredity on the unit test. Use a checklist or rubric to assess the lab design and report.

Accommodations

- Some students may require additional support in the collection and analysis of data.

Resources
Mendel Web – www.netspace.org/MendelWeb/ - background about Mendel and his experiments.
http://library.advanced.org/28599/
www.biology.arizona.edu:80/ – genetics problem sets and tutorials.
Biology Labs Online: subscription information. A set of 12 virtual labs on genetics (requires paid subscription) http://www.biologylab.awlonline.com/ordering.html#international

Activity 5.5: Inheritance of Traits and Patterns of Variability
Time: 300 minutes

Description
Students use the experiment performed in Activity 5.4.3 as the context for defining genetics terminology. They examine data resulting from a variety of crosses, and use the Punnett Square as a tool in solving various types of crosses which they collect in a set of solved problems. The intention of this activity is to begin with data resulting from a particular cross and then develop a Punnett Square to aid in predictions rather than a traditional word-problem based activity. Once this concept is established, word problems may be used for reinforcement.

Strand(s) & Learning Expectations
Strand(s): Genetic Continuity

Learning Expectations
GC1.06 - explain, using Mendelian genetics, the concepts of dominance, co-dominance, incomplete dominance, recessiveness and sex-linkage;
GC1.07 - predict the outcome of various genetic crosses;
GC2.02 - solve basic genetic problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes using the Punnett method;
GCV.01 - demonstrate an understanding of the necessity of meiosis and describe the importance of genes in transmitting hereditary characteristics according to Mendel's model of inheritance.

Prior Knowledge & Skills
- Knowledge of ratios from studies in Mathematics.

Planning Notes
- Collect data from the results of real or simulated crosses prior to this activity.
- Students should examine the data and ratios prior to the use of Punnett Squares.
- This section will require sufficient time for students to analyse data and solve all of the types of problems required. The students will be creating a set of solved problems from this activity only. Student participation in the preparation of the rubric used to assess this problem set should be done prior to the start of the activity so that students have a clear understanding of how they will be assessed.

Teaching/Learning Strategies

5.5.1 Student Activity: Using the results of Activity 5.4.3 as a context, students define the meaning of homozygous, heterozygous, and recall the meaning of gametes, germ line cells, somatic cells, genotype, phenotype, allele and gene.

Teacher Facilitation: Assist the students in linking the meaning of the terms to Activity 5.4.3 and to previous activities.

5.5.2 Student Activity: Students examine the data produced in Activity 5.4.3, and data provided by the teacher which is the result of other crosses. They identify patterns in the data (similar ratios). Students use the Punnett Square as a model to explain the possibilities for inheritance and solve problems to identify patterns, predict outcomes and solve problems given monohybrid, dihybrid and test crosses. Students select problems to include in their problem set.

Teacher Facilitation: Introduce the Punnett Square as a useful tool for making predictions only after the students have examined some real data and noted the common ratios. It is suggested that the first Punnett Square be used to make a prediction about the cross done in Activity 5.4.3. The shift is to use alternatives to traditional word problems such as the *Virtual Fly* software and computer simulations (see Resources). The Punnett Square must be presented as a useful tool in problem solving rather than the point of the problem. Where possible, students should pose their own questions and use Punnett Squares to make and test predictions. Students should also be made aware in this activity that the term "dominance" applies to traits that are expressed if present, not necessarily traits that are "better".

5.5.3 Student Activity: After a teacher-led discussion, students identify patterns, predict outcomes and solve problems involving codominance, incomplete dominance, sex-linkage and polygenic traits. Students select problems to include in their problem set.

Teacher Facilitation: Present data from non-Mendelian crosses (examples: blood typing, snapdragons, colour-blindness, hair, eye or skin colour) and encourage students to develop a model to explain it. Data for these types of problems is available in many Grade 11 Biology textbooks. Introduce the concepts of codominance, incomplete dominance, sex-linkage and polygenic traits in relation to the examples presented. Students use the skills developed in Activity 5.5.2 to solve problems involving these types of traits.

