Unit 1
MAINTAINING DYNAMIC EQUILIBRIUM II

Suggested Time: 23 Hours

Unit Overview

Introduction

Cells, tissues, organs, organ systems and ultimately organisms must maintain a biological balance despite changing external conditions. Homeostasis is the state of internal balance so critical to existence. It represents a dynamic equilibrium, displaying constant interactions and checks and balances both within organisms and between organisms and their environment. There are a variety of systems within living things responsible for the maintenance of this delicate balance and this unit will identify and introduce the role of some of the nervous (electrochemical) and endocrine (chemical) systems in humans.

Focus and Context

This unit focuses primarily on decision-making (STSE) as social and environmental issues are considered. This STSE component contributes to the development of scientific literacy and a sense of global citizenship. In addition, numerous opportunities for problem-solving and scientific inquiry are incorporated into the discussion of electrochemical and chemical control systems.

Science Curriculum Links

Biology students have studied the components of body systems at a number of different levels prior to Biology 3201. Students in the primary grades are introduced to the importance of maintaining a healthy lifestyle. When they reach the elementary level, students begin to discuss the role of growth and reproduction in human system. They are introduced to the major components of the structure and function of the digestive, excretory, respiratory, circulatory and nervous systems. The skeletal, muscular and nervous systems and their contributions to movement are also integrated into this study. In addition, the curriculum provides an opportunity for students to discuss body defences against infection and nutritional requirements to promote health. When students reach Biology 2201, they begin to consider the factors that affect the functioning and efficiency of the human respiratory, circulatory, digestive, and excretory systems and are encouraged to discover and describe examples of the interdependence of various systems of the human body. This provides a good background for the study of the role of biological systems in the maintenance of homeostasis within an organism. A cross-curricular link exists between the life sciences and physical sciences in the discussion of dynamic equilibrium incorporated into the provincial chemistry and physics curriculum.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

115-5 analyse why and how a particular technology was developed and improved over time

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-7 analyse natural and technological systems to interpret and explain their structure and dynamics

Social and Environmental Contexts of Science and Technology

117-11 analyse examples of Canadian contributions to science and technology

118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability

Skills

Students will be expected to

Initiating and Planning

212-6 design an experiment and identify specific variables

Performing and Recording

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

Analysing and Interpreting

214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

Knowledge

Students will be expected to

314-2 identify the role of some compounds, such as water, glucose, and ATP, commonly found in living systems

314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids

314-4 explain the critical role of enzymes in cellular metabolism

317-1 explain how different plant and animal systems, including the vascular and nervous systems, help maintain homeostasis

317-2 analyse homeostatic phenomena to identify the feedback mechanisms involved

317-4 evaluate the impact of viral, bacterial, genetic and environmental diseases on an organism's homeostasis

317-5 evaluate, considering ethical issues, the consequences of medical treatments such as radiation therapy, cosmetic surgery and chemotherapy

317-7 describe how the use of prescription and non-prescription drugs can disrupt or help maintain homeostasis

Nervous System: Structures

Outcomes

Students will be expected to

- analyze the nervous system and explain its structure and dynamics (116-7)
  - explain the basic structure and function of the central nervous system. Include:
    (i) brain
    (ii) spinal cord
  - explain how the nervous system is protected. Include:
    (i) skull
    (ii) meninges
    (iii) cerebrospinal fluid
  - explain the basic structure and function of the brain. Include:
    (i) cerebrum
    (ii) cerebellum
    (iii) medulla oblongata
    (iv) thalamus
    (v) hypothalamus
    (vi) midbrain
    (vii) pons
    (viii) corpus callosum
  - describe the basic functions of a peripheral nervous system. Include:
    (i) autonomic
    - sympathetic
    - parasympathetic
    (ii) somatic

Suggested Learning and Teaching Strategies

Students should be given the opportunity to observe the principle features of the central nervous system, using models, dissected mammalian brains or computer simulations, and to identify and label major physical structures and their functions from drawings or photos of that organ.

Students should understand that the basic function of the cerebrum is to sort and interpret all the information from our senses. It is the part of the brain that makes humans different from animals because it is the centre of human consciousness. Students should also understand that the cerebrum can be divided into two hemispheres (left and right) or into four lobes (frontal, parietal, temporal, occipital). For this course it is not necessary for students to know the function of each hemisphere or lobe individually.

Students can prepare a chart to visually contrast the sympathetic and parasympathetic components of the autonomic nervous system on various parts of the body (e.g., heart, digestive tract, blood vessels, bladder, bronchi, eye).

Nervous System: Structures

Suggested Assessment Strategies

Presentation

- Teachers could invite a physician or public health specialist to give a presentation. Students should research and prepare questions related to the topic. Working in groups, students should review and revise questions. The questions selected should be asked during the presentation. Following the presentation students should prepare a brief summary of the answers given. (116-7)

Journal

- The teacher could ask students what happens to their bodies when they are faced with a stressful situation (e.g., danger, fright, and so on? How long does it usually take for their bodies to return to normal? (116-7)

Laboratory Activities

- Students could identify regions of preserved sheep brain. (116-7, 213-5, 214-10, 215-2)

Performance

- Students could be asked to create their own model of the human brain. (317-1)

Resources/Notes

www.gov.nl.ca/edu/science_ref/main.htm

MGH Biology, pp. 392-393

MGH Biology, p. 393

MGH Biology, pp. 399-401

MGH Biology, pp. 392-394

Nervous System: Neurons

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain how the nervous system helps to maintain homeostasis (317-1)	The nervous system is responsible for receiving information from internal and external stimuli and the quick response to that information. Students have explored the concept of homeostasis in Biology 2201. This concept can be reviewed with students and related to the nervous system.
– identify requirements necessary for a nervous response to occur. Include: (i) sensory receptors (skin, eye, ear) (ii) impulse transmission (neurons) (iii) interpretation and analysis of impulses (brain, spinal cord) (iv) effectors (muscle, gland)	
– describe the structure of the typical neuron and explain the function of each part. Include: (i) dendrite (ii) cell body (iii) axon (iv) axon terminal (v) Schwann cells (myelin sheath and nodes of Ranvier)	Students can observe microscopically the structure of neurons and neuromuscular junctions on prepared microscope slides within the laboratory. Teachers should note that the axon terminal is not specifically named in the textbook. The axon terminal is described as the bulb-like ends of the axon. Other terms for this structure may include end brushes or terminal endings.
– describe the function of sensory neurons, motor neurons and interneurons	
– describe the transmission of an impulse along the length of a neuron. Include: (i) the ion distribution of the neural membrane (rest, depolarization, repolarization) (ii) threshold (iii) action potential (iv) all-or-none response	Students should be able to describe the role of the sodium-potassium (Na^+/K^+) pump as it pertains to ion distributions. Discussion of action potential should also be included here.

Nervous System: Neurons

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the available laboratory activities provided to illustrate some aspects of the nervous system. These may include microscopic examination of components of the nervous system, dissection of specimens, or observation of models in order to observe the structure of the nervous system. Assessment would depend on the nature and depth of the activities selected. Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that arise from these activities. (317-1)

MGH Biology, p. 392

- Students could perform the available laboratory activities provided to illustrate some aspects of the nervous system. These may include activities to investigate reflex times, observation of the behaviour in response to stimuli of specimens like Planaria or the effect of the stimulant caffeine on Daphnia. Assessment would depend on the nature and depth of the activities selected. Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (212-6, 213-5, 214-10, 215-2, 317-1)

MGH Biology, pp. 395 and 404

Paper and Pencil

- Students could research the effects of drugs (such as codeine, heroin, caffeine) on the synapse. Students could then write up their findings in the form of a magazine article. (317-1)

Performance

- Students could design a model of an electro-chemical event across a synapse. (317-1)

MGH Biology, pp. 395-396

MGH Biology, pp. 402-404

Resources/Notes

Nervous System: Neurons (continued)

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain how the nervous system helps to maintain homeostasis (317-1) **(Cont'd)**	
– describe the transmission of an impulse across a synapse and the effects of neurotransmitters involved. Include: (i) acetylcholine (ii) noradrenaline (iii) glutamate (iv) GABA (v) dopamine (vi) serotonin	Students may investigate the neurological and physiological basis behind the effectiveness of acupuncture and the production of a "runners high". Students can investigate how nerve poisons interfere with synaptic transmission (curare, botulism, tetanus, organophosphate pesticides, nerve gas). Teachers should note that a curriculum connection exists with the Core STSE #1.
• describe the critical role of cholinesterase in nerve transmission (314-4)	Students should understand the role of cholinesterase in the breakdown of neurotransmitters across the synapse. Teachers should note that a curriculum connection exists with the Core STSE #1.
• identify the role of certain compounds to neuron function (oxygen, glucose, ATP, sodium ions) (314-2)	Cells within the nervous system require enormous amounts of energy to function. This energy is provided by the processing of glucose and the production of ATP within these tissues, requiring an adequate supply of carbohydrates and oxygen (Na^+/K^+ pump). ATP energy is required to operate the sodium-potassium pump which convert cellular chemical signals into electrical signals along a nerve cell and in between individual nerve cells (i.e., synapse).
• analyze homeostatic phenomena to identify the feedback mechanisms involved (317-2) – define reflex arc	Students can design and/or perform experiments to investigate other physiology of reflex arcs (pupil dilation and reaction time, page 410 - optional activity)

Nervous System: Neurons (continued)

