Public District School Board Writing Partnership

Science

Course Profile

Biology

Grade 12
University Preparation
SBI4U

• *for teachers by teachers*

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Course Overview
Biology, SBI4U, Grade 12, University Preparation

Policy Document: *The Ontario Curriculum, Grades 11 and 12: Science, 2000.*
Prerequisite: Biology, SBI3U Grade 11, University Preparation

Course Description

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

Course Notes

The Goals of Grade 12 Biology

SBI4U has three goals as identified in The Ontario Curriculum, Grades 11 and 12: Science, 2000, (p. 4):

- 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. A design-down approach was used in developing the overall course and individual units. The Final Assessment Tasks for the course were developed first, followed by the End-of-Unit Tasks. The Expectations in each unit were clustered into activities that connected together logically and provided the necessary background knowledge and skills to be applied in the completion of the End-of-Unit Tasks. However, this is by no means the only possible clustering. The unit activities were then expanded following each overview chart. The suggested activities are intended to be neither restrictive nor prescriptive; instead, the intent is to provide teachers with suggestions for course development. Teachers should adapt the profile to suit their circumstances and to match the students' needs while ensuring that all learning expectations of the course are addressed fully.

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 also in all areas of life.

This is emphasized in *The Ontario Curriculum, Grades 11 and 12: Science, 2000*, (p. 6): "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, SBI4U must adequately prepare those students who will opt for further study of the subject in university and other postsecondary institutions. It is important to note that SBI4U is a university preparation course and not a copy of a first-year university course in biology.

Knowledge and skills must be learned, practised, assessed, and evaluated at a standard that enables students to assess realistically their aptitude and chances for success in further studies in biology and possible employment in a related field.

Students would benefit from visits by guest speakers employed in a variety of biology-related careers. These individuals can relate first-hand experience as to how biological knowledge is applied in the workplace, as well as information about postsecondary education requirements. A nutritionist or a personal trainer would enhance either the Metabolic Processes or Homeostasis unit, while a wildlife biologist would contribute significantly to the delivery of the Population Dynamics unit.

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 (*The Ontario Curriculum, Grades 11 and 12: Science, 2000*, 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 are called Science Investigative Skills (SIS). For SBI4U, they are found on p. 33 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 12 Biology

As teachers organize and plan the delivery of Expectations of SBI4U, using and/or adapting activities described in this profile, they should consider the following:

- SBI4U 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
- 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.
- Students interpret new information in terms of what they already know. They try to make sense of what is taught by trying to fit it with their experiences. A key concept is understood when students examine significant examples that represent the concept, then create a generalization from those personal experiences. The teacher must be aware of the experiences that students have had prior to Grade 12 and use them as the basis 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 clarifying concepts using concrete examples may be required at times. A number of diagnostic tools and activities are suggested throughout the profile.
- Terminology should be viewed by students as a 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, to interpret the answers critically, and to identify unstated assumptions.

Resources

Resources are listed throughout the unit overviews and the full unit, wherever the writers felt it provided the most support for teachers.

The URLs for the websites were 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.

Units in this course profile make reference to the use of specific texts, magazines, films, videos, and websites. Teachers need to consult their board policies regarding use of any copyrighted materials. Before reproducing materials for student use from printed publications, teachers need to ensure that their board has a Cancopy licence and that this licence covers the resources they wish to use. Before screening videos/films with their students, teachers need to ensure that their board/school has obtained the appropriate public performance videocassette licence from an authorized distributor, e.g., Audio Cine Films Inc. Teachers are reminded that much of the material on the Internet is protected by copyright. The copyright is usually owned by the person or organization that created the work. Reproduction of any work or substantial part of any work on the Internet is not allowed without the permission of the owner.

Many of the resources used in OS:IS Biology courses will be applicable to SBI4U. The following are some suggestions:

Blake, Leesa, et al. *McGraw-Hill Ryerson Biology 12*. McGraw-Hill Ryerson Limited, 2002. ISBN 0-07-088713-6

Campbell, Neil A. *Biology,* 5th ed. Menlo Park, Calif: Benjamin/Cummings Publishing. 2000. ISBN 0805365737

Keeton, W. and J. Gould. *Biological Science*. New York: W.W. Norton Co., 2000. ISBN 0393969495

Nelson, D. and M. Cox. *Lehninger Principles of Biochemistry*. New York: Worth Publishing, 2000. ISBN 1572599316

Ritter, Robert, et al. *Nelson Biology 12.* Nelson Thomson Learning 2002. ISBN 0-17-612144-7

The two resources listed below offer excellent suggestions for cooperative work groups and the use of graphic organizers such as concept maps.

Bennet, Barrie and Carol Rolheiser. *Beyond Monet – The Artful Science of Instructional Integration*. Toronto: Bookation, Inc., 2001. ISBN 0-9695388-3-9

Barton, Mary Lee and Deborah L. Jordan. *Teaching Reading in Science: A Supplement to Teaching Reading in the Content Areas Teacher's Manual.* Aurora: McRel, 2001. ISBN 1-893476-03-0

Magazines

Popular Science, Times Mirror Magazines
– http://www.popsci.com

Discover Magazine, Disney Corp. – http:// www.discover.com

National Geographic
http://nationalgeographic.com

Scientific American
– http://www.sciam.com

Rationale for the Unit Sequence of the Course Profile

The Metabolic Processes unit requires students to review basic biochemistry from the SBI3U course and introduces appropriate new models and reactions for the other strands in the 4U course. As an introductory unit, it offers several opportunities to assess inquiry skills and problem-solving abilities. The Final Assessment Task for the course will be introduced during this unit and preparations will begin with an End-of-Unit Task that requires students to design a model of an effective "metabolic factory" and present their work in the format of a model, poster or creative display of their choosing.

Studying biochemical processes provides excellent background for examining the chemical changes involved in the maintenance of homeostatic balance within living organisms. For that reason, Homeostasis is the second unit in this profile. Opportunities to use graphic organizers to communicate systems are found throughout this unit. There are also opportunities for dissection (kidney, brain, eyes) and development of the inquiry process. The use of a graphic display in the End-of-Unit Task will also serve to prepare students for the Final Assessment Task.

Molecular Genetics is the third unit presented in this profile. The systems described in the first two units are largely enzyme-controlled, making this unit, which is focused on the transcription and translation of proteins, an ideal follow up. This unit also offers much in the way of ethical issues on genetic research and manipulation. The End-of-Unit Task requires students to research and prepare an analytical report arguing a specific societal issue in the realm of genetic advances.

The Evolution unit relies on an understanding of modern genetics as old theories are presented and implications of modern science discussed. It is important that teachers focus on teaching this unit through a scientific model of how living things have evolved, avoiding the trap of devoting too much time to religious and cultural interpretations/views. There are also many misconceptions surrounding Human Evolution as proposed by Charles Darwin that should be addressed early in the unit. The End-of-Unit Task requires students to propose a specific evolutionary pathway for a given organism and write a supported opinion piece to justify their proposal.

Unit 5, Population Dynamics, could just as easily be used as the initial unit. It does not directly require background from any of the other strands and so can conveniently be moved to fit the semester, allowing teachers to take students outside for population studies. If this unit (or any other) is selected as the first unit, the concepts of the initial inquiry activities suggested in the expanded unit should be transferred to the selected unit. The End-of-Unit Task is the development of a human population growth timeline.

The Final Assessment Task requires students to apply information and skills developed throughout the course. Students will choose to study either a genetically modified product or a metabolic disorder. The focus of the task is to connect the topic to all of the units covered and show these connections using their choice of visual display.

One method of organizing a unit is to focus the activities on a current event. Many current science news stories are biological in nature. The homeostasis unit might use blood doping at the Olympics; molecular genetics might centre on stem cell research. The issue used could be local or global. This approach will help students realize the STSE connections and build on their curiosity. The content of the unit can be used to provide background for more complete understanding of an issue, and as a means of clarifying misconceptions that students may have surrounding the issue.

Rubrics for some of the End-of-Unit Tasks have been included (Appendices A and B) to help in the planning of the course and assignments. End-of-Unit Tasks were designed to give students a variety of formats for assessment throughout the semester and the tools to prepare a successful Final Assessment Task product. It should be noted that the expectations for the various strands in this course often look misleadingly limited, however, closer inspection indicates that these expectations have multiple layers that often require several activities to achieve successfully. It is important to refer to the overall expectations when looking at time allotments in each of the strands. There is justification to use a midterm exam in this course. By combining two units together, students are given the opportunity to prepare for a more comprehensive written examination. This would in effect act as a practice for the final examination, but still be a part of the (70%) term assessment. If a midterm examination is given after the first two units, making connections questions that link the two units can be posed.

Units: Titles and Times

* Unit 1	Metabolic Processes	22 hours
Unit 2	Homeostasis	20 hours
Unit 3	Molecular Genetics	20 hours
Unit 4	Evolution	20 hours
Unit 5	Population Dynamics	18 hours
Unit 6	Final Assessment Tasks	10 hours

* This unit is fully developed in this Course Profile.

Unit Overviews

Unit 1: Metabolic Processes

Time: 22 hours

Unit Description

In this unit, students explore the biochemical pathways organisms use to create metabolically useful energy. Students examine energy transformations in living cells through examination of the structure and function of biologically essential macromolecules and a series of laboratory investigations. This unit has a strong experimental-inquiry focus where students can improve their skills in formulating testable questions and designing and carrying out investigations. The unit culminates with an oral presentation explaining the design of their effective "metabolic factory."

Unit Overview Chart

Activity/Time/Focus	Learning Expectations	Assessment Categories
1.1 Biological Molecules 4 h	MPV.01, MPV.02, MP1.02, MP2.01, MP2.02, MP2.03 SIS.02, SIS.03, SIS.07, SIS.08, SIS.09	Knowledge/Understanding Inquiry Communication
1.2 Thermodynamics and Reactions 2 h	MPV.01, MPV.02, MP1.01, MP1.04, MP2.01 SIS.06	Knowledge/Understanding Communication Making Connections
1.3 All about Enzymes 5 h	MPV.01, MPV.02, MPV.03, MP1.03, MP2.03, MP2.04, MP3.02 SIS.01, SIS.02, SIS.03, SIS.07, SIS.10	Inquiry Communication Making Connections
1.4 Cellular Respiration and Photosynthesis 7 h	MPV.01, MPV.02, MPV.03, MP1.05, MP1.06, MP2.05, MP2.06, MP3.01, MP3.03, HS3.02 SIS.01, SIS.02, SIS.03, SIS.04, SIS.05, SIS.06, SIS.07	Inquiry Communication Knowledge/Understanding Making Connections
1.5 End-of-Unit Task: Designing an Effective Metabolic Factory 4 h	MPV.01, MPV.02, MPV.03 SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections

Unit 2: Homeostasis

Time: 20 hours

Unit Description

Through analysis of a variety of changing conditions, students examine the complexity of homeostatic mechanisms, including those used in the maintenance of water, ionic, thermal and acid-base equilibria, and construct models to illustrate them. This unit provides students with applications of biochemistry studied in the first unit, and links to the animal anatomy and physiology unit in SBI3U. Students consider the impact of environmental factors on the maintenance of homeostasis, and examine related societal issues. The unit culminates in the production of a graphic organizer illustrating the effect of an environmental factor on a homeostatic mechanism.

Unit Overview Chart

Activity/Time/Focus	Learning Expectations	Assessment Categories
2.1 Homeostatic Mechanisms 7 h	HSV.01, HSV.02, HS1.01, HS1.04, HS2.01, HS2.03, HS2.04 SIS.03, SIS.05, SIS.06	Knowledge/Understanding Inquiry Communication Making Connections
2.2 Reproduction 1 h	HSV.01, HSV.02, HS1.02, HS2.01, HS2.04 SIS.06, SIS.10	Knowledge/Understanding Communication
2.3 The Kidney and Homeostasis 8 h	HSV.01, HSV.02, HSV.03, HS1.03, HS1.04, HS2.02, HS2.04, HS3.01, HS3.02, HS3.03 SIS.01, SIS.02, SIS.03, SIS.05, SIS.07, SIS.09, SIS.10	Knowledge/Understanding Inquiry Communication Making Connections

Activity/Time/Focus	Learning Expectations	Assessment Categories
2.4 Human Health 2 h	HSV.01, HSV.02, HS1.04, HS1.05, HS1.06, HS2.01 SIS.06	Knowledge/Understanding
2.5 End-of-Unit Task: Graphic Display 2 h	HSV.01, HSV.02, HSV.03, HS1.01, HS1.04, HS1.06, HS2.01, HS2.04, HS3.01 SIS.05, SIS.06	Knowledge/Understanding Inquiry Communication Making Connections

Suggested Activities

Homeostatic Mechanisms

2.1.1 Students complete a diagnostic activity related to human organ systems – circulatory, respiratory and digestive. A review of SBI3U may be necessary so that students can make the necessary connections between homeostatic mechanisms and the various organ systems.

2.1.2 Students formulate a testable question, design, and conduct an experiment using earthworms or other invertebrates to study the response to external stimuli, e.g., light or temperature.

2.1.3 Conduct a class discussion to explain the mechanisms an earthworm uses to respond to change. Information about the anatomy and physiology of the earthworm's nervous system is provided to the students to aid in the discussion. The students construct a flow chart illustrating the homeostatic mechanism used by the earthworm in response to the change. Introduce the End-of-Unit Task (Activity 2.5) and make reference to the Final Assessment Tasks. Time is given for clarification questions.