Assessment & Evaluation of Student Achievement

- Assessment of problem-solving skills through a set of problem solutions. This is an opportunity for a rubric which could be developed with the input of the students.
- Assessment of the ability to identify patterns and predict outcomes of various crosses using the proper terminology will be done on the Unit test.

Accommodations

- Some students may require additional support in developing their problem set.
- For enrichment, students could consider post-Mendelian phenomena such as epistasis (interaction of non-allelic genes) and pleiotropy (producing an effect in more than one trait) as additional background for the debate in Activity 5.7.

Resources

http://www.athro.com/evo/gen/genefr2.html – interactive Punnett Squares for dihybrid crosses of polygenic traits.

http://esg-www.mit.edu:8001/esgbio/mg/mgdir.html – genetics problems requiring the use of the Punnett square as a tool.

Activity 5.6: Genetic Disorders

Time: 270 minutes

Description

The focus of this activity is to establish that the inheritance of a particular genotype may result in an altered phenotype due to the production of an abnormal protein. In inborn errors of metabolism, often the protein is an enzyme or other factor essential to a metabolic reaction. By recalling the inheritance patterns of certain phenotypes from Activity 5.5.3, a greater understanding of the origin and impact of particular genetic diseases and disorders results. By revisiting prior expectations, student knowledge of DNA structure can be applied to the investigation of the gene location (locus) for many diseases/disorders.

Strand(s) & Learning Expectations

Strand(s): Genetic continuity

Learning Expectations

GC1.05 - describe genetic disorders in terms of the chromosomes affected, physical effects, and treatment.
GC2.05 - research genetic technologies using sources from print and electronic media, and synthesize the information gained.
GC3.02 - describe and analyse examples of genetic technologies that were developed on the basis of scientific understanding.
GC3.03 - identify and describe examples of Canadian contributions to knowledge about genetic processes.
GCV.02 - perform laboratory studies of meiosis and analyse the results of genetic research related to the laws of heredity.

Prior Knowledge & Skills

- Knowledge that cells operate as systems from Unit 2: Cellular Basis of Life.
- Knowledge of the function of the ribosome and its dependence upon the nucleus for accurately transcribed mRNA.

Planning Notes

- Collect karyotypes, photographs, case studies, text sources, articles and/or electronic media (list of websites) which students will use in their Jig-Saw Activity to enhance their understanding of particular genetic diseases or disorders.
- Reserve time in the Library/Resource Centre or computer lab for research if the teacher does not provide materials.
- For the pedigree analysis, provide print resources or use electronic sources (most diseases will have a foundation or association website).
- Teachers are reminded of the possibility of sensitive issues arising during this activity, such as personal experience with a disease/disorder, blended families, adoption, etc.

Teaching/Learning Strategies

5.6.1 Student Activity: Following a brief teacher-led pre-lab discussion to introduce the phrase "inborn errors of metabolism" and to recall the effects of mutation on variability, students participate in a Jig-Saw Activity to investigate the inheritance and phenotype of particular genetic diseases or disorders and the use of genetic technologies in their diagnoses. Each individual is assigned a particular inborn error of metabolism with peer teaching and sharing to follow. Each student compiles notes on all of the diseases as a result of the peer teaching and sharing in preparation for a class test on all the genetic diseases covered.

Teacher Facilitation: Establish an understanding that these genetic diseases are a result of faulty protein production at the ribosome, either through a mutation in the DNA or through an error in protein synthesis. The key concept to establish is that a missing or faulty protein causes the manifestation of a malfunctioning (i.e., less adaptive) phenotype. Revisit mutation as a source of variability and its influence on inheritance. After this discussion, students participate in the jigsaw activity to investigate a particular genetic disease or disorder (including Canadian contributions) with the intention that a sharing and peer-teaching exercise will follow. Areas to investigate include: inheritance pattern; phenotype; statistical incidence; gene locus (if possible); faulty protein and its action (if possible); treatment; genetic testing/screening availability; description of genetic technology required for diagnosis or identification. Diseases/disorders to investigate include: cystic fibrosis, muscular dystrophy; Huntington's chorea; sickle-cell anemia; ALS; phenylketonuria; hemophilia; Tay-Sachs disease; Thalassemia. The teacher could provide all resources necessary in the classroom to allow for an efficient exercise (see Planning Notes). Alternatively, Library/Resource Centre research may be necessary.