Suggested Assessment Strategies

Journal

- With a partner, students could test each others' reflexes (for example, knee jerk test or reaction time). Teachers could ask students, "What do you think can be learned from tests like this?" (317-2)

Paper and Pencil

- Students could construct a flow chart that shows the path of a reflex arc. (317-2)
- Students could draw a cartoon strip of ATP in action. (317-2)

Resources/Notes

MGH Biology, pp. 405-406

MGH Biology, p. 406

MGH Biology, pp. 397, 402

MGH Biology, p. 395

Nervous System: Neurons *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to • perform an experiment to investigate and collect data on the nervous system (reflexes) and identify specific variables involved (212-6) • compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5) • identify and explain sources of error and uncertainty in measurement and express results from this nervous system activity in a form that acknowledges the degree of uncertainty (214-10) • select and use symbolic and linguistic modes of representation to communicate ideas and results (215-2)	The Laboratory outcomes 212-6, 213-5, 214-10 and, in part, 317-2 are addressed by completing *The Nervous System and Reflex Responses* CORE LAB #1.
• describe disorders linked to the nervous system and their effect on homeostasis of the system and the organism as a whole. (317-4) Include: (i) Multiple Sclerosis (ii) Alzheimer's Disease (iii) Parkinson's Disease (iv) Meningitis (v) Huntington's Disease	Specific pathologies of the nervous system should be discussed or researched along with the capability of technology to diagnose, treat or cure the problem. During this discussion, students should investigate the physiological basis and causes of neurological diseases and discuss the effectiveness and the ethics of new innovative treatments (e.g., transplant of fetal brain tissue into patients as a treatment for Parkinson's). Students may be interested in other conditions related to nervous function, such as polio, stroke, Bell's palsy, ALS, Tourette's Syndrome, epilepsy or mental disorders related to chemical imbalances.

Nervous System: Neurons *(continued)*

Suggested Assessment Strategies

Presentation

- Students could be introduced to individuals knowledgeable in nervous system pathologies by using community resources such as physicians, organizations (Alzheimer Society, Parkinson Foundation, Heart and Stroke Foundation, Canadian Mental Health Association, Multiple Sclerosis Society), sufferers of, or caregivers of those who possess these disorders. (317-1, 317-4, 317-7)
- Students could research and prepare questions related to the topic being presented by the guest speaker. Working in groups, these questions should be reviewed and revised, and questions selected to be asked during the presentation. Following this presentation, students could be asked to prepare a brief summary of it, or of the answer to their question. Assessment may be based on a student summary of the guest's talk or answers provided to one of their questions. (317-1, 317-4, 317-7)
- Working within assigned groups, students could select a nerve poison to investigate. They could report to the class on the physiological effect it has on the nervous system, its source, and the historical and/or current reasons for its use. (317-4, 115-5)

Resources/Notes

Core Lab #1: *"The Nervous System and Reflex Responses", pp.* 396-397

MGH Biology, pp. 406-408

Nervous System: Disrupting Homeostasis

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to • analyze why and how technologies related to the treatment of nervous system disorders were developed and improved over time (115-5) – include the technologies: (i) MRI (ii) EEG (iii) CAT Scan (iv) PET Scan	Students may investigate and discuss how these technologies influence our ability to explore the human brain.
– describe the methods used to treat stroke and spinal cord injury	Students may evaluate the consequences of damage or injury to the nervous system (e.g., stroke, spinal injury). Students may investigate the research being done on treatments for the conditions of stroke and spinal injury and the potential these have for the improvement of the lifestyle of victims of these conditions. Teachers should note that a curriculum connection exists with Core STSE #2 in Unit 2, which covers stem cell research and its potential for curing spinal cord injury.

Nervous System: Disrupting Homeostasis

Suggested Assessment Strategies

Presentation

- Working within assigned groups, students could select a substance (chocolate might be an example) or procedure (acupuncture) that affects the nervous system. They could report to the class on its physiological effects on the nervous system. (317-4, 115-5)
- The teacher could invite a radiologist/x-ray technician to give a presentation on MRI, CAT, scan of EEG. Students should research and prepare questions related to the topic. Working in groups, students should review and revise questions. The questions selected should be asked during the presentation. Following the presentation students should prepare a brief summary of the answers given. (116-7)

Resources/Notes

MGH Biology, pp. 398-399

MGH Biology, pp. 404-405

Nervous System: Disrupting Homeostasis *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to • describe how the use of prescription and non-prescription drugs can have a role in maintaining or disrupting homeostasis (317-7) Include: (i) anaesthetics (ii) prescription drugs (OxyContin™, Valium™, Ritalin™) (iii) illegal drugs (marijuana, ecstasy, cocaine) (iv) legalized drugs (alcohol, nicotine, caffeine)	The CORE STSE component of this unit incorporates a broad range of Biology 3201 outcomes. More specifically it targets (in whole or in part) 317-1, 317-4, 115-5, 317-7, 118-8 and 118-10. The STSE component, *Drugs and Homeostasis*, can be found in Appendix C. Students may analyze evidence concerning the influence of anaesthetics, drugs and chemicals, natural and synthetic, on the functioning of the nervous and endocrine systems and their relationship to addiction theory (e.g., nicotine, oxycontin, morphine, LSD). Students may compare the relative physiological and societal impacts of chemical and drug use on adult development as compared to fetal development.
• distinguish between questions that can be answered by science and those that cannot and between problems that can be solved by technology and those that cannot (118-8)	Students can debate the merits of using drugs for treatments of nervous disorders against the long-term side effects.
• propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability. (118-10)	Students can debate the legalization of certain drugs such as marijuana for medicinal purposes

Nervous System: Disrupting Homeostasis *(continued)*

Suggested Assessment Strategies

Performance

- Students could participate in a debate as a means of exploring the use of drugs for the treatment of nervous disorders (118-8, 317-7)
- Students could participate in a debate regarding the legalization of drugs (118-10, 317-7)

Presentation

- Students could be introduced to individuals knowledgeable in the influence of the use of prescription and non-prescription, legal and illegal drugs on the maintenance of homeostasis within the human system by using community resources such as physicians, pharmacists and available organizations. (317-1, 317-4, 317-7)
- Students could use outside sources (media, Internet, etc.) to find out how drugs affect the central nervous system. Students could discuss findings and create a class chart that summarizes the effects of common drugs. (317-7)

Paper and Pencil

- Students could select a particular pharmaceutical or drug to investigate. They should include the sources of the chemical, medical or non-medical uses, effects of use, and any other appropriate information. Students should present their information to the class. This will provide a comprehensive overview. Assessment could be based on completeness and accuracy of information obtained. (115-5, 116-4, 118-8, 118-10, 317-7)

Resources/Notes

MGH Biology, p. 408

Core STSE #1: *"Drugs and Homeostasis",* Appendix C

Nervous System: Sense Organs

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain how the eye as a sense organ helps maintain homeostasis (317-1)	The investigation of sense organs serves as a cross-curricular link with the waves/sound/light sections of high school physics. Students should observe the principal features of the mammalian eye, using models, dissected structures or computer simulations, and identify and label major visible structures and their functions from drawings or photos of those organs.
– describe the general structure and function of the eye. Include: (i) lens (ii) iris (iii) retina (iv) cornea (v) choroid layer (vi) fovea centralis (vii) rods (viii) cones (ix) pupil (x) blind spot (xi) optic nerve (xii) aqueous humour (xiii) vitreous humour	For an elaboration on the blind spot see Minilab on page 413 and Figure 12.21 on page 412.
– trace the path of light through the eye and explain how the amount of light entering the eye is regulated	Student activities dealing with the sensory organ of the eye can illustrate binocular vision, dominant eye, focussing, resolution, blind spot and retinal fatigue.
• analyze and describe examples of disorders of the eye and where technologies for the correction of visual defects were developed based on scientific understanding (116-4) Include:	Students may research the development of new technologies for the treatment of sensory malfunctions (e.g., corneal laser surgery and extended-wear contact lenses).
– eye disorders (glaucoma, cataracts, astigmatism, myopia, hyperopia)	Students should know that myopia and hyperopia are also known as near-sightedness and far-sightedness respectively.
– treatments for the eye disorders (corneal transplant, laser surgery, corrective lenses, lens replacement)	Corneal transplant is one of the most successful transplant surgeries. The chance of rejection is low and the operation is relatively quick and cost-effective. Many people, however, suffer because too few donor cornea are available. One possible solution is for mandatory donation to be enforced. This could be a very controversial solution and should be discussed by students.