2.1.4 Working in pairs, students examine the response of the human eye to changes in light, and compile their data. Conduct a class discussion to explain the mechanisms used by a human to respond to change. Information about the anatomy and physiology of the human nervous system is provided to the students to aid in the discussion. A comparison of the complexity of the nervous systems of earthworms and humans, and the relationship between complexity and the ability to respond to change is made. Dissection/models/simulation of the cow/sheep eye as an example of a receptor (specialized nerve ending) in the PNS or the sheep brain in a discussion of the CNS as the processing centre may be used in the anatomy and physiology lesson. Safety caution: proper use and disposal of biological specimens.

2.1.5 Students brainstorm a list of changing temperature conditions that a human being might face during a one-year period. Through class discussion and direct instruction, students examine the homeostatic mechanisms used for thermal regulation. The need for a link between the nervous system and the endocrine system is emphasized. Students construct a flow chart illustrating the response of humans to changing temperatures.

2.1.6 Working in small groups, students research one endocrine gland and present information about the anatomy and physiology of this gland to the class. Each student creates a table summarizing the anatomy and physiology of the endocrine system, stressing the connections among the various glands and the other organ systems.

Assessment Lab design and report (Inquiry), Flow Charts (Knowledge/Understanding, Communication, Making Connections), Quiz (Knowledge/Understanding)

Reproduction

2.2.1 Students examine the action of the hormones in the male and female reproductive systems. They construct a flow chart to illustrate the action of these hormones.

2.2.2 Inquiry Activity: Given data tables, students graph the female hormone levels over the period of a month. Students also consider changes in hormone levels in males. They then examine the effect of changing the hormonal balance in males or females, e.g., the use of birth control pills, the use of hormones in reproductive technology, the development of a male "pill." Students could explore careers related to reproductive technology and/or participate in a visit from a fertility specialist during this section.

Assessment Flow Chart (Knowledge/Understanding, Communication), Quiz (Knowledge/Understanding)

The Kidney and Homeostasis

2.3.1 Students examine the anatomy and physiology of the kidney. They focus on the role of the kidney in maintaining water, ion and acid/base balance. Dissection/models/simulation of cow/sheep kidney may be used in anatomy lesson.

2.3.2 Students design and carry out an experiment to investigate the feedback systems of the kidney. For example, students could examine the effect of increasing or decreasing water intake or the effect of caffeine. They present their findings as a graphic organizer (diagram, flow chart, table and/or graph).

2.3.3 Students research the effects of chemical substances, e.g., steroids, creatine, vitamins on the kidney. Students create an information sheet about the effects of one substance. These sheets could be collated into one package as a resource for Activity 2.5.

2.3.4 Based on the results of Activity 2.3.3, students examine the impact of lifestyle choices on the healthy functioning of the kidney. Students investigate current medical treatment options, including Canadian contributions. Students write an opinion piece about the relationship between lifestyle choices and treatment, e.g., Should a person who has used steroids be eligible for the kidney transplant list? What legislation should exist concerning the use of performance-enhancing drugs? Students could explore careers related to health care during this section.

Assessment Graphic Organizer (Inquiry, Communication, Knowledge/Understanding), Information Sheet (Communication, Making Connections), Opinion Piece (Communication, Making Connections)

Human Health

2.4.1 The teacher directs a lesson on the mammalian immunological response to a viral or bacterial infection and to allergens, incorporating the connection between homeostatic mechanisms and environmental "invaders." A discussion of the effect of medical treatments on homeostasis is included.

2.4.2 Students modify a previous graphic organizer to illustrate the effect of a viral or bacterial infection or allergen on the homeostatic response of the system.

Assessment Flow Chart (Knowledge/Understanding), Quiz (Knowledge/Understanding)

End-of-Unit Task: Graphic Display

2.5.1 Students choose a factor, e.g., a drug, an infection, an environmental change that impacts on the homeostasis of one element, e.g., water, ionic, thermal, acid/base equilibria. They research and create a graphic display illustrating the normal homeostatic mechanisms at work to maintain equilibrium of that element and the impact of the chosen factor.

2.5.2 A written test may be used to assess this unit.

Assessment Graphic Organizer Knowledge/Understanding, Inquiry, Communication, Making Connections), Unit Test (Knowledge/Understanding, Making Connections)

Resources

Homeostasis, a 6-part TVO series, 1984.

– http://www.colorado.edu/epob/academics/web_resources/cartoons/index.html
A collection of biology cartoons that illustrates some of the basic principles of biology, including homeostasis.

– http://www.ultranet.com/~jkimball/BiologyPages/K/Kidney.html
An overview of the role of the kidney in urine formation and homeostasis, including the role of hormones and the use of dialysis.

– http://www.liv.ac.uk/~petesmif/teaching/1bds_mb/notes/homeo/kidney.htm
An overview of the role of the kidney in homeostasis.

– http://www.tmc.tulane.edu/ecme/eehome/basics/endosys/glands.html
A summary chart of the products of the major endocrine glands.

– http://www.gen.umn.edu/faculty_staff/jensen/1135/webanatomy/wa_endocrine/
An interactive quiz site about the endocrine system.

Unit 3: Molecular Genetics

Time: 20 hours

Unit Description

In this unit, students examine the structure and function of DNA and RNA, and their role in protein synthesis and control of gene expression. Students investigate the advances in knowledge about genetics during the 20th and 21st centuries and, using the most current information available, explore a variety of genetic technologies. The unit culminates with the preparation of an analytical report summarizing the students' recommendations for the regulation of a genetic technology presented by classmates. There are many connections between the content of this unit and current events – cloning, xenotransplantation, stem cell research, genetically modified foods, genetic (DNA) profiling, etc. Any one of these issues could provide a theme or connecting thread for this unit.

Unit Overview Chart

Activity/Time/Focus	Learning Expectations	Assessment Categories
3.1 Structure and Function of DNA and RNA 2 h	MGV.01, MGV.02, MG1.01, MG1.02, MG2.01 SIS.02, SIS.03, SIS.04, SIS.06, SIS.07	Knowledge/Understanding Communication
3.2 Protein Synthesis 6 h	MGV.01, MGV.02, MG1.01, MG1.03, MG1.04, MG2.02, MG2.03 SIS.01, SIS.02, SIS.03	Knowledge/Understanding Inquiry
3.3 Genetics: Past, Present and Future 5 h	MGV.01, MGV.02, MGV.03, MG1.07, MG2.04, MG3.01, MG3.02 SIS.05, SIS.06	Knowledge/Understanding Inquiry Communication Making Connections
3.4 Genetic Engineering 6 h	MGV.01, MGV.02, MGV.03, MG1.05, MG1.06, MG2.01, MG3.01, MG3.02 SIS.02, SIS.04, SIS.05, SIS.06, SIS.10	Inquiry Communication
3.5 End-of-Unit Task: Analytical Report 1 h	MGV.01, MGV.02, MGV.03, MG1.05, MG1.06, MG1.07, MG2.04, MG3.02	Knowledge/Understanding Communication Inquiry Making Connections

Suggested Activities

Structure and Function of DNA and RNA

3.1.1 As a starting point, students build models of DNA and RNA, describe the structure and function of the molecules, and simulate the replication process of DNA. Students use a graphic organizer, e.g., T-chart or Venn diagram to compare the structure and function of DNA and RNA. This begins building the background knowledge necessary for completion of the End-of-Unit Task. This task, an analytical report on reproductive issues, is introduced to the students at this point, with time allowed for clarification questions.

3.1.2. Inquiry Activity: Students design and conduct an investigation into the process of DNA replication in the cell using model kits and text references. They also examine methods of repair for DNA during replication.

3.1.3 Students compare DNA sequences of a segment of DNA coding for a particular enzyme from humans and another animal. Discussion should emphasize the structure and generalities of the genetic code.

Assessment Graphic Organizer (Knowledge/Understanding, Communication)

Protein Synthesis

3.2.1 Teacher-led discussion of the steps involved in protein synthesis, including the role of DNA and RNA. A variety of simulations, models, videos and games are available commercially and online to assist in the comprehension of this material.

3.2.2 Students examine micrographs illustrating the process of protein synthesis. Based on the information learned in Activity 3.2.1, they identify the structures involved in protein synthesis and explain the role of each. As a quiz, students examine micrographs of cells that are missing key components for protein synthesis. They explain the impact of the change on the process of protein synthesis.

3.2.3 Students complete a lab activity related to protein synthesis. Options include extracting DNA, analysing different proteins or separating DNA or polypeptides using electrophoresis. A computer simulation of the electrophoresis process could be considered in schools where electrophoresis equipment is not available.

3.2.4 Using the lac operon model as an example, the teacher leads a discussion about the control of gene expression.

3.2.5 Students complete a simulation activity illustrating the effect of mutations on protein synthesis. Students choose a specific disorder resulting from a mutation, research the mutation which causes the disorder, and prepare a data sheet which explains the difference between the "normal" protein and the "mutated" protein. Students participate in a class discussion about the causes of mutations.

Assessment Quiz (Knowledge/Understanding, Inquiry), Lab Activity (Inquiry), Data Sheet (Knowledge/Understanding)

Genetics: Past, Present, and Future

3.3.1 Students view a short clip from a science fiction video related to genetic issues, or read an excerpt from a science fiction novel related to genetic issues. They analyse the clip for fact and fiction according to their most recent knowledge about genetics.

3.3.2 Working in small groups, students are assigned an appropriate time period, e.g., a decade. They research the key discoveries in the field of genetics during the time period, including the scientists involved in the discovery where possible. They assemble the information into a timeline. Groups present the timelines in chronological order. Students revisit and update their analysis of the science fiction clip based on the timelines. Students write a reflection paper about the impact of one discovery (from a decade researched by another group) on their current understanding of genetics.

3.3.3 Lead a class discussion about the ethical issues resulting from knowledge of genetics. Students investigate current legislation surrounding biotechnology in Canada. This information will be needed in Activity 3.4. Revisit the End-of-Unit Task (Activity 3.5) and make reference to the Final Assessment Tasks.

Assessment Timeline (Knowledge/Understanding, Inquiry, Communication), Reflection paper (Making Connections, Communication)

Genetic Engineering

3.4.1 Students participate in a lab activity or simulation demonstrating the processes of genetic engineering, e.g., they simulate the insertion of a new gene into a bacterial plasmid. Students extend this knowledge by exploring the techniques involved in a variety of biotechnological applications, e.g., cloning, genetically modified food, DNA profiling, stem cell research, xenotransplantation.

3.4.2 Students choose one genetic technology explored in Activity 3.4.1. They research and present information to the class about the development of the technology, the advantages and disadvantages of the technology, the ethical issues arising from its use, and existing regulations. This information will be used by classmates in Activity 3.5. Students could explore careers in biotechnology during this section.

Assessment Lab Activity (Inquiry), Presentation (Inquiry, Communication)

End-of-Unit Task: Analytical Report

3.5.1 Students view presentations about genetic engineering issues prepared as part of Activity 3.4.2. Individually, students prepare an analytical report summarizing the background knowledge about one genetic technology, and their recommendations for drafting laws to regulate the genetic technology (not the technology they originally presented.)

3.5.2 A written test may be used to assess this unit.

Assessment Analytical Report (Making Connections, Communication, Inquiry), Test (Knowledge/Understanding, Making Connections)

Resources

Nelson, D. and M. Cox. *Lehninger Principles of Biochemistry*. New York: Worth Publishing, 2000. ISBN 1572599316

Protein Synthesis, a 6-part TVO series, 1984.

– http://photoscience.la.asu.edu/photosyn/courses/BIO_343/lecture/DNA-RNA.html
A summary of the basic genetic information, with links to other topics, such as genetic engineering and the Human Genome Project.

– http://esg-www.mit.edu:8001/esgbio/dogma/dogma.html
A summary of the central dogma of DNA.

– http://gened.emc.maricopa.edu/bio/bio181/BIOBK/BioBookPROTSYn.html
A summary of the basic genetic information, including some good graphics.

– http://tipnet.taranaki.ac.nz/~mfenton/TRAIN/dna.htm
One of many websites available which gives instructions for the extraction of DNA.

– http://library.thinkquest.org/C0111983/timeline.html
A timeline of genetic discoveries, to 1998.

– http://www.google.com/search?q=genetics+time+line&hl=en
A timeline of biotechnology, to 2001.

– http://www.accessexcellence.org/
A collection of resources for biology teachers, including lesson plans, and background information.

Unit 4: Evolution

Time: 20 hours

Unit Description

In this unit, the theory of evolution and the evidence that supports it are explored thoroughly. Students are expected to trace modern mechanisms for speciation and the influence of scientific discovery on developments in the field of evolution. The End-of-Unit Task requires students to assimilate information from the unit and hypothesize as to the ancestral history and development of a present day organism. Mechanisms for its evolution should be proposed and supporting evidence presented (or an inquiry design to derive the evidence proposed). The contrast between the natural forces driving evolution and modern technological forces is a key to connecting this unit to other units in the course, e.g., genetics, populations.