5.6.2 Student Activity: Students investigate the inheritance of disease using pedigree analysis. The teacher will make print or web site resources available. The implications of ownership of this genetic information knowledge and its use in genetic counselling are introduced. The application of the use of pedigree analysis in dog breeding and in the building of personal "family trees" is noted.

Teacher Facilitation: Provide the resources for analysis either in print or in the use of web-sites (see Resources). Students analyse the pedigrees of actual and/or hypothetical families (e.g., hemophilia in some Royal families) to follow inheritance patterns through gender, carriers and phenotype. The societal implications of "ownership" of personal genetic information and its availability to employers, insurers, schools and/or partners can be introduced as preparation for the final end-of-unit tasks.

Assessment & Evaluation of Student Achievement

- Assessment of the Jig-Saw Activity through the use of a rubric designed specifically for this activity by the students and the teacher.
- Knowledge-based quiz is used to evaluate the inheritance and phenotypes of the diseases.

Accommodations

- Enrichment opportunities arise when studying some diseases such as Huntington's disease (Mature-onset of this disease after childbearing age presents the selfish gene concept.)
- Some students may need additional support during the jigsaw activity.

Resources

Biology Labs On Line http://biologylab.awlonline.com – this site contains a variety of interactive labs, including one on pedigree analysis, but requires a subscription for access.

Activity 5.7: End-of-Unit Tasks

Time: 270 minutes

Description

The end-of-unit tasks for this unit conclude with a fact-based opinion piece of writing. Based on the knowledge and skills obtained throughout the unit, students debate an issue as part of a team and then write an individual reflective piece supported by concepts and facts from the unit.

Strand(s) & Learning Expectations

Strand(s): Genetic Continuity and Diversity of Living Things

Learning Expectations

GCV.03 - outline the scientific findings and some of the technological advances that led to the modern concept of the gene and to genetic technology, and demonstrate an awareness of some of the social and political issues raised by genetic research and reproductive technology;
DLV.03 - relate the role of common characteristics and diversity within the kingdoms of life (including Eubacteria and Archeabacteria) to the importance of maintaining biodiversity within natural ecosystems, and explain the use of micro-organisms in biotechnology;
DL3.01 - explain the relevance of current studies of viruses and bacteria to the field of biotechnology.

Prior Knowledge & Skills

- Knowledge and skills from this unit.
- Introduction to these tasks took place in Activity 5.1

Planning Notes

- Divide students into groups prior to the activity. Be sure that there is a "pro" and "con" team for each debate question chosen.
- Rules for debating should be established prior to the activity. Refer to Appendix 1 below for a suggested debate model and an assessment rubric. Timing may be adjusted as appropriate to the topics and class.

Teaching/Learning Strategies

5.7.1 Student Activity: In small groups, students choose a position (pro or con), conduct further research, organize their team's position and participate in a debate on a particular issue concerning genetic research and society. Debates on three or four different questions allow all students to experience the process of debate on one topic and to record information about other topics.

Teacher Facilitation: Assist the students in brainstorming and selecting appropriate resolutions for debate. It may be necessary for the teacher to provide additional genetic background to groups working on certain topics. For example, the influence of epistatically and pleiotropically interacting genes has implications for some of these topics. Final resolutions to debate may include:

Be it resolved that:

- An individual's genome should be made available to third parties.
- Deleterious genes/alleles should be removed from the gene pool.
- An individual should be informed if he/she is carrying a deleterious gene/allele.
- The information collected from the Human Genome Project should be public domain.
- The government should develop laws to control future genetic research and genetic technologies.
- A couple should be "allowed" to test an embryo for genetic diseases or other traits (such as gender or intelligence).

If there are time constraints a second option is to choose only one question with two large debate teams. The debate teams could be dynamic groups, wherein students who change their stand on an issue are free to move to the "other side" of the issue.