Nervous System: Sense Organs

Suggested Assessment Strategies

Laboratory Activities

- Following the procedure outlined, students could dissect the sheep eye provided and identify the parts. They could complete a table that relates the structure of the parts of the eye with their function. (317-1)

Journal

- Birds of prey often have much greater visual resolution (the ability to distinguish between objects at great distances) than humans. Students could answer, "What is it about a bird's eye that gives it this ability?" (317-1)

Performance

- Students could design an experiment to investigate the effect of light intensity on pupil diameter. They should show the procedure to the teacher for approval. All safety precautions and procedures should be followed. (317-1)
- Students may use eye-charts to test their vision. (317-1)
- Students could design a model of the human eye. Lenses could be used to show image formation. (317-1)

Presentation

- Students could construct a chart of eye disorders (e.g., cataracts, crossed eyes, sty, etc.). They should describe the disorder and the possible medical treatments. This could be done individually or in groups, with each group completing one eye disorder and the results combined to make a large class display. (116-4)

Resources/Notes

MGH Biology, pp. 409-413

MGH Biology, pp. 411-413

MGH Biology, pp. 413-414

Nervous System: Sense Organs *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain how the ear as a sense organ helps maintain homeostasis (317-1) – describe the general structure and function of the ear. Include: (i) pinna (ii) tympanic membrane (iii) ossicles (i.e., malleus, incus, stapes) (iv) eustachian tube (v) semi-circular canals (vi) cochlea (vii) auditory nerve	The investigation of sense organs serves as a cross-curricular link with the waves/sound/light sections of high school physics. Students should observe the principal features of the mammalian ear, using models, dissected structures or computer simulations, and identify and label major visible structures and their functions from drawings or photos of those organs. Students should know that the ossicles are also known as the hammer, anvil and stirrup respectively.
• trace the pathway of sound through the ear	When the pathway is traced through the ear, the structures should be limited to only those discussed above. Students should recognize the importance of hair cells in transmission of sound through the cochlea to the auditory nerve.
• analyze and describe examples of disorders of the ear and where technologies for the correction of auditory defects were developed based on scientific understanding (116-4) – ear disorders - conduction deafness, nerve deafness – treatments for ear disorders - eustachian tube implants, hearing aids	Students should research and discuss the potential health effects of repeated exposure to loud noises (noise pollution and the use of cochlear and digital implants).
• evaluate, considering ethical issues, the consequences of medical treatments for visual and auditory disorders (317-5) – sense of exclusion – mandatory organ donation	The ethical issues regarding the treatment of visual and auditory disorders may include the sense of loss experienced by the treated individual. These individuals may then find themselves excluded from the deaf and blind community. The long term success of laser surgery and the potential risks can be evaluated.

Nervous System: Sense Organs *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could construct a flow chart that shows the path of sound energy through the auditory system. (317-1)
- Students could investigate the development of new technologies for the correction of malfunctions of the sense organs and/or the potential health effects of environmental factors such as noise pollution and extended wearing of contact lenses. They should be prepared to present their findings to the class. Assessment may be based on completeness and accuracy of research as observed during presentation to the class by the students or through a written summary. (116-4, 317-5)

Presentation

- The teacher could introduce students to individuals knowledgeable in sensory organ pathologies by using community resources such as physicians, organizations (Canadian National Institute for the Blind, Eye Banks, Canadian Association for the Deaf and Blind), corneal and cochlear transplant recipients or persons suffering from these disorders. Students should research and prepare questions related to the topic being presented by the guest speaker. Working in groups, students should review and revise these questions, and questions selected to be asked during the presentation. Following this presentation, students may be asked to prepare a brief summary of it, or of the answer to their questions. Assessment may be based on a student summary of the guest's talk or answers provided to one of their questions. (317-5)

Performance

- Students could be asked to devise a model of the human ear. Tuning forks or oscilloscopes could be used to demonstrate sound patterns. (317-5)

Resources/Notes

MGH Biology, pp. 414-416

MGH Biology, pp. 415-416

MGH Biology, p. 416

Endocrine System: Maintaining Homeostasis

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain how the endocrine system helps maintain homeostasis (317-1)	The endocrine system of animals releases chemical hormones into the blood to be circulated. These help maintain homeostasis by causing or preventing change in specific organs or tissues of the body. The endocrine system is slower in producing an effect than the nervous system; however, it is a more sustained effect. It is important for students to realize that the nervous system and endocrine system work together in a coordinated fashion.
– understand the general concept of a hormone and target cell or organ	Teachers could review the basic biochemical structure of carbohydrates, proteins and lipids/steroids. Students should examine diagrams that illustrate the location of receptors for non-steroid hormones compared to steroid hormones. They should recognize the importance of the solubility of steroid hormones in the cell membrane and the critical nature of the shape of non-steroid hormones. Additional hormones may also be of interest to students (antidiuretic hormone, cortisol, aldosterone).
– compare how non-steroid and steroid hormones cause changes in target cells. Include: (i) solubility in cell membrane (ii) location of receptors (iii) end result	Students should understand that the non-steroid hormones cause chain reactions in the target cells while steroid hormones stimulate genes to produce a protein. Students should be provided with the opportunity to observe the principal features of the endocrine system, utilizing models, dissection or computer simulations and to identify and label those structures through the use of drawings or photographs.
– identify the location and function of principal endocrine glands in the human organism. Include: (i) pituitary (ii) hypothalamus (iii) pineal (iv) thyroid (v) parathyroid (vi) adrenal (vii) pancreas (Islets of Langerhans) (viii) thymus (ix) ovaries (x) testes	It is not necessary that students know the function of all hormones associated with every gland. Students should know the general function of each gland. Specific hormones will be dealt with in later outcomes. Ovaries and testes have a dual function. For this reason they are dealt with in more detail in Unit 2.

Endocrine System: Maintaining Homeostasis

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the laboratory activities provided to illustrate some aspects of the endocrine system. These may include the following:
  - microscopic examination of pancreas to distinguish endocrine tissue from digestive enzyme producing tissue
  - effect of epinephrine on the heartbeat of Daphnia
  - metamorphosis of tadpoles
  - development of models to illustrate visually the concept of negative feedback
  - growth of plants in response to hormonal stimulation (e.g., Giberlic acid)

Assessment of these activities above would depend on the nature and depth of the activities selected. Some of them involve collection of data that maybe tabulated and graphed. Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (317-1)

Resources/Notes

MGH Biology, pp. 420-422

MGH Biology, pp. 424-425

MGH Biology, p. 422

MGH Biology, pp. 427-431
MGH Biology, p. 427
MGH Biology, p. 438
MGH Biology, pp. 431-432
MGH Biology, pp. 433-434
MGH Biology, p. 441
MGH Biology, p. 435

MGH Biology, p. 440
MGH Biology, pp. 490-493
MGH Biology, pp. 486-487

Endocrine System: Maintaining Homeostasis *(continued)*

Outcomes

Students will be expected to

- identify and describe the structure and function of important biochemical compounds, including non-steroid and steroid hormones (314-3)
  - identify the following hormones, their source gland, and explain their general effect on the human organism:
    (i) melatonin
    (ii) thyroxine
    (iii) adrenaline
    (iv) somatotropin (HGH–human growth hormone)
    (v) insulin
    (vi) glucagon

Suggested Learning and Teaching Strategies

Students can discuss the social, ethical and health issues associated with hormone therapy for the treatment of humans (e.g., growth hormones, steroid use in sports, hormone use to slow the effects of aging or to minimize jet lag). This may lead to questions such as "Should physicians provide HGH as a treatment for individuals who have normal levels of human growth hormone, yet are genetically shorter than average, simply to increase their height?" Students may investigate the hormonal connection with biorhythms and seasonal affective disorder (SAD). Students may investigate the abuse among athletes of steroid hormones as they attempt to build body tissue quickly and increase their athletic ability and the long-term side effects that result.

Because of the volume of information and the way it is inter-related, teachers could use a series of tables to summarize the glands, their hormones and functions. An extension of this may include problems with hypersecretion and hyposecretion of the hormone and target organs.

Students may research, identify and summarize the main hormonal and nervous components of reactions to stress. They may discuss why some individuals may experience the following symptoms when they are nervous: cool hands, knots in their stomach, dilated pupils, dry mouth and rapid heart rate.

Endocrine System: Maintaining Homeostasis *(continued)*

Suggested Assessment Strategies

Laboratory Activities

- Students could develop a visual model that illustrates enzyme function. The design of these models may range from physical ones to visual animations, so students can be creative! The assessment will be based on accuracy and effectiveness of the product submitted and/or presented to the class. (317-1)

Presentation

- Within a debate format, students will be required to display the results of research and "argue" against other stakeholders concerning issues such as, "Should doctors prescribe HGH as a treatment for individuals who have normal levels of human growth hormone in their system, yet are genetically shorter than average, simply as a means to increase their height?", "Should steroids (performance enhancing drugs) be legalized for use by all athletes?", "Should random drug testing of athletes be permitted or is it an invasion of privacy?", "Should hormones be used within the beef industry to increase production?" Assess the participation of students, preparation of the argument, thoroughness of the research and their familiarity with the topic. (314-3)

Pencil and Paper

- Students could be provided with a partial flow chart to illustrate hormones and feedback systems within the human body. Working within groups, they should complete the chart. When this is complete, within their own group, they could develop partial charts of their own design for completion by other groups within the class. (317-2, 314-3)
- Students could select a hormone and investigate the effects of its hypersecretion and hyposecretion in the body. They should prepare a visual display to illustrate this. Hormones may include HGH, aldosterone, cortisol, thyroxine, insulin, or glucagon. (317-1, 314-3)

Resources/Notes

MGH Biology, pp. 438, 440
MGH Biology, p. 432
MGH Biology, pp. 444-446
MGH Biology, pp. 428-429