When teaching this unit, it is important to emphasize the focus on scientific explanations of evolution; the unit is not designed to challenge students' religious or cultural beliefs, but rather to provide them with background on a scientific theory.

Unit Overview Chart

Activity/Time/Focus	Learning Expectations	Assessment Categories
4.1 Theories and Evidence for Evolution 6 h	EVV.01, EVV.02, EVV.03, EV1.02, EV2.01 EV2.05, EV3.02 SIS.02, SIS.03, SIS.05, SIS.06, SIS.07	Communication Inquiry Knowledge/Understanding Making Connections
4.2 Mechanisms of Evolution 6 h	EVV.01, EVV.02, EVV.03, EV1.03, EV2.03, EV2.05, EV3.01 SIS.03, SIS.05, SIS.08, SIS.09	Communication Inquiry Knowledge/Understanding Making Connections
4.3 Speciation 4 h	EVV.01, EVV.02, EV1.01, EV1.04, EV2.02 EV2.04 SIS.03, SIS.04, SIS.05, SIS.06, SIS.08, SIS.09	Communication Inquiry Knowledge/Understanding Making Connections
4.4 End-of-Unit Task: The Evolution of an Organism 4 h	EVV.01, EVV.02, EVV.03 SIS.05, SIS.06	Communication Inquiry Knowledge/Understanding Making Connections

Suggested Activities

Theories and Evidence for Evolution

4.1.1 Working in groups (and using pictures, symbols, or written responses), students complete a graffiti activity using chart paper to record answers to questions such as, "What is a theory?" and "What is evolution?" As a follow-up, the graffiti is presented and discussed. Special emphasis is given to correcting misconceptions.

4.1.2 As an introduction to a jigsaw activity, the theory of evolution is described and the historical development of the theory briefly outlined. A brief and sensitive discussion of cultural differences may be appropriate at this time. During the jigsaw activity, expert groups focus on the contributions of Lyell, Malthus, Lamarck, Darwin, Gould and Eldridge. When home groups come back together, each student organizes the information logically, e.g., into a chart set up chronologically, indicating: Significant Dates; Scientist; and Contributions.

4.1.3 This is a teacher-led lesson. The evidence for evolution is outlined with particular focus on paleontology, embryology, anatomy, biochemical structure and function and geographic distribution. The role of technology in extending and modifying the understanding of the theory of evolution is discussed.

4.1.4 Students are assigned one of the areas of evolutionary evidence (from 4.1.3). They must research the origin of this evidence and summarize it in a graphic organizer (flow chart, Venn diagram, concept map). Discussion of how technology has advanced/refuted this form of evidence is discussed, e.g., Buffon originally proposed the idea of transfer of characteristics from parent to offspring – genetics has extended this immensely.

4.1.5 Students design and conduct an investigation of the evidence for evolution. Possible examples include:

- a simulation of different animal serums that are analysed based on reactions with human antiserum. Results indicate ancestral relatedness.
- a study of different skeletons or single bone structures. Similarities may indicate ancestral relatedness.
- an Internet or software-based examination of DNA structure, cell structure or amino acid sequencing in different organisms. Similarities may indicate ancestral relatedness.

4.1.6 Students work in small groups to examine historical perspectives of the evidence for the theory of evolution. They consider the time before Darwin's publication of *The Origin of the Species*, the public's response to Darwin in Victorian England, and the Scopes monkey trial in Tennessee, in the 1920s. Students need to be aware of how and why theories change with the discovery of new evidence, as well as questions that are not explained by the theory. Groups share the results of their discussion with the class.

Assessment Chart (Communication, Knowledge/Understanding),
Graphic Organizer (Communication, Inquiry),
Lab Report (Inquiry, Making Connections),
Presentation (Making Connections)

Mechanisms of Evolution

4.2.1 The teacher leads a lesson where the mechanisms and models for evolution are outlined. Terminology such as natural selection, sexual selection, genetic variation, genetic drift, artificial selection and biotechnology are emphasized. The central role of the environment in dictating the direction of evolution (disruptive, stabilizing or directional) is discussed.

4.2.2 Given a particular evolutionary scenario, e.g., industrial melanism, students prepare an explanation (a brief written report) of the connection between evolutionary mechanism involved and how this mechanism is related to biodiversity and extinction in terms of variations within species.

4.2.3 Following a brief teacher-led introduction to the Hardy-Weinberg Law, students design and carry out an investigation to explain factors that lead to evolution. Use beans of different colours or sizes or confetti pieces of different colours to illustrate the tendency toward selection. Hypothesize genotype frequency of future generations using mathematical equations and compare these to results from the investigation.

4.2.4 Conduct a discussion on genetics and evolution. Using current articles or medical periodicals, relate evolutionary mechanisms to ideas in molecular genetics. Topics may include: adaptations of microorganisms to medical technology, mutations and evolution, cloning, and a variety of genetic engineering applications.

Assessment Report (Communication, Knowledge/Understanding, Making Connections),
Lab Report (Communication, Inquiry, Knowledge/Understanding),
Quiz (Knowledge/Understanding)

Speciation

4.3.1 Revisit the End-of-Unit Task, making reference to the Final Assessment Task as well.

4.3.2 Using Darwin's observations of the finch as a model for studying variation in species, students design and conduct an investigation into the frequency of occurrence of various hereditary traits in a given population of organisms. Information gathered is used to emphasize the variations with populations.

4.3.3 The teacher leads a lesson as a quick review of the organization of living things based on similarities (into kingdom, phylum, class, etc.) focusing on the definition of species. The mechanisms of speciation are outlined with reference to natural (disruptive) selection. Timelines of evolution and models of speciation (phyletic gradualism and punctuated equilibrium) are developed as a class. A follow-up activity requires students to draw connections between lifespan/reproductive cycles and evolution, and complete a comparison between human evolution and bacterial evolution using a Venn diagram.

4.3.4 In a brainstorming activity, students propose investigative questions that arise from an understanding of diversity and evolution. Connections with domestication, breeding, mimicry and camouflage should be made, and the nature of variations within populations discussed. The teacher introduces the topic of rapid evolution of certain species of microorganism and the impact on pharmaceutical companies. Students may be asked to respond to a related news article.

Assessment Lab Report (Inquiry, Knowledge/Understanding),
Venn Diagram (Communication, Making Connections),
Questions on Article (Knowledge/Understanding, Making Connections)

End-of-Unit Task: The Evolution of an Organism

4.4.1 Students will each be assigned a present-day organism. They research and describe the organism's possible ancestors and propose a theory and mechanism for the evolution of the present organism from the ancestor. Intermediate species should be described and the mechanism should include the pressures that led to each. The report should be written as a supported opinion piece that continually justifies the proposed mechanism as being the most reasonable explanation for evolution of their given organism. See the "Evolution Mechanism" rubric in Appendix A.

4.4.2 Unit test.

Assessment Supported Opinion Paragraph (Communication, Inquiry, Making Connections)
Unit Test (Knowledge/Understanding, Making Connections)

Resources

Organic Evolution, a 6-part TVO series, 1984.

– http://cas.bellarmine.edu/tietjen/images/Evolanimal_diversity.htm
link to sites on evolution basics, evidence, mechanisms and other resources.

– http://www.bbc.co.uk/education/darwin/index.shtml
information on Charles Darwin and his contributions.

– http://www.pbs.org/wgbh/evolution/educators/course/index.html
online course for teachers teaching evolution – great links to evolution sites for students as well.

– http://www.ucmp.berkeley.edu/history/evolution.html
link to tracing the historical development of evolution.

– http://www.chineseprehistory.org//
fossil evidence of human evolution in China.

– http://www.cs.colorado.edu/~lindsay/creation/
creation vs. evolution commentary.

– http://www.becominghuman.org/
human evolution information and evidence.

Unit 5: Population Dynamics

Time: 18 hours

Unit Description

Designed as an overview of population dynamics, this unit focuses on the effects of relationships within ecosystems and other factors that regulate and limit population growth. The carrying capacity of Earth will also be studied in terms of human population trends. The End-of-Unit Task is a timeline of changes that have contributed to the increase in the growth rate of the human population over the last 10 000 years. Quizzes in this unit are used to check the quality of note-taking skills that have been developed, and therefore focus on information presented in class discussions and teacher-led lessons.

Unit Overview Chart

Activity/Time/Focus	Learning Expectations	Assessment Categories
5.1 Interactions 3 h	PDV.01, PDV.02, PD1.01, PD2.02, PD2.03, SIS.02, SIS.03, SIS.04, SIS.09, SIS.09	Communication Inquiry Making Connections
5.2 Population Growth 3 h	PDV.01, PDV.02, PD1.02, PD1.03, PD2.01 SIS.02, SIS.04, SIS.06, SIS.08, SIS.09	Communication Inquiry Knowledge/Understanding
5.3 Agricultural Resources 4 h	PDV.01, PDV.03, PD1.04, PD3.01, PD3.02 SIS.05, SIS.06	Communication Knowledge/Understanding Making Connections
5.4 Human Population: Growth and Impact 3 h	PDV.01, PDV.02, PDV.03, PD1.05, PD1.06, PD2.04, PD3.03 SIS.05, SIS.10	Inquiry Knowledge/Understanding Making Connections Communication
5.5 End-of-Unit Task: Timeline 5 h	PDV.01, PDV.02, PDV.03 SIS.05, SIS.06	Communication Inquiry Knowledge/Understanding Making Connections

Suggested Activities

Interactions

5.1.1 Students take part in a discussion related to interactions within ecosystems. A specific ecosystem is chosen (could be as large as a swamp or as small as a classroom aquarium) and a list of plants, animals, and other organisms living in that system generated. Review biological organization and group organisms based on an ecological hierarchy. Students then draw as many connections as possible among the organisms based on their interactions, including predation, symbiosis, competitive relationships, and parasitic relationships.

5.1.2 Students formulate a question to extend the discussion from Activity 5.1.1, e.g., How would the removal of one population affect the rest of the system discussed in the last activity? This could be a jigsaw type activity where expert groups look at the removal of different plants or animals and prepare "hypothetical results." Group members then return to home groups to share discussions.

5.1.3 Students complete an online or in class predator/prey simulation or create one of their own. Populations will be graphed and analysed. (See Resource for resources for this activity.)

5.1.4 Students study and evaluate the ecological and economic effects of the loss of organisms from specific environments. This may be done through the use of a video or a periodical (Internet or print) search. A written or an oral presentation of findings follows.

Assessment Lab Report (Inquiry, Communication, Making Connections), Connections Assignment (Paragraph/Presentation) (Communication, Making Connections)

Population Growth

5.2.1 The teacher conducts a lesson to introduce the idea of density-dependent and density-independent effects. Include characteristics and population growth curves for each. At this time, the End-of-Unit Task is introduced and students are given time to ask clarification questions.

5.2.2 Students use mathematical equations to generate population data for exponential growth of yeast cells under ideal conditions. The population (unlimited food and space) pattern is graphed. Students explore factors that will alter the biotic potential of the yeast (food supply, pH levels, temperature, waste removal and space) and generate the associated graphs. This exploration may be done as discussion or controlled lab activities.

5.2.3 Conduct a lesson on population characteristics including growth patterns (using growth curves) and potential, density, distribution, carrying capacity, sustainability. Use examples of plant populations, animal populations and microorganisms, and analyse curves based on carrying capacity and fecundity.

5.2.4 Using the model of a non-overlapping generations population such as salmon, students graph either a real or hypothetical population over the period of a few years. The equation for non-overlapping populations is generated.

Assessment Graphs (Communication), Lab report (Communication, Inquiry, Making Connections), Quiz (Knowledge/Understanding)

Agricultural Resources

5.3.1 As a class, students review food chains and food webs and tie the concept of thermodynamics to biological systems. Use examples of energy pyramids from the Grade 10 course to explain the production and distribution of food resources.

5.3.2 Students work in small groups to analyse different food production technologies from past to present. Groups then come together to create a timeline of technology and agriculture. A follow-up discussion should focus on limitations of different economies and landscapes in the availability and use of food technologies.

5.3.3 The teacher leads a discussion on Canadian involvement locally and globally in the development and use of agricultural technology. This may include a video or materials from such organizations as the Canadian International Development Agency (CIDA). A follow-up activity requires students to find an appropriate current news article. The article, a summary and a statement regarding its significance will be put on a small poster display for classmates to see.

Assessment Mini Timeline (Communication, Knowledge/Understanding), News Article Poster (Communication, Making Connections)

Human Population Growth and Impact

5.4.1 The teacher conducts a lesson on the history of human population growth using the human population curve as the focus. Highlight significant advances in society (agricultural revolution, industrial revolution, technological revolution) and introduce the kinds of impacts each might have had on the growth rate of the human population.

5.4.2 Revisit End-of-Unit Task. Students create a timeline for the human population. See Activity 5.5.1. Make reference once again to the Final Assessment Task.

5.4.3 Students participate in a field trip or use a case study to investigate the effect of human population growth on the environment in their local area. This may involve expansion of subdivisions where once there was farmland, paving over of green spaces for industrial or commercial use, the development of waterfront properties, overuse of parkland/natural areas, development of sanctuaries or protected areas. A follow-up activity should include a risk-benefit analysis of such developments.