5.7.2 Student Activity: As a result of participating in and witnessing the above debate(s), each student writes a reflective "opinion" piece on one of the questions debated, supporting arguments with concepts and facts from the unit and debates.

Teacher Facilitation: Encourage the students to choose an issue that appeals to them.

Assessment & Evaluation of Student Achievement

- A performance assessment highlighting the Communication and Making Connections Achievement Chart categories can be conducted on the student's debate contribution.
- Learning skills can also be self and peer-assessed using a checklist.
- The reflective piece can be assessed using a checklist or rubric designed by the teacher with input from the students.
- A unit test to evaluate the knowledge and skills of the unit is to be included.

Accommodations

- ESL students may require additional time and assistance with the reflective writing piece.
- This activity represents an extension opportunity for some students to expand their breadth and depth of knowledge through further research.

Appendix 1

Mini-Debates Assignment - Genetics

In this activity, you will be debating one of the following topics in class. You will work in groups of three people to prepare one side (Pro or Con) of one of the resolutions below. You should prepare for the debate by doing research and by preparing notes for the various speakers. During the debate you will also need to take notes to prepare challenging or rebutting arguments for the other side. Your teacher will review the assessment rubric with you.

The debate will involve the following stages:

(a) Introduction (Pro/Con): first debater defines key terms, the point of view of his/her group and his/her fellow debaters (2 minutes).
(b) Speaker(s) (Pro/Con): second debater from each side introduces the main arguments and facts/examples in support of the group's point of view (3-4 minutes).
(c) Rebuttal (Pro/Con): both sides state counter-arguments to the opposing and/or weaknesses in the opposing side's arguments or use of facts (any member of the team may speak) (2 minutes).
(d) Conclusion: third debater summarizes the key points made by the team and answers questions (1 minute – more time for questions).

Here are sample resolutions.

Be it resolved that:

- An individual's genome should be made available to third parties.
- Deleterious genes/alleles should be removed from the gene pool.
- An individual should be informed if he/she is carrying a deleterious gene/allele.
- The information collected from the Human Genome Project should be public domain.
- The government should develop laws to control future genetic research and genetic technologies.
- A couple should be "allowed" to test an embryo for genetic disease.

Debate Planning Sheet – Answer these questions on a sheet of notepaper.

Name: _____ Working with: _____

Debate Topic: _____

1. What are you trying to prove in your side of the debate?
2. List three to five arguments and/or facts that you can use to support your side of the debate.
3. List one to two arguments you are certain that the opposing side will use to support its side.
4. Explain at least one way in which you could challenge the arguments of the opposition.
5. Explain how you will divide the responsibilities for speaking in the debate:
   (a) introduction
   (b) main arguments
   (c) conclusion
   (d) rebuttals (person mainly responsible)
6. What areas will you need to research for your debate to provide arguments and examples?
7. In what ways can you prepare and practise to make your debating more interesting and persuasive?

Appendix 1 (Continued)

Rubric for a Class Debate

Categories/ Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-89%)
Knowledge **Communication** Clear articulation of position	- position is not clearly stated	- position is recognized, but only clarified through prompting	- a clear position is stated	- a clear position is stated and fully articulated
Knowledge **Making Connections** **Communication** Provides support for position	- limited support for initial position	- support for initial position is present but lacks clarity of presentation	- support for initial position is clearly presented and reasoned based on evidence	- supporting arguments for position are both reasoned and persuasively presented
Knowledge **Making Connections** **Communication** Considers other positions	- limited sensitivity to other positions	- other positions acknowledged but not considered	- other positions acknowledged and considered	- other positions considered and effectively incorporated or countered
Knowledge **Making Connections** **Communication** Effectively critiques positions	- limited sensitivity to opponents and their positions	- opposing views acknowledged and moderately critiqued or dealt with	- opposing views acknowledged and effectively critiqued	- opposing views effectively critiqued and opponents treated with sensitivity

Note: A student whose expectations are below level 1 (50-59%) has not met the expectations for the assignment or activity.