MGH Biology, pp. 435-436

Endocrine System: Feedback Mechanisms

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• analyze homeostatic phenomena to identify the feedback mechanisms involved (317-2) – describe representative positive and negative feedback loops. Include: (i) hypothalamus-pituitary complex as a negative feedback control (ii) oxytocin as positive feedback control	Students should be able to use flow charts to describe representative positive and negative feedback mechanisms in living systems. They may compare technological feedback control systems with the natural electrochemical control systems of organisms and discuss sensitivity, response time, effectiveness. Within the discussion of the hypothalamus-pituitary complex, RF (releasing factor), pituitary hormones and target tissues (e.g., TSH on thyroid) should be included. Oxytocin should be used to illustrate a positive feedback loop in a human system. When the "water breaks" pressure is exerted on the cervix, an increase in uterine contractions occurs. In turn more oxytocin is released which, then increases the contractions. This cycle would continue until the Expulsion Stage is finished. This will be covered futher in unit 2.
– describe the regulation of blood sugar by controlled release of insulin and glucagon	Teachers could contact the Canadian Diabetes Association or do an Internet search to obtain sample data concerning blood and/or urine composition. Data can be analyzed and interpreted in order to infer the role of hormones in homeostasis. Students could perform an experiment to investigate the presence of sugar in simulated urine samples, and compare the results with other urinalysis data. Using a table, students may compare the conditions of juvenile diabetes and adult-onset diabetes. Headings may include age of onset, cause, severity, method of treatment. Students could research and present modern approaches to the detection, treatment and control of diabetes, e.g., the onset of diabetes in relation to diet and exercise and culture (some populations).
• describe disorders and treatments linked to the secretions of the endocrine system and their effect on the homeostasis of the system and the organism as a whole. (317-4) Include: (i) dwarfism (ii) giantism (iii) hyperthyroidism (iv) hypothyroidism (v) diabetes mellitus	Students may hypothesize the effect on organisms of the oversecretion (hypersecretion) or undersecretion (hyposecretion) of hormones.
• analyze examples of Canadian contributions to science and technology (117-11) – investigate the role played by Frederick Banting and Charles Best in the discovery of insulin	Students should be aware of the importance of Canadian researchers Frederick Banting and Charles Best in the discovery of insulin and the control of diabetes.

Endocrine System: Feedback Mechanisms

Suggested Assessment Strategies

Pencil and Paper

- Students could analyze and interpret the data provided on blood or urine composition. They should use it to determine the role of hormones in homeostasis. (317-2)
- Students could prepare a short report on the role played by Canadian researchers Frederick Banting and Charles Best in the discovery of insulin. Assessment should be based on quality of work submitted. (117-11)

Journal

- Students could describe an everyday example (such as thermostat) to explain the process of negative feedback. (317-2)

Resources/Notes

MGH Biology, pp. 302-303

MGH Biology, pp. 424, 427, 432

MGH Biology, p. 431

MGH Biology, pp. 435-438

MGH Biology, p. 429

MGH Biology, p. 432

MGH Biology, p. 437

MGH Biology, p. 439

Endocrine System: Feedback Mechanisms *(continued)*

Outcomes

Students will be expected to

- perform an experiment to investigate and collect data on the endocrine system and identify specific variables involved (212-6)
- compile and organize data, using appropriate formats and data treatments, to facilitate interpretation of the data (213-5)
- identify and explain sources of error and uncertainty in measurement and express results from this endocrine system activity in a form that acknowledges the degree of uncertainty (214-10)
- select and use appropriate symbolic and linguistic modes of representation to communicate ideas and results (215-2)

Suggested Learning and Teaching Strategies

The Laboratory outcomes (212-6, 213-5, 214-10) and, in part, 317-4 are addressed by completing *Identifying Diabetes Mellitus* CORE LAB #2. Teachers should note that the Core Lab requires the preparation of four solutions of glucose for the students to test. An easy method to prepare a class set of stock solutions is to prepare the most concentrated solution first and then prepare the others by diluting it with water. The following table (procedure) will produce enough for a class of thirty students.

Solution	%	Solute		Solvent
A	1.7	8.5g of $C_6H_{12}O_6$		500.0 mL H_2O
B	1.3	50.0 mL of Soln A	Add to	15.0 mL H_2O
C	0.85	50.0 mL of Soln A		50.0 mL H_2O
D	0.3	50.0 mL of Soln A		230.0 mL H_2O

In order to see changes in the solutions during lab time, it will be necessary to increase the temperature of the water bath significantlty higher than what is indicated in the text. You may wish to boil the water. Fresh Benedicts Solution will give the best results. It could be useful for students to observe the rate of color change in solutions during heating as an indication of the differences between concentrations.

Other possible laboratory investigations can be used to further illustrate some of the effects of hormones. In season, tadpoles (preferably bullfrog tadpoles with legs) can be placed in a solution of one part thyroxine to five million parts water at room temperature. The first metamorphic changes induced by the hormone, which would normally take two to three years under natural conditions, may occur after two days. The effect of epinephrine on the heartbeat of Daphnia can be investigated and data collected. Treatment of additional Daphnia with quantitative or qualitative data can be compared, interpreted and extrapolated via the question "Based on the results of this experiment, what effects might you expect these chemicals to have on the heartbeat of humans?"

Endocrine System: Feedback Mechanisms *(continued)*

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the available laboratory activities provided to illustrate some aspects of the nervous system. These may include activities to investigate the sensitivity of the touch receptors of the skin and/or the taste receptors of the tongue. Assessment would depend on the nature and depth of the activities selected. Some of these activities involve collection of data that may be tabulated and graphed. Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (212-6, 213-5, 214-10, 215-2, 317-1)
- Students could develop a physical working model to illustrate visually the concept of negative feedback. (317-1)

Performance

- Students could design an experiment to show the effects of the removal of the thyroid gland in mice. They should identify the physiological characteristics that should be observed and explain how the data should be recorded. (214-10)

Paper and Pencil

- Within groups students could develop a concept map for the electrochemical and chemical control systems that will illustrate their close integration and interconnected nature. Assessment should be based on student participation and final product as appropriate. (116-7, 317-1)

Resources/Notes

Core Lab #2: *"Identifying Diabetes Mellitus", pp.* 436-437

Endocrine System: Feedback Mechanisms *(continued)*

Outcomes

Students will be expected to

- distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot (118-8)
  - debate the merits of developing and using life support technology, identifying questions that are scientific, technological and social in nature
- propose courses of action on the social issues related to life support technologies, taking into account an array of perspectives (118-10)

Suggested Learning and Teaching Strategies

Students may investigate and discuss the development and use of technologies to maintain, prolong, sustain or terminate life and the resulting social, moral, ethical and legal issues.

Note: Outcomes 118-8, 118-10 can be covered in other units such as Reproduction.

Endocrine System: Feedback Mechanisms *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could select a nervous system disorder or injury. Students should research the modern treatments for it. They will be expected to make a brief presentation to the class and submit a written report. Assessment should be based on the quality of the information presented to the class and the written report. (115-5, 116-4, 118-8, 118-10, 317-7)

Presentation

- Students could research and prepare questions related to the topic being presented by a guest speaker. Working in groups, students should review and revise these questions, and questions selected to be asked during the presentation. Following this presentation, students may be asked to prepare a brief summary of it, or of the answer to their question. Assessment should be based on a student summary of the guest's talk or answers provided to one of their questions. (215-2, 118-8)

Resources/Notes

MGH Biology, pp. 441, 445-446

MGH Biology, p. 445

Unit 2
REPRODUCTION AND DEVELOPMENT
Suggested Time: 31 Hours

Unit Overview

Introduction

This unit helps the student to understand the principles of how living organisms reproduce and develop at both the cellular and individual levels. The primary emphasis is placed on human systems. Students should begin to appreciate the complexity and importance of reproductive technologies and be able to discuss and analyse from a variety of perspectives the relative risks and benefits these technologies create.

Focus and Context

This unit has its primary focus on scientific inquiry and observation. However, through its review of reproduction and development, there are numerous opportunities to meet curriculum outcomes utilizing decision-making (STSE). Discussions concerning the potential impacts of reproductive technologies lead into problem-solving and technology.

Science Curriculum Links

Students begin at the primary level to discuss life cycles of familiar animals and the changes that humans undergo as they grow, and to investigate the life cycle of some plants. At the elementary level, students begin to relate body changes to growth and development and the role played by body systems in helping both humans and other organisms grow and reproduce. At the intermediate level, students are introduced to the differences between sexual and asexual reproduction. Although not specifically taught in the intermediate science program, other curriculum areas such as health cover the structure and function of the human reproduction systems.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

115-1 distinguish between scientific questions and technological problems

Relationships between Science and Technology

116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

116-3 identify examples where technologies were developed based on scientific understanding

116-7 analyse natural and technological systems to interpret and explain their structure and dynamics

Social and Environmental Contexts of Science and Technology

117-4 debate the merits of funding specific scientific or technological endeavours and not others

118-4 evaluate the design of a technology and the way it functions on the basis of a variety of criteria that they have identified themselves

118-6 construct arguments to support a decision, using examples and evidence and recognizing various perspectives

118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

Skills

Students will be expected to

Initiating and Planning

212-3 design an experiment, identifying and controlling major variables

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-3 use instruments effectively and accurately for collecting data

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Analysing and Interpreting

214-9 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information

214-18 identify and evaluate potential applications of findings

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

Knowledge

Students will be expected to

313-2 describe in detail mitosis and meiosis

313-3 analyse and describe the structure and function of female and male mammalian reproductive systems

313-4 explain the human reproductive cycles

313-5 explain current reproductive technologies for plants and animals

313-6 evaluate the use of reproductive technologies for humans

317-5 evaluate the physiological and ethical consequences of medical treatments such as radiation therapy, chemotherapy and cosmetic surgery

Cell Division

Outcomes

Students will be expected to

- describe mitosis (313-2)
  - describe the events of interphase, mitosis and cytokinesis (the cell cycle)
  - explain the importance of maintaining a constant number of chromosomes through the processes of cell and organism reproduction
- use instruments effectively and accurately for collecting data on the cell cycle (213-3)
  - observe, identify and describe (using prepared slides of plant and animal cells) the events of the cell cycle. Include:
    (i) growth
    (ii) cytokinesis
    (iii) chromosome behaviour
- perform an experiment, identifying and controlling major variables to observe the chromosomes during cell division (212-3)
- select appropriate instruments for collecting evidence on cell division and appropriate processes for problem-solving, inquiring, and decision-making (212-8)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data on cell division (213-5)

Suggested Learning and Teaching Strategies

Classroom or laboratory simulations of the processes of mitosis may be useful. Students may use pipe cleaners to simulate chromosomes and follow the process by preparing pipe cleaner models of chromosomes during each stage in mitosis.