5.4.4 Students take part in a brainstorming session to lead into a teacher-directed lesson focused on whether or not the agricultural revolution led to a more suburban organization of the population, and the role this might have played in the increased occurrence of epidemics. The class also discusses factors related to medical care and technology that contribute to increased human life span. Students write a brief report on these and/or other demographic issues that result from an increasing global population.

Assessment Field Trip/Case Study Investigation (Inquiry, Knowledge/Understanding, Making Connections, Communication), Quiz (Knowledge/Understanding)

End-of-Unit Task: Timeline

5.5.1 End-of-Unit Task. Students produce a timeline for the human population. The timeline should include four to eight entries. The first entry describes the earliest information regarding human population and factors that controlled the growth rate. The second-last entry indicates the current state of the human population. The final entry focuses on the potential future direction of population growth. This prediction of changes in growth rate should be supported by evidence, including that provided by graphs of growth rates for other populations. The other entries focus on descriptions of key changes or occurrences and the effects of these developments. Each entry could include dates (range of years) and major changes in societal structure responsible for the development along with illustrations. An examination of the costs, risks and benefits associated with new technology is also to be completed. A variety of formats can be used to present the final products: Bristol board timelines, museum displays, webpages, and/or presentations to the class. The graph of the human population should be a central component of the timeline, and an analysis of that graph based on carrying capacity should be included with either the final entry or an introductory entry. The task should be introduced part way through the unit and some class time given for research. See "Human Population Growth" Rubric in Appendix B.

5.5.2 A written test may be used to assess this unit. If so, consideration should be given to replacing the quiz marks with the unit test mark if the unit test gives a better indication of students' most recent and most consistent performances. Ensure that all expectations evaluated on quizzes are evaluated on the unit test if this is done.

Assessment Timeline (Inquiry, Communication, Making Connections), Unit Test (Knowledge/Understanding, Making Connections)

Resources

Diamond, Jared. *Guns, Germs, and Steel*. W. W. Norton & Co., New York, 1997. ISBN 0393317552

Nebel, B. and R. Wright. *Environmental Science, The Way the World Works*. New Jersey: Prentice Hall, 1993. ISBN 0132854465

A digital field trip to the wetland. Digital Frog Inc. Information is available at www.digitalfrog.com.

– http://www.uwinnipeg.ca/~simmons/ysesp/comeco2.htm
population interactions background information and examples in terms of co-evolution.

– http://www.sci.sdsu.edu/classes/biology/bio354/williams/Lee's_Stuff/PopEcol_Lect06.html
interactions classified and analysed in graphic form.

– http://www.messiah.edu/hpages/facstaff/deroos/CSC171/PredPrey/PPIntro.htm
predator-prey online simulation.

– http://www.accessexcellence.org/AE/AEPC/WWC/1991/predator.html
predator-prey in class activity.

– http://www.math.duke.edu/education/ccp/materials/diffeq/predprey/contents.html
predator-prey models.

– http://www.backgroundbriefing.com/poplmlth.html
Malthus: notes on population growth.

http://www.statcan.ca/english/Pgdb/People/Population/demo33a.htm
Canadian statistics on population growth.

– http://www.nwf.org/population/
National Wildlife Federation page on population impacts.

http://www.prb.org/Content/NavigationMenu/PRB/Educators/Human_Population/Human_Population__Fundamentals_of_Growth_and_Change1.htm
link to information on human populations – fundamentals and growth.

Unit 6: Final Assessment Tasks

Time: 10 hours

Unit Description

The final assessment of this course consists of two components. In the first component, students choose a genetically modified product, assess its impact considering all the strands covered by this course, and present their findings in a visual display. Alternatively, the student uses a metabolic disorder as the focal topic to link the units. As there is a choice of topics, the design of evaluation rubrics could be proposed (using those rubrics already seen in the course and using the specifics of each topic) by the groups of students focusing on each of the areas. Since the teacher is responsible for setting standards and evaluation, the rubric must be approved by the teacher before use. The second component of the Final Assessment Task consists of a written final exam.

Unit Overview Chart

Activity/Time	Learning Expectations	Assessment Categories
6.1 Presentation 7 h	MPV.01, MPV.03, MGV.01, MGV.02, MGV.03, HSV.01, HSV.02, HSV.03, EVV.01, EVV.03, PDV.01, PDV.02 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/Understanding Inquiry Communication Making Connections
6.2 Final Exam 3 h (2 h + 1 h of prep)	MPV.01, MPV.02, MPV.03, HSV.01, HSV.02, HSV.03, MGV.01, MGV.02, MGV.03, EVV.01, EVV.02, EVV.03, PDV.01, PDV.02, PDV.03 SIS.04, SIS.08, SIS.09	Knowledge/Understanding Inquiry Communication Making Connections

Suggested Activities

6.1 Students choose a genetically modified or altered product, e.g., a genetically modified food, a genetically modified organism capable of producing a medication, a chemical or other consumer product produced through genetic manipulation, and examine the impact of the product on the following areas:

- The impact of the product on the metabolism of the user;
- The effect of the product on the homeostatic mechanisms of the user;
- An explanation of the genetic engineering involved in the production of the product;
- A hypothesis of the impact the product will have on evolution;
- A hypothesis of the impact the product will have on human population dynamics.

OR

Students choose a metabolic disorder such as mitochondrial myopathy, multiple sclerosis. Parkinson's disease, etc., and examine the disorder as a connecting focus for all the units of this course.

- Description of the disorder and its metabolic effects;
- The impact on the homeostatic mechanisms of the individual suffering from the disorder;
- An examination of the genetic transmission and expression of the disorder;
- Insight into the history of the disorder in terms of evolution – and the prevalence in "related" species;
- A statistical analysis of the global and local population trends for the disorder.

Students present their findings through the use of a visual display, e.g., poster, graphic organizer, etc., and present a written or oral supported opinion, either for or against the existence or continued production of the product or on the expected future developments around the disorder.

6.2 Written Exam: Students write an exam to evaluate all four Achievement Chart categories.

Resources

http://scope.educ.washington.edu/gmfood/ – risks and benefits of genetically modified foods

http://news.bbc.co.uk/hi/english/special_report/1999/02/99/food_under_the_microscope/newsid_280000/280868.stm – BBC special report: questions and answers on genetically modified foods

http://news.bbc.co.uk/hi/english/special_report/1999/02/99/food_under_the_microscope/newsid_280000/280868.stm – Genetically modified nonsense: an overview of the use of biotechnology to create medically useful products and used in food production

http://www.kumc.edu/gec/support/metaboli.html – Excellent link to sites on genetic metabolic disorders.

http://www.merck.com/pubs/mmanual/section2/sec2.htm – Merck manual link to metabolic disorders.

http://kobiljak.msu.edu/CAI/Pathology/Toxic_Index.html – Toxic-metabolic-nutritional disorders of the nervous system.

Teaching/Learning Strategies

Since the aims of this course are to develop scientific literacy in all students and to prepare students for science courses at university, the teacher should use a wide variety of instructional strategies that accommodate an equally wide variety of learning styles and interests. In planning activities, students should have:

- opportunities to work individually, in pairs, in small groups, and in large groups;
- direct instruction as well as opportunities for 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;
- opportunities to develop skills that would help them succeed at university: note taking, preparing for an examination, taking a multiple-choice test, conducting in-depth, independent research, writing a report, and establishing good time management habits.

Students need to be informed in advance of methods of assessment and evaluation. From the beginning, students should understand the nature and scope of the course's Final Assessment Tasks and how the completion of the End-of-Unit Tasks assists them in gaining the skills and knowledge necessary for their successful completion. Expectations are presented in such a way as to prepare students for the End-of-Unit Tasks. Assessment and evaluation then become an integral part of the teaching/learning strategies.

Skills are Developed through Experience and Refined with Practice

Lesson design should evolve during the course. Initially, lessons could centre around the familiar guided discovery approach, but the final unit(s) of the course could be organized around a lecture, laboratory, tutorial, and seminar format. Early experiences with the use of the lecture format should include assessment opportunities. The adequacy of recorded notes may be assessed by the teacher, peers or self, using a checklist, or they may also be assessed by the teacher by means of an open-note quiz.

Seminars can be used to enhance class discussions of science issues as they relate to technology, society and the environment. An article, selected by the teacher or students, could be assigned for pre-reading prior to the seminar. A quiz could be used to assess whether the article had been read before involving the class in a discussion that could be teacher- or student-led. Teacher-led discussions could occur near the start of the course with student-led discussions taking place later in the course.

Many of the Learning Expectations describe **Inquiry Skills**. Students should be given 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, and the criteria of success. Biology Course students should have multiple opportunities to practise a variety of inquiry styles, including the following:

- **Research:** accessing information that has been previously gathered by themselves or others, selecting relevant details, analysing that information for patterns and meaning, and communicating their findings or conclusion. This will require instruction and practice in techniques for using library/resource centre resources effectively, searching the Internet and interviewing experts.
- **Experimentation:** developing questions, identifying controls and variables, designing experimental procedures, observing and measuring, analysing data for patterns and meaning, and communicating conclusions. This may occur in laboratories or the field. Ensure that laboratory techniques and safety procedures are taught and assessed. Students of SBI4U should be able to complete true inquiry activities with minimal teacher direction. Teacher input is necessary when considering safety issues and in teaching laboratory techniques that are new to students. Many traditional laboratory activities require minimal input on the part of the student and can be presented as teacher demonstrations, allowing more in-class time for genuine inquiry.
- **Design/Innovation:** applying knowledge to define a problem or challenge, setting criteria for a satisfactory solution, devising and executing a procedure, and assessing the result.

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, help students develop **Communication Skills**. Although the traditional written report is one form of communication, students need to describe what they do and what they learn through other presentation formats as well, e.g., poster, computer, video, oral, graphical, musical. Through various forms of cooperative learning, communication skills are practised as students discuss, debate and reflect on their own thinking and learning.

In addition to key biological concepts, individual learning activities should emphasize a technique or skill that is to be taught or reinforced and assessed. Over the length of the course, all skills required to meet the Overall Expectations should be practised repeatedly in a variety of contexts.

Use of Computer Technology

Computer applications should be included in activities whenever they enhance student learning by enabling them to complete work more efficiently, or to complete work that otherwise could not be done. A wide variety of software tools should be used to record and display information. Examples include 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 traditional reporting of 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.

Online communication between teacher and students could occur throughout the course. Homework assignments and answers could be posted, along with reminders about upcoming assignment deadlines and evaluation dates. Sample exam questions could be included and links made to pertinent sites, covering a variety of STSE topic. Online tutorials could be arranged and one of the later units in the course could be presented online. Many of these experiences will mirror what students will encounter at university.

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 experiences provide opportunities to develop teamwork.

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 necessary for Making Connections. For example, 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

Seventy per cent of the grade will be based on assessments and evaluations conducted throughout the course. Thirty per cent of the grade will be based on a final evaluation in the form of an examination, performance, essay, and/or other methods of evaluation.

Assessment is a process of gathering information and providing descriptive feedback about student learning. Evaluation is the process of judging work and assigning a value, based on established criteria. The purpose of assessment is to improve student learning. This means that judgements 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.

- For assessing/evaluating a test or quiz, a marking scheme is used.
- 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. Although the final decision must be the teachers', wherever possible, students should be involved in the development of rating scales or rubrics by helping to identify criteria and describe levels of achievement in terms they understand.
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 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 directly linked to the Learning Expectations and Achievement Chart for Science (*The Ontario Curriculum, Grades 11 and 12: Science, 2000*, pp. 172-175). Every learning activity and its assessment should produce 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, the teacher must collect sufficient data (in kind and number) to make valid judgements about student performances in all categories.

In the end, the evaluation of the assessment data is expressed as a percentage based on Achievement Chart levels. That evaluation must be based on individual student performances relative to the criteria, not to other students' performances. Final evaluations should reflect the teacher's informed, professional judgement of each student's most consistent level of performance in each category of the Achievement Chart. Added weight could be given to more recent performances.

The teacher needs a wide and balanced range of assessment strategies 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.
The teachers should consult individual student IEPs for specific direction on accommodation for all exceptional students and the specific learning strategies that work best with each student.

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;
- teacher assessment and student (self- and peer) assessment. With clearly articulated criteria, students become partners in the assessment process;
- 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.

The Examination Component of the Final 30%
Much of the evaluation in first-year university science courses focuses on a single examination encompassing the concepts taught throughout the year. Students of SBI4U need to be properly prepared for this form of evaluation. Study skills, including chunking of content, use of different graphic organizers, and preparation of study sheets, should be integrated into a number of lessons. Multiple-choice questions should be used as one of a variety of ways of evaluating a wide range of Expectations. Students should experience these questions throughout the course and be taught strategies for answering them.

Students would benefit from more than one opportunity at writing a multi-unit examination. A midterm exam can be scheduled; after the examination is evaluated, students receive feedback and a chance to reflect on their results. The final examination allows them to adjust strategies and learn from their first experience.

Examination design is also crucial. Examinations must allow for evaluation of all four categories and all levels to occur. Examination questions should be equally distributed across the course units, and consideration should be given to a range of question types, such as multiple choice, short and extended answer, laboratory-based and higher-order questions.

Group Work Considerations

A number of group activities are described in this profile. These allow students opportunities to practise and be assessed and evaluated for Teamwork, one of the five Learning Skills. Teamwork is often identified as a key employability skill. Initiative, Organization, and Work Habits/Homework, three other Learning Skills, can also be practised, assessed, and evaluated to some extent through group work. However, when group assignments are used to evaluate course Expectations, the teacher must ensure that evaluation is done on an individual basis. This can be accomplished in a number of ways:

- Arrange individual teacher/student conferences. Student responses to a series of questions can be used to evaluate Knowledge, Communication Skills and Making Connections most easily, but can also be used for Inquiry.
- On a regular basis, collect and evaluate work journals or log books, where students describe their role and responsibility in completion of an activity.
- Students use reflection journals to describe their learnings from a certain activity, and then are evaluated for Knowledge and Making Connections.
- Work logs and reflection journals can be in formats other than pencil and paper. Some students might produce more complete and detailed answers if they were using a tape recorder or a concept map. This would allow different learning styles to be addressed.
- Students could pool their experimental or research results, and produce an independent, individual final product that would be evaluated.
- Students could contract for different aspects of research or communication for a group project. This is another opportunity to address individual learning styles. When evaluating the group presentation, the teacher must be aware of individual responsibilities.
- A quiz could be used to evaluate specific Knowledge or Making Connection expectations gained through a group activity.
- Teacher observation, using a checklist, and on-the-spot questioning can be used to assess and evaluate meeting of expectations on an individual basis.
- Acquisition of technical skills could be evaluated in another, individual situation such as a summative, practical skills test.

Self- and peer assessment of individual performances within a group setting are appropriate and useful to assist students in becoming self-monitoring. However, such assessments are not to be the basis for evaluation; evaluation is the sole responsibility of the teacher.

Accommodations

Students with special needs, whether identified formally or not, need additional supports to succeed in Grade 12 Biology to their full potential. Teachers should consult individual student IEPs for specific direction on accommodation for exceptional students. The following are examples of accommodations and aids that may be helpful in a general way. Where there are specific accommodations required in an activity, the suggestions are noted within the activity.

- 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.
- 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.
- Utilize student strengths by permitting them a wide range of options for recording and reporting their work, e.g., drawings, diagrams, flow charts, concept maps.
- Extend timelines to give students more time to process language and put their thoughts into words.
- Give readings in advance to students or provide a selection of materials at different reading levels.
- Provide extended timelines in situations where students do not have access to computers outside of school.
- Check the IEPs of all identified students for specific adaptations in teaching methodologies and evaluation.
- Have students keep a science dictionary of terms using pictures and first-language words.
- Permit the use of a translation dictionary on assessments.
- Provide additional time on assessments for dictionary use and processing language.
- Provide assistance to identify resources with appropriate reading level when research is required.

OSS Policy Considerations

Students can apply and refine the skills, knowledge and habits of mind they acquire in SBI4U through Cooperative Education, work experience and service placements within the community.

A work site placement must be directly connected to the Expectations of SBI4U 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. "The 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 a major goal of SBI4U. "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.

Appendix A

Evolution Mechanism – Supported Opinion Rubric

Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Knowledge/ Understanding Making Connections				
Understanding of the mechanism for evolution	- demonstrates limited understanding of the mechanism for evolution	- demonstrates some understanding of the mechanism for evolution	- demonstrates considerable understanding of the mechanism for evolution	- demonstrates thorough understanding of the mechanism for evolution
Provides explanation to support proposed theory	- rarely gives explanation to support proposed theory	- sometimes gives explanation to support proposed theory	- usually gives complete explanations to support proposed theory	- consistently gives complete explanations to support proposed theory
Communication				
Clarity and precision of communication	- rarely communicates with clarity and precision	- sometimes communicates with clarity and precision	- usually communicates with clarity and precision	- consistently communicates with clarity and precision
Use of scientific terminology	- uses appropriate scientific terminology with limited accuracy and effectiveness	- uses appropriate scientific terminology with some accuracy and effectiveness	- uses appropriate scientific terminology with considerable accuracy and effectiveness	- uses appropriate scientific terminology with a high degree of accuracy and effectiveness

Note: A student whose achievement is below Level 1 (50%) has not met the expectations for this assignment or activity.

Appendix B

Human Population Growth Timeline Rubric

Criteria	Level 1 (50-59%)	Level 2 (60-69%)	Level 3 (70-79%)	Level 4 (80-100%)
Knowledge/ Understanding, Making Connections				
Understanding of changes affecting human population growth	- demonstrates understanding of few of the changes associated with historical and current human population growth	- demonstrates understanding of some of the changes associated with historical and current human population growth	- demonstrates understanding of most of the changes associated with historical and current human population growth	- demonstrates understanding of all of the changes associated with historical and current human population growth
Understanding of population changes in general	- infrequently gives explanations related to the population changes	- sometimes gives explanations related to the population changes	- usually gives complete explanations related to the population changes	- consistently gives complete explanations related to the population changes
Making Connections, Inquiry, Communication				
Communication of information	- few aspects of the design of the timeline show a connection to the topic	- some aspects of the design of the timeline show a connection to the topic	- many aspects of the design of the timeline show a connection to the topic	- the design and topic of the timeline have been totally integrated
Problem analysis	- analyses problems with limited effectiveness	- analyses problems with some effectiveness	- analyses problems with considerable effectiveness	- analyses problems with a high degree of effectiveness
Use of timeline format	- timeline format is used with limited effectiveness	- timeline format is used with some effectiveness	- timeline format is used with considerable effectiveness	- timeline format is used with a high degree deal of effectiveness

Note: A student whose achievement is below Level 1 (50%) has not met the expectations for this assignment or activity.

Appendix C: Lab Report Fastfax

[**Note to the teacher:** For consistency, especially for students enrolled in more than one science course, it is suggested that one model of lab report writing be used by all Grade 12 science courses within a school. The example below is a suggested format and should be adapted to meet the needs of individual schools and communities.]

Writing Scientific Lab Reports

The purpose of a scientific lab or research report is to reveal to others some specific data you have collected and what you think they mean. A report must be written as concisely and clearly as possible so that the reader can grasp the material quickly and could accurately repeat or expand on your research. Whether you are writing a lab report for a course, a graduate thesis, or a paper for publication in a scholarly research journal, the format is similar to the one described below.

1. Title

The title of a report should indicate exactly what you have studied, e.g., The Effects of Light and Temperature on the Growth of the Bacterium, *Escherichia coli*. This title explains the environmental factors manipulated (light and temperature), the parameter measured (growth), and the specific organism used (*E. coli*). If a large number of variables or organisms were used, the title could say "Several Factors..." or "Various Chemicals...." It is unnecessary to include words such as "Observations on the Effects of..." or "A Report on the Effects of..." or "A Study on the Effects of...."

2. Abstract

The abstract is a condensed version of the entire paper. It allows a reader to quickly understand the purpose, methods, results and significance of your research without reading the entire paper. Abstracts or papers published in scholarly journals are useful when conducting library research, because the researcher can quickly determine whether the research report will be relevant to the topic. The material in the abstract is written in the same order as that within the paper, and has the same emphasis. An effective abstract should include a sentence or two summarizing the highlights from each of the sections: introduction (including purpose), methods, results, and discussion. To reflect the content of the paper accurately, the abstract should be written after the final draft of your paper is complete, although it is placed at the beginning of the paper.

3. Introduction

WHY DID YOU STUDY THIS PROBLEM?

The introduction should identify the problem or issue and give background information (historical and/or theoretical) about that problem. The introduction contains a brief literature review which should describe previous research conducted on the problem, and explain how the current experiment will help to clarify or expand the knowledge. This information should justify why you conducted the experiment. All references to previous studies should be properly documented. The introduction should end with a purpose statement, sometimes in the form of a hypothesis or null hypothesis. The purpose statement is a single sentence which specifically states the answer to the question that the experiment was designed to answer; e.g., the purpose of this investigation was to determine the effects of environmentally realistic exposures of acid precipitation on productivity of field-grown and chamber-grown peanuts.

4. Materials and Methods

WHAT DID YOU DO? HOW DID YOU DO IT?

In the materials and methods section of a formal lab report, you should describe how and when you did your work, including experimental design, experimental apparatus, methods of gathering and analysing data, and types of control. This section must include complete details and be written clearly enough to allow readers to duplicate the experiment if they so wish. This section is written in past tense because you have already done the experiment. It should not be written in the form of instructions or as a list of materials, as in a laboratory manual.

Appendix C (Continued)

Instead, it is written as a narrative describing, either in first person active voice or in passive voice, what you did, e.g., first person active voice: I filled six petri plates with agar; passive voice: six petri plates were filled with agar. Methods adapted from other sources should be referenced. Photographs, maps and diagrams may be used to help describe the experimental set up (see Tables and Figures below).

5. Results

WHAT DID YOU FIND?

In the results, you present your observations and data with no interpretations or conclusions about what they mean. Tables and graphs should be used to supplement the text and to present the data in a more understandable form (see Tables and Figures below). Raw data will probably be most effective in table format, with the highlights summarized in graph form. The written text of the results section may be as short as one sentence summarizing the highlights and directing the reader to specific Tables and Figures. Use past tense to describe your results. Sample calculations for a lab report in a course may be included in a separate section titled, "Calculations," or in an Appendix at the end of the report.

6. Discussion

WHAT DOES IT MEAN? HOW DOES IT RELATE TO PREVIOUS WORK IN THE FIELD?

Explain what you think the data means. Describe patterns and relationships that emerged. Compare these results to trends described in the literature and to theoretical behaviour. Explain how any changes to, or problems with, the experimental procedure may have affected the results, or offer other suggestions as to why the results may have been different from or similar to related experiments described in the literature. Interpretations should be supported whenever possible by references to the lab manual, the text, and/or other studies from the literature, properly documented. Remind the reader of your own results, when relevant, without repeating endless information from Results. If the lab manual includes questions to be answered in the Discussion, integrate the responses into a logical discussion, rather than answering them one by one. In addition, do not include only the answers to the questions – use them as a guideline for supplementing your discussion, not limiting it.

7. Literature Cited

Also called "References" or "References Cited," this is a list only of papers actually mentioned (cited) within the report. (A "Bibliography," on the other hand, refers to a list of all materials used to get background knowledge on a subject; you will not usually be required to include one in a scientific lab report.) Remember that all information within the report that is not your original work or ideas should be referenced (not necessarily quoted, but paraphrased or summarized – quotations are rare in scientific writing.) There are several standard styles for documenting references. Check with the teacher for their preference. You may be asked to follow the format of a particular journal in your field. If so, follow that format exactly.

8. Tables and Figures

Tables and figures are often used in a report to present complicated data. Use the following guidelines to incorporate them effectively. Each table or figure must be introduced within the text, and the comment should point out the highlights, e.g., The temperature increased on the third day (Figure 1). All tables and figures must be numbered and have self-explanatory titles so that the reader can understand their content without the text, e.g., Table 1. Per cent of soybean plants exhibiting visible injury after exposure to acid rain. Tables and figures are assigned numbers in the order they are mentioned in the text. Tables and figures are numbered independently of each other, e.g., Table 1 and 2, and then Figure 1 and 2 as well. Tables are referred to as tables, and all other items (graphs, photographs, drawings, diagrams, maps, etc.) are referred to as figures. Tables are labelled at the top and figures at the bottom. Tables and figures may be placed at the end of the paper, or within the text as soon as possible after they are mentioned without interrupting the text, e.g., at the end of a paragraph or section.

Coded Expectations, Biology, Grade 12, University Preparation, SBI4U

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 handling, storing, and disposing of bacteria, chemicals, and bio-hazardous waste);

SIS.02 - select appropriate instruments and use them effectively and accurately in collecting observations and data (e.g., use molecular models to represent functional groups; perform gel electrophoresis or DNA extraction);

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 investigate the effect of temperature on enzymes);

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 chemical formulae for biological molecules);

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 (e.g., create a chart of hormone actions, or of homologous and analogous structures; create a timeline of recent discoveries in biotechnology);

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 effect of chemical stimuli on invertebrates, or the causes of fluctuation of a population);

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;

SIS.10 - identify and describe science- and technology-based careers related to the subject area under study (e.g., genetic engineer, biochemist, genetic counsellor, microbiologist, pharmacologist, histologist, immunologist, palaeontologist, population ecologist, nutritionist).

Metabolic Processes

Overall Expectations

MPV.01 · describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;

MPV.02 · conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;

MPV.03 · explain ways in which knowledge of the metabolic processes of living systems can contribute to technological development and affect community processes and personal choices in everyday life.

Specific Expectations

Understanding Basic Concepts

MP1.01 – apply the laws of thermodynamics to the transfer of energy in the cell, particularly with respect to respiration and photosynthesis;

MP1.02 – identify the functional groups within biological molecules (e.g., hydroxyl, carbonyl, carboxyl, amino, phosphate) and explain how they contribute to the function of each molecule (e.g., use molecular models to determine whether a molecule is polar or non-polar, and relate this property to diffusion through a plasma membrane);

MP1.03 – describe the chemical structure, mechanisms, and dynamics of enzymes in cellular metabolism (e.g., the function of enzymes in metabolic reactions in mitochondria or chloroplasts);

MP1.04 – identify and describe the four main types of biochemical reactions: redox, hydrolysis, condensation, and neutralization;

MP1.05 – describe how such molecules as glucose, ATP, pyruvic acid, NADH, and oxygen function within energy transformations in the cell, and explain the roles of such cell components as mitochondria, chloroplasts, and enzymes in the processes of cellular respiration and photosynthesis;

MP1.06 – compare matter and energy transformations associated with the processes of cellular respiration (aerobic and anaerobic) and photosynthesis (e.g., for each process, compare the role of oxygen and the role of organelles, such as mitochondria and chloroplasts).