The Laboratory outcomes 213-3, 212-3, 212-8, 213-5 and, in part, 313-2 are addressed by completing *Observing the Cell Cycle in Plant and Animal Cells* CORE LAB #3. A complementary laboratory approach would be to have the students propagate their own fast-growing plant tissue (onion root tips) and prepare their own slides for viewing by fixing, squashing and staining the fresh tissue.

Students can observe some chromosomal detail and banding patterns from an observation of prepared slides of chromosomes. The common fruit fly, *Drosophila*, with its large chromosomes is useful for this study. Should apparatus and materials be available, students can prepare, squash and stain slides of the salivary gland chromosomes that they extract from *Drosophila*.

Students should be given the opportunity to observe and investigate the stages of the cell cycle and cytokinesis within both plant and animal cells through laboratory or computer simulations, diagrams, photographs, laser disc or time lapse video technology. Stages of mitosis can be observed using prepared slides of plant cells (onion root tips) or animal cells (whitefish blastula). Some comparisons between the process of mitosis in plant and animal cells may be demonstrated by careful examination of these prepared slides. Students may be asked to identify, sketch, and discuss what is occurring during each of the stages. Use of a video microscope display can assist the teacher in initially illustrating, as a class activity, how to distinguish between cells in each of the different stages. Videos and laser disc clips are available to show mitosis and meiosis.

Cell Division

Suggested Assessment Strategies

Laboratory Activities

- Students could perform available laboratory activities to illustrate some aspects of the process of cell division. These may include examination of prepared microscope slides of chromosomes, preparation of squashes of *Drosophila* salivary glands, examination of prepared microscope slides of animal and plant cell mitosis and cytokinesis or growth of onion root tips and preparation of squashes to observe chromosomes. Assessment would depend on the nature and depth of the activities selected, ranging from the development of microscope diagrams to answering of questions to a more detailed discussion of procedures and results.
- Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (212-3, 212-8, 213-3, 313-2, 213-5)
- Using a prepared root tip slide, students could predict the amount of time spent by these cells in each stage of mitosis. (212-3, 212-8, 213-3, 313-2, 213-5)

Paper and Pencil

- Students could develop a glossary of new terms they discover and will use during their discussions in this reproduction unit. (313-2)
- Using pipe cleaners of two colours, students could construct models of a pair of homologous chromosomes and follow their progress through the stages of meiosis (reduction-division). Students could construct one member of the pair from one colour, the second from another. They could illustrate an example of crossing over and follow its transmission. Assessment should be based on accuracy of models and completeness of exercise. (215-2, 313-2)

Resources/Notes

www.gov.nl.ca/edu/science_ref/main.htm

MGH Biology, pp. 460-465

MGH Biology, pp. 461-462

Core Lab #3: *"Observing the Cell Cycle in Plant and Animal Cells", pp.* 466-467

Cell Division *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• evaluate the physiological and ethical consequences of radiation therapy and chemotherapy in cell division (317-5)	Students may research some alternative methods for the treatment of cancer that are currently being developed.
– describe their use and effectiveness	
– describe positive and negative aspects of these treatments	One significant side effect of these treatments is sterility (as a result of its impact on cell meiosis). Teachers may incorporate this as an introduction to the further study of meiosis.
• describe meiosis (313-2)	
– describe the events of meiosis (reduction-division) and cytokinesis	Crossing over (chiasma) in meiosis can also be illustrated through the pipe cleaner activity from page 59 of this guide if different pipe cleaner colours are available. This provides the student with a visual confirmation of the exchange of genetic information and its effect on randomizing gene combinations within the chromosomes.
– explain the necessity of chromosome reduction during the production of sex cells	
– describe the crossing-over process and explain its role in helping randomize the gene combinations for sex cells	Teachers should note that chromosomal disorders associated with crossing-over are done in detail in the genetics unit.
• analyze and describe the function of spermatogenesis and oogenesis (313-3)	
– examine the processes of spermatogenesis and oogenesis	To highlight the differences between spermatogenesis and oogenesis, students could develop a table or chart which summarizes gamete formation.
– explain why there is only one functional egg produced during oogenesis	

Cell Division *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could research a method for the treatment of cancer that is currently being developed. Examples may include monoclonal antibodies, immunotherapy using tumour infiltrating lymphocytes, hyperthermia—utilizing heat, cryotherapy—cold, photodynamic therapy—light, or an alternate as appropriate. Students should discuss the pros and cons of each method of treatment. (317-5)

Presentation

- Teacher could invite a guest speaker to talk about the diagnosis, treatment, and recovery from the various types of cancer. Suggestions could include a representative from the Canadian Cancer Society, a palliative care nurse, or oncologist. (317-5)
- Students could create a moving image, using a flip-chart book, slide show, video, or digital animation to show the sequence of events in cell division. They should present their finished product to the class. (213-2, 215-2, 313-2)
- Students could be introduced to individuals knowledgeable in the importance of cell division and the effects on the homeostasis of an organism should it be disrupted, by using community resources such as physicians or available organizations (Canadian Cancer Society). Students should research and prepare questions related to the topic being presented by the guest speaker. Working in groups, these questions should be reviewed and revised, and questions selected to be asked during the presentation. Following this presentation, students may be asked to prepare a brief summary, or the answer to their question. Assessment may be based on a student summary of the guest's talk or answers provided to one of their questions. (213-7, 215-2, 313-2)

Performance

- Students could make a model and demonstrate the events of meiosis. It should include homologous chromosomes, dominant and recessive alleles. Students should illustrate the randomness of allele assortment during meiosis. Sample materials that may be used include marshmallows, pipe cleaners, Plasticine, Popsicle sticks, Velcro ™, toothpicks, push pins, etc. (315-2, 315-3)

Journal

- Students could select a website that contains activities on meiosis and/or mitosis. Students should perform an activity that interests them and write a brief report, including the web address, activity, and any comments about it. (313-2)

Resources/Notes

MGH Biology, pp. 468-469

MGH Biology, pp. 470-475

MGH Biology, pp. 477-478

Cell Division *(continued)*

Outcomes

Students will be expected to

- analyze and describe the function of spermatogenesis and oogenesis (313-3) (**Cont'd**)
  - describe and compare the structure of sperm and egg cells. Include:
    (i) relative sizes
    (ii) energy reserves
    (iii) mitochondria
    (iv) numbers produced
    (v) motility
    (vi) enzyme cap (acrosome)
- identify and describe examples of technologies that were developed based on cell division. (116-3, 213-7) Include:
  (i) stem cell research
  (ii) cell transplant
  (iii) cancer treatment
  (iv) spinal cord injury
  (v) therapeutic cloning
  (vi) reproductive cloning
- construct arguments to support a decision, using examples and evidence and recognizing various perspectives (118-6)
- debate the merits of funding specific scientific or technological endeavors and not others (117-4)
- distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot. (118-8)

Suggested Learning and Teaching Strategies

The female and male mammalian reproductive systems will be dealt with in greater detail later in this unit.

The CORE STSE component of this unit incorporates a broad range of Biology 3201 outcomes. More specifically, it targets (in whole or in part) 116-3, 317-4, 115-5, 213-7, 118-6 and 117-4. The STSE component, *Stem Cell Research*, can be found in Appendix C.

Students can investigate the role of biotechnology in cell growth and the potential it may hold for the regeneration of damaged tissues or parts of organisms. They may evaluate the role of cell division in the development of cancer and how knowledge of cell division might be applied to limiting cancerous growth in plants and animals. They may investigate the newer approaches to the chemical treatment of cancer, and the basis upon which they are effective.

Cell Division *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could select an aspect of biotechnology related to cell division that is of interest to them (e.g., regeneration of lost limbs) or a type of cancer for which they will study causes, treatments and statistics. They should investigate the topic using more than one source of electronic or print information. Students will be required to prepare a written summary and to present the topic to the class. Assessment should be based on accuracy and relevance of information gathered and completeness of research based upon written report and class presentation. Students should also be evaluated based on the response to questions generated by the class during the discussion. (116-2, 212-8, 213-7, 214-18, 215-2, 317-5)

Presentation

- Students could debate issues related to stem cell research (e.g., the use of embryonic tissue). (116-3, 213-7)

Resources/Notes

MGH Biology, p. 478

MGH Biology, pp. 478-479

Core STSE #2: *"Stem Cell Research",* Appendix C

MGH Biology, pp. 628-630

Reproductive Systems: Strategies

Outcomes

Students will be expected to

- analyze natural reproductive strategies to interpret and explain their structure and dynamics (116-7)
  - distinguish between asexual and sexual reproduction
  - define various types of asexual reproduction. Include:
    (i) budding
    (ii) binary fission
    (iii) spore production
    (iv) fragmentation
    (v) parthenogensis
- compile and organize data, using appropriate formats, to facilitate interpretation of the data (213-5)
- select and use appropriate symbolic and linguistic modes of representation to communicate results (215-2)

Suggested Learning and Teaching Strategies

Investigation of the range of reproductive strategies found within the plant and animal kingdom serves to reinforce the concept of biodiversity. This information can be presented to the class in the form of charts, tables or diagrams.