Developing Skills of Inquiry and Communication

MP2.01 – formulate operational definitions of the terms related to metabolic processes (e.g., use the following terms in relation to cell metabolism: *electronegativity, isomer, functional group, polymer, organic acid, organic base, solubility, enzyme, substrate, reaction rate*);

MP2.02 – investigate the structures of biological molecules and functional groups using computer-generated, three-dimensional images and/or by building molecular models (e.g., simple carbohydrates, amino acids, simple polypeptides);

MP2.03 – investigate and explain the relationship between metabolism and the structure of biomolecules, using problem-solving techniques (e.g., analyse the difference between the metabolic rates of sweet corn and starchy corn);

MP2.04 – design and carry out an experiment related to a cell process (e.g., enzyme activity, membrane transport), controlling the major variables and adapting or extending procedures where required (e.g., conduct an experiment to find optimal conditions [pH, concentration, and temperature] for various enzymes and membrane transport);

MP2.05 – determine the similarities and differences between mitochondria and chloroplasts (e.g., compare the structure and function of a mitochondrion and a chloroplast by examining micrographs and identifying reactants, products, and pathways);

MP2.06 – interpret qualitative and quantitative observations, gathered through investigation, of the products of cellular respiration and photosynthesis (e.g., type and quantity produced) and, either by hand or by computer, compile and display the results in an appropriate format.

Relating Science to Technology, Society, and the Environment

MP3.01 – relate knowledge gained from their current studies of metabolism to their learning in the fields of chemical thermodynamics and physical energy;

MP3.02 – describe technological applications of enzyme activity in the food and pharmaceutical industries (e.g., the production of dairy products using micro-organisms; the use of yeast to make bread; the use of enzymes to control reaction rates in the pharmaceutical industry);

MP3.03 – explain the relevance, in their personal lives and the life of the community, of the study of cell biology and related technologies (e.g., explain how their learning about metabolic processes is relevant to their personal choices about exercise, diet, and the use of pharmacological substances).

Molecular Genetics

Overall Expectations

MGV.01 · explain the concepts of gene and gene expression and the roles of DNA, RNA, and chromosomes in cellular metabolism, growth, and division, and demonstrate an awareness of the universality of the genetic code;

MGV.02 · explain, through laboratory activities and conceptual models, processes within the cell nucleus;

MGV.03 · describe some of the theoretical issues surrounding scientific research into genetic continuity; the general impact and philosophical implications of the knowledge gained; and some of the issues raised by related technological applications.

Specific Expectations

Understanding Basic Concepts

MG1.01 – compare the structure and function of RNA and DNA, and explain their roles in protein synthesis;

MG1.02 – describe the current model of DNA replication and methods of repair following an error;

MG1.03 – explain the steps involved in protein synthesis (e.g., transcription and translation) and the control mechanisms for genetic expression using regulatory proteins (e.g., lac operon, tryp operon);

MG1.04 – describe how mutagens such as radiation and chemicals can change the genetic material in cells by causing mutations (e.g., point mutations and frame-shifts);

MG1.05 – demonstrate an understanding of genetic manipulation, and of its industrial and agricultural applications (e.g., describe the processes involved in cloning, or in sequencing of DNA bases; explain the processes involved in the manipulation of genetic material and protein synthesis; explain the development and mechanisms of the polymerization chain reaction);

MG1.06 – describe the functions of the cell components used in genetic engineering (e.g., the roles of plasmids, restriction enzymes, recombinant DNA, and vectors);

MG1.07 – outline contributions of genetic engineers, molecular biologists, and biochemists that have led to the further development of the field of genetics (e.g., the findings of Cohen-Boyer [1973], Chilton [1981], and Stanford [1988]; transfer of the somatotropine gene [1990]).

Developing Skills of Inquiry and Communication

MG2.01 – illustrate the genetic code by examining/analysing a segment of DNA (e.g., compare base sequences of DNA for an enzyme in humans and another animal; compare base sequences in DNA in order to recognize an anomaly);

MG2.02 – interpret micrographs that demonstrate the cellular structures involved in protein synthesis;

MG2.03 – investigate and analyse the cell components involved in protein synthesis, using laboratory equipment safely and appropriately (e.g., extract DNA; compare different proteins; separate DNA or polypeptides using electrophoresis);

MG2.04 – describe the major findings that have arisen from the Human Genome Project (e.g., create a timeline of the project, or make a chart of the discoveries).

Relating Science to Technology, Society, and the Environment

MG3.01 – explain the roles of evidence, theories, and paradigms in the development of scientific knowledge about genetics (e.g., explain the impact of cloning a sheep on the theory of differentiation; explain the impact of the discovery of the structure of DNA as the universal molecule for living organisms);

MG3.02 – describe the principal elements of the Canadian regulations on biotechnological products, and explain their implications (e.g., consult Environment Canada or Food and Health Canada for the regulations; or use current websites for agencies such as Agriculture Canada that list new products).

Homeostasis

Overall Expectations

HSV.01 · describe and explain the physiological and biochemical mechanisms involved in the maintenance of homeostasis;

HSV.02 · analyse, through experiments and the use of models, the feedback mechanisms that maintain chemical and physical homeostasis in animal systems;

HSV.03 · analyse how environmental factors (physical, chemical, emotional, and microbial) and technological applications affect/contribute to the maintenance of homeostasis, and examine related societal issues.

Specific Expectations

Understanding Basic Concepts

HS1.01 – describe the anatomy and physiology of the endocrine and nervous systems, and explain their roles in homeostasis;

HS1.02 – explain the action of hormones in the female and male reproductive systems, including the feedback mechanisms involved;

HS1.03 – explain the role of the kidney in maintaining water and ion balance;

HS1.04 – describe and explain homeostatic processes involved in maintaining water, ionic, thermal, and acid-base equilibria in response to both a changing environment and medical treatments (e.g., explain the feedback mechanisms involved in water balance or thermo-regulation; explain the buffering system of blood; describe the effect of disorders of the nervous system or endocrine system; describe how chemotherapy affects homeostasis);

HS1.05 – describe the mammalian immunological response to a viral or bacterial infection;

HS1.06 – predict the impact of environmental factors such as allergens on homeostasis within an organism.

Developing Skills of Inquiry and Communication

HS2.01 – construct a model that illustrates the essential components of the homeostatic process (e.g., use a flow chart to describe representative feedback mechanisms in living things);

HS2.02 – design and carry out an experiment to investigate a feedback system (e.g., record physiological effects of drinking coffee);

HS2.03 – design and conduct an experiment using invertebrates to study the response to external stimuli (e.g., instinctive behaviour in response to chemical stimuli or light);

HS2.04 – compile and display, either by hand or computer, data and information about homeostatic phenomena in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots (e.g., create a chart of hormones showing the source, stimulation, target organ, action and nature, and related disorders for each; make a graph of the reaction time of the pupil of the eye when stimulated by light of different colours; create a chart of allergies and the foods that trigger them).

Relating Science to Technology, Society, and the Environment

HS3.01 – synthesize case study information about the effects of taking chemical substances to enhance performance or improve health (e.g., explain the effect of steroids on health; debate the wisdom of taking large quantities of vitamins or amino acids; describe substances people use to cope with stress);

HS3.02 – present informed opinions about problems related to the health industry, health legislation, and personal health (e.g., describe issues related to transplants or kidney dialysis; discuss the difficulties in treating neurological and infectious diseases);

HS3.03 – describe some Canadian contributions to knowledge and technology in the field of homeostasis (e.g., the discovery of a new blood stem cell; the discovery of insulin).

Evolution

Overall Expectations

EVV.01 · analyse evolutionary mechanisms, and the processes and products of evolution;
EVV.02 · evaluate the scientific evidence that supports the theory of evolution;
EVV.03 · analyse how the science of evolution can be related to current areas of biological study, and how technological development has extended or modified knowledge in the field of evolution.

Specific Expectations

Understanding Basic Concepts

EV1.01 – define the concept of speciation and explain the mechanisms of speciation;
EV1.02 – describe, and put in historical and cultural context, some scientists' contributions that have changed evolutionary concepts (e.g., describe the contributions – and the prevailing beliefs of their time – of Lyell, Malthus, Lamarck, Darwin, and Gould and Eldridge);
EV1.03 – analyse evolutionary mechanisms (e.g., natural selection, sexual selection, genetic variation, genetic drift, artificial selection, biotechnology) and their effects on biodiversity and extinction (e.g., describe examples that illustrate current theories of evolution, such as the darkening over time, in polluted areas, of the pigment of the peppered moth, an example of industrial melanism);
EV1.04 – explain, using examples, the process of adaptation of individual organisms to their environment (e.g., explain the significance of a short life cycle in the development of antibiotic-resistant bacteria populations).

Developing Skills of Inquiry and Communication

EV2.01 – outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth (e.g., evaluate current evidence that supports the theory of evolution and that feeds the debate on gradualism and punctuated equilibrium);
EV2.02 – identify questions to investigate that arise from concepts of evolution and diversity (e.g., Why do micro-organisms evolve so quickly? What factors have contributed to the dilemma that pharmaceutical companies face in trying to develop new antibiotics because so many micro-organisms are resistant to existing antibiotics?);
EV2.03 – solve problems related to evolution using the Hardy-Weinberg equation;
EV2.04 – develop and use appropriate sampling procedures to conduct investigations into questions related to evolution (e.g., to determine the incidence of various hereditary characteristics in a given population), and record data and information;
EV2.05 – formulate and weigh hypotheses that reflect the various perspectives that have influenced the development of the theory of evolution (e.g., apply different theoretical models for interpreting evidence).

Relating Science to Technology, Society, and the Environment

EV3.01 – relate present-day research and theories on the mechanisms of evolution to current ideas in molecular genetics (e.g., relate current thinking about adaptations to ideas about genetic mutations);
EV3.02 – describe and analyse examples of technology that have extended or modified the scientific understanding of evolution (e.g., the contribution of radiometric dating to the palaeontological analysis of fossils).

Population Dynamics

Overall Expectations

PDV.01 · analyse the components of population growth, and explain the factors that affect the growth of various populations of species;

PDV.02 · investigate, analyse, and evaluate populations, their interrelationships within ecosystems, and their effect on the sustainability of life on this planet;

PDV.03 · evaluate the carrying capacity of the Earth, and relate the carrying capacity to the growth of populations, their consumption of natural resources, and advances in technology.

Specific Expectations

Understanding Basic Concepts

PD1.01 – explain the concepts of interaction (e.g., competition, predation, defence mechanisms, symbiotic relationships, parasitic relationships) among different species of animals and plants;

PD1.02 – describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/viable size;

PD1.03 – compare and explain the fluctuation of a population of a species of plant, wild animal, and micro-organism, with an emphasis on such factors as carrying capacity, fecundity, and predation;

PD1.04 – use examples of the energy pyramid to explain production, distribution, and use of food resources;

PD1.05 – explain the demographic changes observed over the past ten thousand years (e.g., explain the effect on populations of such factors as epidemics, the rise of agriculture, the Industrial Revolution, and the development of modern medicine);

PD1.06 – explain, using demographic principles, problems related to the rapid growth of human populations and the effects of that growth on future generations (e.g., relate the carrying capacity of the Earth to the growth of populations and their consumption of resources).

Developing Skills of Inquiry and Communication

PD2.01 – use conceptual and mathematical models to determine the growth of populations of various species in an ecosystem (e.g., use the concepts of exponential, sigmoid, and sinusoidal growth to describe and predict various populations);

PD2.02 – determine experimentally the characteristics of population growth of two populations (e.g., examine the population cycles of a predator and a prey, or those of two populations that compete for food);

PD2.03 – using the ecological hierarchy for living things, evaluate how a change in one population can affect the entire hierarchy both physically and economically (e.g., the effects of the killing off of species of fish by lamprey eels, or the results of the introduction of zebra mussels into the Great Lakes);

PD2.04 – investigate, individually or collaboratively, the effects of human population growth on the environment and the quality of life (e.g., effects on ecosystems, such as the elimination of wildlife, plants, and farmland; causes and effects of ozone depletion or acid rain).

Relating Science to Technology, Society, and the Environment

PD3.01 – analyse Canadian investments in human resources and agricultural technology in a developing country (e.g., investigate Canadian International Development Agency [CIDA]-funded projects in a developing country);

PD3.02 – describe examples of stable food-production technologies that nourish a dense and expanding population;

PD3.03 – outline the advances in medical care and technology that have contributed to an increase in life expectancy, and relate these developments to demographic issues.

Unit 1: Metabolic Processes

Time: 22 hours

Unit Description

In this unit, students explore the biochemical pathways organisms use to create metabolically useful energy. Students examine energy transformations in living cells through examination of the structure and function of biologically essential macromolecules and a series of laboratory investigations. This unit has a strong experimental-inquiry focus where students can improve their skills in formulating testable questions and designing and carrying out investigations. The unit culminates with an oral presentation explaining the design of their effective "metabolic factory."

Unit Synopsis Chart

Activity/Time	Learning Expectations	Assessment Categories	Task
1.1 Biological Molecules 4 h	MPV.01, MPV.02, MP1.02, MP2.01, MP2.02, MP2.03 SIS.02, SIS.03, SIS.07, SIS.08, SIS.09	Communication Inquiry Knowledge/ Understanding	Diagnostic assessment of prior knowledge; investigations into structure and function of biochemical molecules.
1.2 Thermodynamics and Reactions 2 h	MPV.01, MPV.02, MP1.01, MP1.04, MP2.01 SIS.06	Communication Knowledge/ Understanding Making Connections	Teacher-directed lesson; students create graphic organizers.
1.3 All about Enzymes 5 h	MPV.01, MPV.02, MPV.03, MP1.03, MP2.03, MP2.04, MP3.02 SIS.01, SIS.02, SIS.03, SIS.07, SIS.10	Communication Inquiry Making Connections	Teacher demonstrations; student investigation of enzyme function.
1.4 Cellular Respiration and Photosynthesis 7 h	MPV.01, MPV.02, MPV.03, MP1.05, MP1.06, MP2.05, MP2.06, MP3.01, MP3.03, HS3.02 SIS.01, SIS.02, SIS.03, SIS.04, SIS.05, SIS.06, SIS.07	Communication Inquiry Knowledge/ Understanding Making Connections	Group work and investigations related to photosynthesis and respiration; teacher-directed lesson; examination of micrographs; jigsaw.
1.5 End-of-Unit Task: Design an effective "metabolic factory" 4 h	MPV.01, MPV.02, MPV.03 SIS.05, SIS.06, SIS.07	Communication Inquiry Knowledge/ Understanding Making Connections	Research and presentation; written test.

Unit Planning Notes

- Ensure that molecular model kits and/or appropriate computer programs are available for this unit.
- Online displays of biological molecules/biological processes are a useful resource for this unit.
- Book access to the resource centre and computer room or equipment to view computer displays of biological molecules.
- Prepare examples of good and poor testable questions as well as a model format for a Grade 12 lab report. (See Appendix C – Lab Report Fastfax.)

Activity 1.1: Biological Molecules

Time: 4 hours

Description

Students review the structure and function of biologically important molecules; they are also introduced to functional groups. Students participate in a directed lab investigation that reinforces concepts and provides opportunities to review elements of good lab design. The unit begins with diagnostic opportunities to assess both prior knowledge and acquired laboratory skills.

Strand(s) & Learning Expectations

Strand(s): Metabolic Processes

Learning Expectations

MPV.01 - describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;
MPV.02 - conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;
MP1.02 - identify the functional groups within biological molecules and explain how they contribute to the function of each molecule;
MP2.01 - formulate operational definitions of the terms related to metabolic processes;
MP2.02 - investigate the structures of biological molecules and functional groups using computer-generated, three-dimensional images and/or by building molecular models;
MP2.03 - investigate and explain the relationship between metabolism and the structure of biomolecules, using problem-solving techniques;
SIS.02 - select appropriate instruments and use them effectively and accurately in collecting observations and data;
SIS.03 - demonstrate the skills required to plan and carry out investigations, using laboratory equipment safely, effectively, and accurately;
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory;
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 unit.

Prior Knowledge & Skills

- Knowledge and skills developed from SBI3U in Unit 2: Cellular Basis of Life, i.e., the structure and function of biologically important macromolecules
- Students should know how to write a formal lab report.

Planning Notes

- Use models, 3-D diagrams of molecules, molecular model kits (or toothpicks and coloured gelled candies) to complement student learning.
- Ensure the class is aware of any reactions or potential sensitivities to tissue/chemicals (such as organic solvents) used in the labs.

Teaching/Learning Strategies

1.1.1 **Student Activity:** Students use computer-generated three-dimensional images or build molecular models of biological molecules. They identify the functional groups within these molecules and relate their structure to the function of each biological molecule. Students learn and use appropriate terms related to metabolic processes as required.

Teacher Facilitation: The teacher directs students to build biologically useful macromolecules such as a monosaccharide, e.g., glucose; a disaccharide, e.g., maltose; an amino acid, e.g., glycine; a polypeptide; a fat; a phospholipid; an alcohol, e.g., glycerol. Since this material should be a review of the structure and function of biologically important macromolecules covered in SBI3U, students could work in small groups to build one type of molecule and display it for the class in a "carousel" format (see Resources). The teacher uses this activity for diagnostic assessment of the students' knowledge about these molecules; it will also serve to introduce the concept of functional groups, e.g., hydroxyl, carboxyl, amino, phosphate, and the relationship between the functional groups and the function of each molecule.

1.1.2 **Student Activity:** Students conduct experiments to investigate the relationship between the structure and metabolic function of polymers and their structural monomers, and collect, display, and analyse data, e.g., students could compare the energy produced by carbohydrates, fats and proteins using a calorimeter, and explain how structural differences account for their observations. Students also review the components of good lab design with a focus on formulating a testable question, designing a controlled experiment to attempt to answer the question, and analysing error.

Teacher Facilitation: Since this is the first lab of the course, the teacher provides directions for the investigation, but uses the lab as a model for good lab design. This is also an appropriate time to introduce a more "university-like" approach to lab reports. (See Appendix C.) The teacher may present the students with examples of possible questions linked to this activity and/or subsequent activities and have students evaluate their usefulness as testable questions. The use of the calorimeter has many possible errors and so provides a starting point for a class discussion of error analysis. In a brief class discussion or as an individual reflection piece, students analyse the lab for elements of good lab design. The teacher organizes the students so that each lab pair collects data for one type of molecule and shares the data with the rest of the class. Individual students are directed to display and interpret the class data in their lab report. The teacher provides feedback and assistance in the collection, display, and analysis of data as required. Safety caution: survey students for nut allergies before deciding to use nuts for this laboratory activity. The teacher should check the board policy pertaining to this issue.

Assessment & Evaluation of Student Achievement

The focus of this activity is diagnostic assessment of both knowledge about biological molecules and the lab skills that students have acquired in previous science courses. The teacher should provide feedback to students about their lab report to clarify expectations for the rest of the course. A quiz to assess knowledge about functional groups may be appropriate.

Quiz (Knowledge/Understanding),
Partial Lab Reports (Inquiry, Communication)

Accommodations

- Online investigations may be appropriate for students unable to perform actual labs due to chemical sensitivities.
- Some students could use graphing calculators to display and analyse data.

Resources

Campbell, Neil A. *Biology,* 5th ed. Menlo Park, Calif: Benjamin/Cummings Publishing, 2000. ISBN 0805365737

Keeton, W. and J. Gould. *Biological Science*. New York: W.W. Norton Co., 2000. ISBN 0393969495

Nelson, D. and M. Cox. *Lehninger Principles of Biochemistry*. New York: Worth Publishing, 2000. ISBN 1572599316

Magazines

Popular Science, Times Mirror Magazines – http://www.popsci.com

Discover Magazine, Disney Corp. – http://www.discover.com

National Geographic – http://nationalgeographic.com

Scientific American – http://www.sciam.com

– http://www.cc.ukans.edu/~micro/picts.html
Images of biological molecules.

– http://www.etl.techbc.ca/data/0022Cooperative LearningActivities/data/carousel.html
Provides information about using a carousel activity.

Activity 1.2: Thermodynamics and Reactions

Time: 2 hours

Description

The teacher introduces the four main types of biological reactions through lecture, demonstrations, video or computer displays. This activity gives students the opportunity to practice note-taking skills from lecture-style presentations.

Strand(s) & Learning Expectations

Strand(s): Metabolic Processes

Learning Expectations

MPV.01 - describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;
MPV.02 - conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;
MP1.01 - apply the laws of thermodynamics to the transfer of energy in the cell, particularly with respect to respiration and photosynthesis;
MP1.04 - identify and describe the four main types of biochemical reactions: redox, hydrolysis, condensation, and neutralization;
MP2.01 - formulate operational definitions of the terms related to metabolic processes;
SIS.06 - compile, organize, and interpret data, using appropriate formats and treatments, including tables, flow charts, graphs, and diagrams.

Prior Knowledge & Skills

- Students should have experience in note taking and using graphic organizers such as flow charts, Venn diagrams, T-charts.
- Students should have knowledge of the overall reactions of photosynthesis and cellular respiration.

Planning Notes

- Prepare lecture notes and/or overheads prior to the lesson.

Teaching/Learning Strategies

1.2.1 **Student Activity:** Students take notes during a teacher-led lesson on the four main types of biochemical reactions.

Teacher Facilitation: Since this is the first teacher-led lesson of the course, some time to review note-taking skills prior to this activity might be required. Using concepts developed in Activity 1.1 as a springboard, the teacher presents information about the four main types of biochemical reactions (redox, hydrolysis, condensation, and neutralization), and introduces terms related to metabolic processes as required. The teacher should monitor note-taking skills during this lesson. This could be achieved by giving students an open-note quiz based on the lesson's material, or providing "model notes" for comparison and self- or peer assessment. Ongoing self- and peer-assessment of note-taking skills could be used throughout the unit for students who require more assistance.

1.2.2 **Student Activity:** Students take notes during a teacher-led lesson on the Laws of Thermodynamics. Students apply the Laws of Thermodynamics to the transfer of energy in the cell during the overall reactions of photosynthesis and cellular respiration, and create a graphic organizer (such as a flow chart) to display this information.

Teacher Facilitation: The teacher presents information about the First and Second Laws of Thermodynamics through the use of lecture and demonstrations. Any conservation of mass activity could be used to demonstrate the First Law. The concept of Entropy could be demonstrated by the building and destruction of a tower of paper cups (see Resources). The teacher may need to review the overall reactions of photosynthesis and cellular respiration before asking students to apply the Laws to these reactions.

Assessment & Evaluation of Student Achievement

Assess note-taking skills through the use of an open-note quiz and/or through peer-assessment. Assess knowledge of the types of reactions and the Laws of Thermodynamics through the use of a written quiz which requires application of the knowledge gained. Evaluate the graphic organizer using a rubric as a scoring tool.

Quiz (Knowledge/Understanding, Making Connections),
Graphic Organizer (Knowledge/Understanding, Communication, Making Connections)

Accommodations

- Some students may require additional support in note-taking skills. Consider having these students partner with a more experienced student to compare notes and fill in any missing information.

Resources

– http://www.accessexcellence.org/AE/ATG/data/released/0087-KatharineNoonan/index.html
Provides a safe and simple demonstration to illustrate the Second Law of Thermodynamics.

Activity 1.3: All about Enzymes

Time: 5 hours

Description

In this activity, students explore the role of enzymes in biological reactions. They design and conduct a lab to determine the optimal conditions for the functioning of a particular enzyme and they analyse the commercial application of enzymes through a case study.

Strand(s) & Learning Expectations

Strand(s): Metabolic Processes

Learning Expectations

MPV.01 - describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;
MPV.02 - conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;
MPV.03 - explain ways in which knowledge of the metabolic processes of living systems can contribute to technological development and affect community processes and personal choices in everyday life;
MP1.03 - describe the chemical structure, mechanisms, and dynamics of enzymes in cellular metabolism;
MP2.03 - investigate and explain the relationship between metabolism and the structure of biomolecules, using problem-solving techniques;
MP2.04 - design and carry out an experiment related to a cell process controlling the major variables and adapting or extending procedures where required;
MP3.02 - describe technological applications of enzyme activity in the food and pharmaceutical industries;
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;
SIS.02 - select appropriate instruments and use them effectively and accurately in collecting observations and data;
SIS.03 - demonstrate the skills required to plan and carry out investigations, using laboratory equipment safely, effectively, and accurately;
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports;
SIS.10 - identify and describe science- and technology-based careers related to the subject area under study, e.g., genetic engineer, biochemist, genetic counsellor, microbiologist, pharmacologist, histologist, immunologist, palaeontologist, population ecologist, nutritionist.

Prior Knowledge & Skills

- Knowledge of the structure of proteins from SBI3U, and of chemical reactions from SNC2D.

Planning Notes

- Collect and prepare materials and equipment for demonstrations.
- Collect lab proposals from students in sufficient time to purchase and prepare fresh materials, e.g., fresh liver, potatoes, and hydrogen peroxide may be required.
- This is a good opportunity to assess student scientific investigations skills related to lab design and reporting.
- Collect appropriate case study information prior to beginning the activity.
- Encourage the use of personal glossaries as needed.
- Use diagrams as appropriate to assist with assembly of equipment.

Teaching/Learning Strategies

1.3.1 **Student Activity:** Students observe demonstrations which illustrate the catalytic nature of enzymes, and make links between the structure of enzymes and their function.
Teacher Facilitation: The teacher prepares a series of demonstrations which illustrate the catalytic nature of enzymes. Demonstrations could include the burning of a cube of sugar with and without ashes, the electrolysis of water with and without acid, a comparison of the rate of reaction of hydrogen peroxide and manganese dioxide at different temperatures. The teacher introduces enzymes as biological catalysts. The teacher assists students in making the link between the structure of enzymes (as proteins) and their functions. Be aware of potential safety concerns during the demonstrations.