See Appendix A **Table 1: Modes of Reproduction**

Students can investigate or research the strategy involved in the use of reproductive technologies with an agricultural plant like canola, an aquaculture animal like the salmon, or any other appropriate example.

The Laboratory outcomes 213-5, 215-2 and, in part, 313-2 are addressed by completing *Reproductive Structures in Flowers* CORE LAB #4.

Reproductive Systems: Strategies

Suggested Assessment Strategies

Paper and Pencil

- Students could select a reproductive strategy found within the animal or plant kingdom and present the information collected to the class in the form of charts, tables, diagrams, visual animation or any other appropriate format. They should use their initiative to find and present unusual or interesting reproductive strategies. Assessment should be based on accuracy and relevancy of information gathered and completeness of research based upon the quality of the class presentation. (116-2, 116-7, 213-5, 213-7, 215-2)

Laboratory Activities

- Students could observe the examples of the reproductive processes provided within the laboratory. These may include prepared slides or wet mounts of budding in yeast, budding in hydra, or wet mounts of mold spores. Assessment would depend on the nature of the activities selected and could range from the development of microscope diagrams to the answering of questions. (212-3, 212-8, 213-3, 215-2, 313-2)

Resources/Notes

Table #1: *"Modes of Reproduction",* Appendix A

MGH Biology, pp. 157, 186
MGH Biology, p. 134
MGH Biology, pp. 166, 154
MGH Biology, pp. 186, 155
MGH Biology, p. 186

Core Lab #4: *"Reproductive Structures in Flowers", pp.* 176-177

Reproductive Systems: Strategies *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• describe mitosis and meiosis within plant reproduction (313-2)	Students can observe the male and female reproductive structures of angiosperms through the use of models, charts, computer simulations or the dissection of a flower within a laboratory setting.
– observe, identify and give the function of the basic structures of sexual reproduction in angiosperms (flowering plants). Include: (i) pistil (ii) stamen (iii) pollen (iv) ovules (v) seed (vi) fruit	
– describe the process of sexual reproduction in flowering plants	The process of sexual reproduction in flowering plants is a complex process. The description should be taken from the production of pollination to the production of a seed. Discussion of pollen containing: 1. a generative nucleus producing two sperm nuclei and; 2. the tube nucleus producing the pollen tube should be included. The process of one sperm nucleus (n) uniting with the egg (n) to produce a diploid zygote (2n) and the other sperm nucleus (n) uniting with two haploid polar nuclei (n each) to produce a triploid endosperm (3n) should also be included.

Reproductive Systems: Strategies *(continued)*

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the available laboratory activities to illustrate some aspects of the reproductive process. These may include examination of prepared microscope slides of ovaries and testes (egg and sperm cells), examination of the reproductive parts of a flower, comparison of a monocot and dicot seed and/or examination of a composite flower (daisy, dandelion). Assessment would depend on the nature of the activities selected, ranging from the development of microscope diagrams to the answering of questions.

  Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (313-3)
- Students could dissect a flower from the lily family. They should draw a picture of each part, label it, and reconstruct the flower using individually drawn sketches. (313-2)

Resources/Notes

MGH Biology, pp. 175-181

Reproductive Systems: Regulation

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• analyze and describe the structure and function of the human male reproductive system. Include: (313-3) (i) testis (ii) scrotum (iii) seminiferous tubules (iv) epididymis (v) sperm duct (vas deferens) (vi) Cowpers (bulbourethral) gland (vii) seminal vesicle (viii) prostate (ix) urethra	Students should be provided with the opportunity to observe and discuss the function of the principal features of the male reproductive system using models, dissections or computer simulations and to identify and label the major structures from drawings or photos of that organ system.
• explain the human male reproductive cycles (313-4)	
– identify and state the functions of the principal reproductive hormones of the human male. Include: (i) inhibin (ii) follicle stimulating hormone (FSH) (iii) luteinizing hormone (LH) (iv) testosterone	Students can analyze sample data on blood hormone levels and physiological events and infer the roles of the male sex hormones. Students can discuss the role of steroid use in sports and run a risk/benefit analysis. They can debate the issue of mandatory doping tests on athletes to determine the presence or absence of banned substances. They can research and develop a list of these banned substances and answer the questions, "Are any of these substances found in over-the-counter medication?", "If so, for what purpose are they used?"
– explain the function and interactions among these hormones in maintaining the male reproductive system	Students could examine the interaction of these hormones in the form of a negative feedback loop.

Reproductive Systems: Regulation

Suggested Assessment Strategies

Presentation

- Individuals such as Canadians athletes, Ben Johnson, Ross Rebliati or Silken Laumann suffered some consequences of a doping test found to be positive for a banned chemical substance. Students could be divided into groups and asked to prepare an argument in support of or against one of the following statements:
  - Doping tests should be mandatory for all professional and amateur athletes.
  - A positive doping test should result in a lifetime ban from his/her competitive sport for the athlete involved.

  Each team will be given the opportunity to research and confer on the approach they will take to their position on this statement. A class debate will ensue. (313-3, 313-4)

Paper and Pencil

- Students should trace the path of a sperm cell from where it is formed to the point of fertilization. (313-3, 313-4)

Portfolio

- Students could research information and prepare a written risk/benefit analysis on topics such as steroid use in sports or hormone treatments for women. Assessment can be based on the analysis presented within the written work of the student. (214-18, 215-2, 313-3, 313-4)

Resources/Notes

MGH Biology, pp. 486-487

MGH Biology, pp. 488-489

MGH Biology, pp. 488-489

Reproductive Systems: Regulation *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• analyze and describe the structure and function of the human female reproductive system. Include: (313-3) (i) ovary (ii) follicles (iii) oviduct (fallopian tube) (iv) fimbriae (v) uterus (vi) endometrium (vii) cervix (viii) vagina	Students should be provided with the opportunity to observe and discuss the function of the principal features of the female reproductive system using models, dissections or computer simulations, and to identify and label the major structures from drawings or photos of that organ system.
• explain the human female reproductive cycle (313-4) – identify and state the functions of the principal reproductive hormones of the human female. Include: (i) estrogen (ii) progesterone (iii) luteinizing hormone (LH) (iv) follicle stimulating hormone (FSH)	Students can analyze sample data on blood hormone levels and the physiological events of a single menstrual cycle, and infer the role of the female sex hormones.
– explain the function and interactions among these hormones in the menstrual cycle	Students could examine the interaction of these hormones in the form of a negative feedback loop.
– research and evaluate the uses and effects of estrogen/progesterone treatment on the health of women. Include hormone therapy among menopausal women and the use of birth control pills	This estrogen/progesterone hormone treatment may involve the use of synthetic chemicals, or herbal and natural sources found within the diet or taken as dietary supplements. Students can investigate the purposes of this hormone therapy among menopausal women.

Reproductive Systems: Regulation *(continued)*

Suggested Assessment Strategies	Resources/Notes
Presentation	*MGH Biology, pp.* 490-491
• Students could select a suitable article from a publication, electronic, or media source for critique and analysis. (214-9)	
• Students could create an STSE question that could be discussed with class members. (214-9)	
Paper and Pencil	
• Students could use a case study to analyze data on blood hormone levels and physiological events during a female menstrual cycle. They should investigate how the cycle is regulated using positive and negative feedback and the roles of pituitary and ovarian hormones. Assessment should be based upon the logical analysis of data and conclusions drawn. (313-3, 313-4)	*MGH Biology, pp.* 490-492
	MGH Biology, pp. 490-492
	MGH Biology, pp. 492-493

Reproductive Systems: Regulation *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• compile and organize data, using appropriate formats and data treatments, to facilitate interpretation of the data (213-5) • select and integrate information from various print and electronic sources or from several parts of the same source (213-7) • identify and evaluate potential applications of findings (214-18) • select appropriate numeric, graphical, and linguistic modes of representation to communicate ideas, plans, and results (215-2)	The Laboratory outcomes 213-5, 213-7, 214-18, 215-2 and, in part, 313-4 are addressed by completing *The Menstrual Cycle* CORE LAB #5.
• explain the human reproductive cycles (313-4) – research and describe the potential health risks on individuals and society associated with exposure to sexually transmitted infections. Include: (i) HIV and AIDS (ii) chlamydia (iii) hepatitis B (iv) genital herpes (v) syphilis (vi) gonorrhea	Students should be encouraged to consider not only immediate health concerns, but also societal impacts (effects on future children, health care systems). HIV transmission or other STI's can be simulated with the use of a base (sodium hybroxide) and an indicator (phenolphthalein). A class set of test tubes of water containing one test tube with diluted base can be arranged. Students can swap "fluids" and the transmission can be detected later using the indicator.