1.3.2 **Student Activity:** Students formulate a testable question related to determining the optimal conditions for the functioning of a particular enzyme, e.g., catalase in liver and potatoes, then design and conduct an experiment to determine the answer. Factors which could be investigated include temperature, pH, concentration of substrate, concentration of enzyme, particle size. Students share the results of their own investigation with the class through a visual and/or oral presentation. Students create a summary note about the factors which affect enzyme function.
Teacher Facilitation: The teacher assists students in refining their lab design as required and approves all designs before the lab is conducted. The teacher ensures that all factors are being investigated by the class and provides opportunity for sharing of findings. When assessing experimental designs, the teacher considers safety aspects, as well as the ability of the proposed investigation to answer the question or problem.

1.3.3 **Student Activity:** Students examine the role of enzymes in biotechnology through a case study or an online article search.
Teacher Facilitation: The teacher provides case studies or articles that explore the biotechnological application of enzyme function, e.g., bread making, production of alcohol, or yoghurt, pharmaceutical applications (see References), or assists students in their own on-line search. The teacher provides a focus question such as "What is the impact of biotechnology on the production of this product?" Alternatively, the teacher assigns students the task of bringing a current article on the use of enzymes in commercial products to class. In groups, students collate the information about different products and write a summary, including bias analysis, of the most current information available. A class discussion about the societal and economic impact of biotechnology is appropriate.

Assessment & Evaluation of Student Achievement

This activity provides an opportunity to assess skills in lab design (SIS) and learning skills (Teamwork, Organization).
Assess the experiment design and the visual and/or oral presentation for Inquiry and Communication.
Assess individual students' summary notes for communication and Knowledge. Assess the summary for Communication and Making Connections. Lab Report (Inquiry, Communication, Making Connections)

Accommodations

- Ensure that students with language difficulties receive information at an appropriate level.

Resources

– http://www.accessexcellence.org.
Using the search engine of this site with the words "enzymes and biotechnology" generates a list of articles about the use of enzymes in commercial products.
– http://www.enzymes.co.uk/index_enzymes_in_industry.htm
Outlines the use of enzymes in industry.

Activity 1.4: Cellular Respiration and Photosynthesis

Time: 7 hours

Description

In this activity, students examine the chemical processes of photosynthesis and cellular respiration. They examine the role of chloroplasts and mitochondria and a plant cell as a model for chemical thermodynamics. Students design and perform labs to investigate factors that affect the rate of photosynthesis and cellular respiration. Students extend their knowledge of these biological processes to examine the effect personal choices have on the metabolism of an entire organism.

Strand(s) & Learning Expectations

Strand(s): Metabolic processes and Homeostasis

Learning Expectations

MPV.01 - describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;

MPV.02 - conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;

MPV.03 - explain ways in which knowledge of the metabolic processes of living systems can contribute to technological development and affect community processes and personal choices in everyday life;

MP1.05 - describe how such molecules as glucose, ATP, pyruvic acid, NADH, and oxygen function within energy transformations in the cell, and explain the roles of such cell components as mitochondria, chloroplasts, and enzymes in the processes of cellular respiration and photosynthesis;

MP1.06 - compare matter and energy transformations associated with the processes of cellular respiration (aerobic and anaerobic) and photosynthesis;

MP2.05 - determine the similarities and differences between mitochondria and chloroplasts;

MP2.06 - interpret qualitative and quantitative observations, gathered through investigation, of the products of cellular respiration and photosynthesis and, either by hand or by computer, compile and display the results in an appropriate format;

MP3.01 - relate knowledge gained from their current studies of metabolism to their learning in the fields of chemical thermodynamics and physical energy;

MP3.03 - explain the relevance, in their personal lives and the life of the community, of the study of cell biology and related technologies;

HS3.02 - present informed opinions about problems related to the health industry, health legislation, and personal health;

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;

SIS.02 - select appropriate instruments and use them effectively and accurately in collecting observations and data;

SIS.03 - demonstrate the skills required to plan and carry out investigations, using laboratory equipment safely, effectively, and accurately;

SIS.04 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results;

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.

Prior Knowledge & Skills

- Students should have knowledge about cell structures from SBI3U and may have examined micrographs.

Planning Notes

- Collect and prepare all necessary resources (including micrographs) prior to the start of this activity.
- This section provides numerous opportunities to assess Scientific Investigation Skills.

Teaching/Learning Strategies

1.4.1 **Student Activity:** Students examine micrographs of mitochondria and chloroplasts. They relate the structure of these organelles to the overall reactions of cellular respiration and photosynthesis. Students create a graphic organizer that illustrates the similarities and differences between mitochondria and chloroplasts.

Teacher Facilitation: The teacher provides the micrographs and a set of guiding questions to assist students in relating the structure of these organelles to the overall reactions of cellular respiration and photosynthesis. Examples of guiding questions could include: How are the membranes of a mitochondrion and a chloroplast organized? What is similar in the organization of these two organelles? What is different about the organization of these two organelles? Suggest a possible reason for the organization of these organelles. This is a good opportunity for teachers to address the misconception that only animals utilize cellular respiration.

1.4.2 **Student Activity:** Students participate in a teacher-directed lesson about the role of the mitochondria and chloroplasts in an isolated plant cell. They examine the reactants, products and energy transformations of cellular respiration and photosynthesis, and the connection among those processes. Students write a reflection piece about the plant cell as a model for chemical thermodynamics.

Teacher Facilitation: The teacher uses diagrams and flow charts to provide information about the reactants, products and energy transformations of cellular respiration and photosynthesis and the connection between these processes and the related organelles. These lessons include details about intermediate compounds, enzymes, etc., but do not require students to memorize long lists of reactions. Instead, the emphasis should be on the overall concept of energy transformation, and the connection between the structure of the organelles and the processes. This lesson provides the teacher with the opportunity to address common misconceptions about metabolism in plants, e.g., the fact that plants require mitochondria even though they produce their own glucose in the chloroplasts, the misleading naming of the light/dark reactions of photosynthesis, the timing of photosynthetic reactions, the nature of ATP's high energy bonds.

The teacher provides feedback on student reflections in preparation for the reflection assignment required as part of Activity 1.4.5.

1.4.3 **Student Activity:** Students brainstorm factors which affect the rate of respiration and photosynthesis. They design and conduct an experiment to investigate the optimal conditions under which an organism produces energy in a metabolically useful form. They produce and "publish" a formal lab report based on their experiment.

Teacher Facilitation: The teacher assists students in brainstorming an appropriate list of conditions to investigate. The teacher ensures that the lab groups formed investigate a sufficient number of different factors to produce the necessary information required for the End-of-Unit Task. Such factors could include temperature, pH, type and/or quantity of reactants, type of organism. The teacher should ensure that experiments involving aerobic and anaerobic respiration and photosynthesis are carried out. The teacher collates "published" lab reports in one place so that students have access to this information for the End-of-Unit Task. Note that these lab reports must be assessed and available to students in Activity 1.5.

1.4.4 **Student Activity:** Students participate in a series of activities designed to convey information about the specific processes of cellular respiration and photosynthesis, and a comparison of the matter and energy transformations associated with each process.

Teacher Facilitation: The teacher presents a series of activities designed to convey information about the specific processes of cellular respiration and photosynthesis. Due to the complexity of this material, the teacher should consider a variety of teaching/learning strategies, to accommodate different learning styles of students. Suggestions include: the use of skits to "act out" the electron transport chain or chemiosmotic theory; the use of magnetic components of the cycles to assemble on the blackboard; the use of three-dimensional models of glucose which could be assembled and disassembled to illustrate the processes; the use of videos; the use of problem-solving activities in which students examine and explain a scenario related to a metabolic demand or disorder.

1.4.5 **Student Activity:** Students monitor their heart rate under various conditions, e.g., sitting, jumping, caffeine intake, and discuss the connection between increased heart rate and cellular metabolism. In small expert groups, students study various current articles relating metabolic processes and technology, e.g., weight loss supplements, drugs, the fitness industry, and evaluate the information for credibility and bias. Students share the information from expert groups with home groups in preparation for a class discussion regarding the value of educated personal life choices to the individual, society and the economy. Students complete a written summary of the class discussion.

Teacher Facilitation: The teacher organizes the groups for the jigsaw activity and ensures that current articles are available for evaluation. Teachers should be aware of students with health concerns such as asthma, and be sensitive to the health and cultural/lifestyle issues around caffeine intake.

Assessment & Evaluation of Student Achievement

Assess knowledge through the use of a quiz or test. Assess the formal lab report. Assess the reflection piece from the jigsaw activity.

Quiz (Knowledge/Understanding, Making Connections), Lab Report (Inquiry, Communication, Making Connections), Reflection (Knowledge/Understanding, Communication).

Accommodations

- Ensure that students receive articles at an appropriate reading level.
- Additional time may be required for students to review information presented through articles or video format.

Resources

Cellular-respiration, a 6-part series from TVO, 1984.

Photosynthesis, a 6-part series from TVO, 1984.

– http://step.sdsc.edu/personal/vanderschaegen/outlines/respiration.html
Introduction to cell respiration – background material for the teacher.

– http://vlib.org/Science/Cell_Biology/metabolism.shtml
An annotated index of major online resources dealing with metabolism and cellular respiration, excellent link for teacher resources.

– http://www.uwinnipeg.ca/~byard/energeti/index.htm
A series of lessons (as slides) on cellular respiration and photosynthesis.

– http://faculty.uca.edu/~march/bio1/photosyn1_sp01.htm
Sample activity measuring photosynthesis using Vernier CO2 sensors.

Activity 1.5: End-of-Unit Task: Designing an Effective "Metabolic Factory."

Time: 4 hours

Description

The final activity requires students to recall basic structural and functional information regarding cellular respiration and photosynthesis from previous activities. The task is to connect this information with that related to energy transformations, and to demonstrate this connection through the creation of a model of an effective metabolic factory. At the teacher's discretion, the End-of-Unit Task may also involve a written test.

Strand(s) & Learning Expectations

Strand(s): Metabolic Processes

Learning Expectations

MPV.01 - describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions;

MPV.02 - conduct laboratory investigations into the transformation of energy in the cell, including photosynthesis and cellular respiration, and into the chemical and physical properties of biological molecules;

MPV.03 - explain ways in which knowledge of the metabolic processes of living systems can contribute to technological development and affect community processes and personal choices in everyday life;

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.

Prior Knowledge & Skills

- These activities evaluate the knowledge and skills acquired throughout the activities of this unit.

Planning Notes

- Ensure that the formal lab reports completed in Activity 1.4.3 are available for student use in the library/resource centre or classroom.
- Design/alter the marking scale used for the effective "metabolic factory."

Teaching/Learning Strategies

1.5.1 **Student Activity:** Using the knowledge and skills acquired during this unit, students design a model of an effective "metabolic factory," and justify their design based on research, including the lab reports "published" by their classmates in Activity 1.4.2. The design must detail the reactants and conditions under which metabolism will occur. Students present their design in a format of their choosing which may include a poster display, a model, a written report or an oral presentation.

Teacher Facilitation: The teacher communicates the criteria that will be used to assess the students' presentations. (See sample marking scale for the effective "metabolic factory" in Appendix D.) Alternatively, this activity may provide an opportunity to develop a rubric with student input. The intention of this activity is that students design a model of an effective "metabolic factory" that would be capable of performing the same tasks that a cell performs with regard to energy production. The design should demonstrate the student's grasp of the essential concepts of cell metabolism. For example, the "metabolic factory" must contain a structure which performs the function of the membrane in the production of ATP. The teacher could consider creating a scenario where such a device would be necessary, e.g., a "futuristic" medical treatment for someone who is suffering from a metabolic disorder.

1.5.2 **Student Activity:** Students write a unit test.

Teacher Facilitation: The teacher prepares and administers the unit test if desired. If so, consideration should be given to replacing the quiz marks with the unit test mark if the unit test gives a better indication of the student's most recent and most consistent performance. Ensure that all expectations evaluated on quizzes are evaluated on the unit test if this is done.

Assessment & Evaluation of Student Achievement

- Evaluate the model metabolic factory using a marking scale or rubric. (Making Connections, Inquiry, Communication, Knowledge/Understanding)
- Evaluate the unit test with a marking scheme. The marking scheme is then posted so that students can check their work when the test has been returned to the students. (Knowledge/Understanding, Making Connections)

Accommodations

- Encourage students to choose presentation formats most appropriate to their individual strengths.
- This project provides an opportunity for open-ended inquiry and enrichment extensions.

Appendix D

(for use with Activity 1.5.1)

Marking Scale for an Effective Metabolic Factory

Criteria	Evaluation				
Knowledge: All structural considerations have been incorporated in metabolic factory. Functional information appropriate to specific design is complete and explanations involving thermodynamic activities are appropriate and complete.	2.0	4.0	6.0	8.0	10.0
Making Connections: Presentation (model, poster, report) shows thorough understanding of connections between cellular conditions and metabolic reactions. Presentation effectively extends analyses of problem of metabolic efficiency into design of effective "factory."	2.0	4.0	6.0	8.0	10.0
Communication: Student communicates information and ideas with a high degree of clarity and precision. Student demonstrates extensive command of the various forms of communication and uses appropriate technology with a high degree of effectiveness.	1.0	2.0	3.0	4.0	5.0
Inquiry: Student demonstrates high degree of competence in the design process.	1.0	2.0	3.0	4.0	5.0