Reproductive Systems: Regulation *(continued)*

Suggested Assessment Strategies

Presentation

- Students could be introduced to individuals knowledgeable in a variety of aspects of human reproductive health and sexually transmitted infections by using community resources such as physicians or available organizations (Sexual Health Centres). Students should research and prepare questions related to the topic being presented by the guest speaker. Working in groups, students should review and revise these questions, and questions selected to be asked during the presentation. Subsequently, students may be asked to prepare a brief summary of the presentation or of the answer to their question. Assessment could be based on a student summary of the guest's talk or answers provided to one of their questions. (213-7, 215-2, 313-3, 313-4)

Resources/Notes

Core Lab #5: *"The Menstrual Cycle"*, pp. 494-495

MGH Biology, pp. 496-499

Reproductive Technologies

Outcomes

Students will be expected to

- distinguish between the scientific causes of infertility and technological solutions (115-1)
- explain and describe the use of reproductive technologies for humans (313-5, 313-6)
  - identify the causes of human infertility. Include:
    (i) blocked oviducts
    (ii) failure to ovulate
    (iii) endometriosis
    (iv) damaged egg
    (v) obstruction in the vas deferens or epididymis
    (vi) low sperm count
    (vii) abnormal sperm
  - identify the technological solutions to human infertility. Include:
    (i) artificial insemination (AI)
    (ii) *in vitro* fertilization (IVF)
    (iii) *in vitro* maturation (IVM)
    (iv) surrogate motherhood
    (v) superovulation using fertility drugs
    (vi) embryo storage (cryopreservation)

Suggested Learning and Teaching Strategies

Students should investigate the importance of utilizing fertility techniques for the human population and consider questions such as the following: What are the ethical and practical issues involved when fertility techniques result in multiple births? Is there an argument within society for fetal selection when a multiple birth pregnancy places the fetuses and/or mother at risk?

Reproductive Technologies

Suggested Assessment Strategies

Presentation

- Teachers could expose students to individuals knowledgeable in a variety of aspects of reproductive technologies and issues by using community resources such as physicians, reproductive technologists, public health workers or representatives of available related organizations. Students should research and prepare questions related to the topic being presented by the guest speaker. Working in groups, students should review and revise these questions, and questions selected to be asked during the presentation. Subsequently, students may be asked to prepare a brief summary of the presentation, or of the answer to their question. Assessment may be based on a student summary of the guest's talk or answers provided to one of their questions. (115-1, 118-4, 215-2, 313-5, 313-6)

Paper and Pencil

- Students could research and evaluate the use of currently available reproductive technologies. The following are potential options:
  - Artificial Insemination
  - Superovulation using gonadotrophins
  - *In vitro* fertilization
  - *In vitro* maturation (IVM)
  - Surrogate motherhood
  - Hormonal treatment allowing pregnancy after menopause

  Students will be expected to present a brief summary of their topic to the class. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)

Journal

- A couple has discovered that they are unable to conceive due to the male partner's sterility. Donor sperm could be used to artificially inseminate the female partner. What ethical and moral issues would arise? (118-6)

Resources/Notes

MGH Biology, pp. 500-501

Reproductive Technologies (*continued*)

Outcomes

Students will be expected to

- evaluate the design of birth control technologies and the way they function (118-4)
  Include:
  - (i) abstinence
  - (ii) birth control pills
  - (iii) Norplant™ (implant)
  - (iv) morning after pill
  - (v) Depo-Provera™ (needle)
  - (vi) IUD (interuterine device)
  - (vii) tubal ligation
  - (viii) diaphragm
  - (ix) spermacidal jellies and foams
  - (x) condom
  - (xi) vasectomy
  - (xii) rhythm method
- construct arguments to support a decision, using examples and evidence and recognizing various perspectives (118-6)
  - assess the effects of birth control technology on the population demographics of developed and underdeveloped countries
- identify and apply criteria, including the presence of bias, for evaluating the evidence and sources of information used in their research (214-9)
- debate the merits of funding solutions to human fertility problems versus human population control (117-4)

Suggested Learning and Teaching Strategies

Students should evaluate the relative effectiveness of various methods of contraception and perform a risk/benefit analysis on the implementation of these for various segments of the population.

Teachers may wish to organize the information according to mode of operation:

a) Barrier Methods (condom, diaphragm, jellies and foams, IUD)

b) Hormonal Methods (birth control pill, Norplant™ , morning after pill, Depo-Provera™)

c) Surgical Methods (tubal ligation, vasectomy)

d) Other (rhythm method, abstinence)

Other STSE topics that students may research include:

- sperm banks for agriculture
- human sperm banks
- folklore concerning reproductive success/control
- choice of sex of child

Students may debate the merits of funding solutions to human fertility problems versus the funding of human population control. Students may investigate the methods of population/birth control (e.g., China's one child rule per family; selection of one gender—usually male—and abortion of females in some developing countries) of various countries around the globe and assess the effects of these conception control population technologies on the demographics of these countries.

Reproductive Technologies (*continued*)

Suggested Assessment Strategies

Paper and Pencil

- Students could research and evaluate types of contraception that are being promoted for the use of population control within developing countries. They will be expected to present a brief summary of their topic to the class. Assessment should be based on accuracy and relevancy of information gathered and completeness of research based upon class presentation. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)
- Students could use a case study to analyze moral and ethical implications of new reproductive technologies. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)
- As a class, students could create a list of world wide web sites useful for information concerning reproductive technologies. (115-1, 117-4, 118-6, 213-7, 313-5, 313-6)

Presentation

- Groups could investigate a variety of chemical and physical methods of contraception. They will explain how these contraceptives work, their effectiveness in prevention of pregnancy and STIs, and societal implications of their use from various perspectives. (118-4, 118-6)

Resources/Notes

MGH Biology, pp. 501-503

MGH Biology, pp. 503-505

Embryonic Differentiation and Development

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain the processes of fertilization and development in human reproduction (313-4)	
– trace the journey of sperm and egg from their origin until fertilization and implantation.	
– explain how fraternal and identical offspring are produced.	Students should recognize the distinction between the fertilization and initial embryonic development that produce identical and fraternal twins, and discuss the mechanism in which multiple births (triplet, quadruplets) may result naturally. Students could consider the question, "Why are fraternal twins no more alike than any set of brothers or sisters?"
– describe the following basic stages of embryonic development. (i) cleavage (ii) morula (iii) blastocyst (blastula) (iv) gastrula (v) germ layers (vi) neural development	Students should have the opportunity to observe the stages of embryo development through the use of preserved materials, prepared slides (cleavage of sea stars), audiovisual presentations or computer simulations, and extrapolate these events to the development of the human fetus. In addition, there are good web sites available on the Internet that illustrate the process of development.
• describe the functions of primary membranes during the embryonic development of animals. Include: (313-4) (i) yolk (ii) allantois (iii) amnion (iv) chorion	Students should know the structure that each primary membrane eventually forms, as well as the function of these strucures. Teachers may compare the functions of the membranes in the chick embryo to that of the human embryo, as outlined in Figure 15.15 on page 509 of the textbook.

Embryonic Differentiation and Development

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the laboratory activities available on the process of development. These might include microscopic examination of prepared slides of stages of cleavage of sea stars or sea urchin development, observation of embryo development in the frog utilizing a culture of frog eggs, or observation of microslides of frog or chick embryo development. Assessment would depend on the nature and depth of the activities selected, ranging from the development of microscope diagrams, answering of questions, to a more detailed discussion. Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (313-4)

Resources/Notes

MGH Biology, pp. 506-509

Embryonic Differentiation and Development *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain the processes of development and birth in human reproduction (313-4)	
– describe the roles of the placenta and umbilical cord during pregnancy	
– examine the effects of teratogens on the development of the embryo. Include: (i) cigarette smoke (ii) alcohol (iii) prescription drugs	The societal impact of chemical and drug abuse on fetal development (alcohol, cocaine, cigarettes) may be investigated and discussed. Prescription drugs, such as thalidamide, have positive effects on adults and children for the treatment of certain medical conditions. These drugs taken during pregnancy, however, may have serious negative effects on fetal development. Thalidamide, used in the 1950's as a treatment for morning sickness, is one example of this.
– describe the process of childbirth. Include: (i) dilation stage (ii) expulsion stage (iii) placental stage	Students should be aware of the physiological events that occur during and after the process of childbirth (cervical dilation, loosening of pelvic ligaments, rupture of the amniotic membrane, uterine contractions, delivery of fetus and expulsion of the placenta) and the role of hormonal control.
– identify chemical control hormones associated with implantation, birth and lactation. Include: (i) progesterone (ii) estrogen (iii) oxytocin (iv) prolactin (v) human chorionic gonadotropin (HCG)	HCG maintains the corpus luteum for the first three months of pregnancy. The functioning corpus luteum continues producing progesterone and estrogen, which maintains the endometrium. Pregnancy tests identify HCG levels in the urine of females. Students should be familiar with the concept of feedback loops during childbirth. The oxytocin feedback from Unit I could be reviewed.
• analyze examples where scientific understanding was enhanced or revised as a result of technology (116-2)	Students may describe how these technologies have benefited the success rate of pregnancies and how this process has led to new technologies. They may investigate the development of fetal surgery techniques to correct biological problems. Students may be able to compare the purposes of these fetal monitoring techniques to those techniques used for genetic testing. Students may investigate the types of diseases and conditions that can be identified by these monitoring techniques (e.g., structural abnormalities, spina bifida).
– describe techniques used to monitor various stages of embryonic or fetal development. Include: (i) ultrasound (ii) amniocentesis (iii) fetoscopy (vi) CVS (chorionic villi sampling)	

Embryonic Differentiation and Development *(continued)*

Suggested Assessment Strategies	Resources/Notes
Paper and Pencil	*MGH Biology, pp.* 510-511
• Students could collect information on techniques used for monitoring the health and well-being of a fetus. Techniques to consider may include blood tests, non-stress fetal monitoring, ultrasound, and fetoscopy. Students will be expected to present a brief summary of their topic to the class. Assessment should be based on accuracy and relevancy of information gathered and class presentation. (116-2, 313-4)	*MGH Biology, pp.* 511-512
• A worksheet could be used to have students research aspects of reproduction using websites. Assessment could be based on accuracy and relevancy of information gathered. (116-2, 313-4)	
Presentation	
• Students could research and present the effects of different types of teratogens. (116-2, 313-4)	*MGH Biology, pp.* 507, 512, 514
	MGH Biology, pp. 429-431
	MGH Biology, p. 510, 607-608

Unit 3
GENETIC CONTINUITY
Suggested Time: 44 Hours

Unit Overview

Introduction

Much of the structure and function of every living organism is determined by deoxyribonucleic acid (DNA). It is important for a scientifically literate person to understand principles and fundamentals about DNA: what it is, how it works, how and for what purposes humans are manipulating it, and why this major area of scientific and technological endeavour has dramatic implications for humans and planet Earth. This unit will provide the Biology 3201 student with the basic information required for the comprehension of genetics.

Focus and Context

Within this unit on genetic continuity the primary focus is on problem solving and technology. However, to appreciate the complexity and uniqueness of DNA and how its structure determines protein construction, scientific inquiry and observation are required. With the inclusion of information on biotechnology and associated bioethics, there is also ample opportunity for decision-making and STSE components.

Science Curriculum Links

Very early in their study of the life sciences students begin to consider the individuality of organisms. Students at the primary level are asked to identify variations that make each person and animal unique from each other and their parents. They also identify traits that remain constant and those that change as organisms grow and develop. The unit Diversity of Living Things at the intermediate level continues this theme.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

114-2 explain the role of evidence, theories, and paradigms in the development of scientific knowledge

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

Relationships between Science and Technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

116-6 describe and evaluate the design of technological solutions and the way they function, using scientific principles

Social and Environmental Contexts of Science and Technology

117-2 analyse society's influence on scientific and technological endeavours

117-7 identify and describe science- and technology-based careers related to the science they are studying

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

118-6 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives

Skills

Students will be expected to

Initiating and Planning

212-4 state a prediction and a hypothesis based on available evidence and background information

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Analysing and Interpreting

214-5 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables

214-12 explain how data support or refute the hypothesis or prediction

Communication and Teamwork

215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

215-5 develop, present, and defend a position or course of action, based on findings

Knowledge

Students will be expected to

314-3 identify and describe the structure and function of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids

315-1 summarize the main scientific discoveries that lead to the modern concept of the gene

315-2 describe and illustrate the role of chromosomes in the transmission of hereditary information from one cell to another

315-3 demonstrate an understanding of Mendelian genetics, including the concepts of dominance, co-dominance, recessiveness, and independent assortment, and predict the outcome of various genetic crosses

315-4 compare and contrast the structure of DNA and RNA and explain their role in protein synthesis

315-5 explain the current model of DNA replication

315-6 describe factors that may lead to mutations in a cell's genetic information

315-7 predict the effects of mutations on protein synthesis, phenotypes, and heredity

315-8 explain circumstances that lead to genetic disease

315-9 demonstrate an understanding of genetic engineering, using their knowledge of DNA

315-10 explain the importance of the Human Genome Project and summarize its major findings

317-4 identify in general terms the impact of viral, bacterial, genetic and environmental diseases on the homeostasis of an organism

Genetics: Mendelian

Outcomes

Students will be expected to

- demonstrate an understanding of Mendelian genetics (315-3)
  - define the terms heredity and genetics
  - explain Mendel's concept of unit characters and describe the unit theory of inheritance
  - explain the meaning of the following terms:
    (i) trait
    (ii) P generation (parent generation)
    (iii) F_1 and F_2 generation (first and second filial generation)
    (iv) hybrid
    (v) purebred
    (vi) dihybrid
    (vii) monohybrid
    (viii) dominant
    (ix) recessive
    (x) gene
    (xi) allele
    (xii) homozygous
    (xiii) heterozygous
    (xiv) product rule
    (xv) punnett square
    (xvi) genotype
    (xvii) phenotype
  - explain how Mendel's experiments support:
    (i) principle of dominance
    (ii) law of segregation
    (iii) law of independent assortment

Suggested Learning and Teaching Strategies

The Genetics unit begins with a number of new terms and students should become proficient in them.

Some possible strategies to cover the terminology effectively are:

- general brainstorming session to assess prior knowledge. Students can discuss the physical traits inherited in their family.
- introduction of terminology through an explanation of Mendel's experiments.
- cooperative learning in the introduction of this unit. Ask small groups to define the terms and then come back to the larger group to present and explain their terms and make connections.

It should be noted that in the province of Newfoundland and Labrador we have an example of a purebred animal, a certified Newfoundland Dog.

Teachers should take the opportunity to connect the terms hybrid and heterozygous and how they are related.

Mendel's detailed experimentation could be emphasized as an example of exemplary scientific processes.

Genetics: Mendelian

Suggested Assessment Strategies

Laboratory Activities

- Students could perform the activities provided that deal with the concept of heredity. Possibilities include examination of ears of genetic corn or performance of crosses of the fruit fly Drosophila to investigate the inheritance of particular characteristics. Assessment would depend on the nature and depth of the activities selected ranging from the answering of questions to a more detailed discussion of procedures and results. (315-3)
- Enrichment may be provided by allowing students the opportunity to design their own investigations from questions that these activities may generate. (212-4, 214-5, 214-8, 315-2, 315-3)

Paper and Pencil

- Students could develop a glossary of new terms that they discover and will use during their discussions in this genetics unit. (315-2, 315-4, 315-5, 315-3)

Resources/Notes

www.gov.nl.ca/edu/science_ref/main.htm

MGH Biology, pp. 526-537

MGH Biology, pp. 526-532, 536

MGH Biology, pp. 529-530, 536-539

Genetics: Mendelian *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• interpret patterns and trends in genetic data (214-5)	Students may investigate their own individual dominance/recessiveness as related to visual/sensory traits (widow's peak, dimples, tongue rolling, attached/free ear lobe, the ability/lack of ability to taste PTC). Data on dominant and recessive characteristics from a class activity of this nature can be collected and discussed in relation to the prevalence within this restricted population sample and the population in general. Activities can be performed that simulate the chance formation and pairing of gametes (e.g., simulate Mendel's experiments substituting the tossing of coins and heads/tails for plant characteristics). Students can investigate visually the phenotypic ratios evident during a laboratory activity using artificially pollinated ears of genetic corn. Genotypes of the parent ears can be determined and the expected phenotypic ratios predicted. Students may perform, as an independent study or group project, crosses using fast growing plants or the fruit fly, *Drosophila,* to investigate the inheritance of various characteristics.
• state a prediction and a hypothesis based on available genetic evidence using genetic problems (212-4)	
– determine the outcome of monohybrid and dihybrid crosses	Students should use Punnett squares and the product rule to determine genotypic and phenotypic ratios in monohybrid crosses. They should use Punnett squares to determine genotypic and phenotypic ratios in dihybrid crosses. Teachers should use multiple resources to find genetic problems of this type. The product rule may be used to determine genotypic and phenotypic ratios in dihybrid crosses as an extension to this topic.
• demonstrate an understanding of Mendelian genetics (315-3)	
– explain the meaning of the following terms: (i) incomplete dominance (ii) co-dominance (iii) multiple alleles	Multiple alleles should be explained with reference to blood types. Students could explore other examples of multiple alleles such as eye colour in *Drosophila* and colour patterns in ducks.

Genetics: Mendelian *(continued)*

Suggested Assessment Strategies

Laboratory Activities

- Human ABO blood type is an example of the expression of multiple alleles. Students could determine the blood type of the simulated blood sample which they are provided and list the potential genotypes that would correspond to this type. (315-3, 212-4)

Paper and Pencil

- Students could solve monohybrid and dihybrid genetics questions prepared for them. In each case, they should analyze the data as requested. Assessment should be based on the accurate solution of the problems using appropriate logic and procedures. (315-3)

Resources/Notes

MGH Biology, pp. 529-540

MGH Biology, pp. 541-543

Genetics: Mendelian *(continued)*

Outcomes

Students will be expected to

- state a prediction and a hypothesis based on available genetic evidence using genetic problems (212-4)
- interpret patterns and trends in genetic data (214-5)

  – predict the outcome of monohybrid and dihybrid crosses for incomplete and co-dominance

  – demonstrate the inheritance of traits governed by multiple alleles by predicting the genotypic and phenotypic ratios in crosses involving human blood types (ABO groups)

  – explain the significance of a test cross

  – use a test cross to determine the unknown genotype of a dominant organism

Suggested Learning and Teaching Strategies

The concepts of incomplete dominance and co-dominance are very similar with respect to phenotypic expression:

1. Co-dominance is the condition in which both alleles of a gene are expressed. Examples include: Roan horses (red and white hair) and barred plumage chickens (black and white feathers).
2. Incomplete dominance is inheritance in which an active allele does not entirely compensate for an inactive allele. Examples include: snapdragon flowers (heterozygous is pink) and Japanese four-o'clock flowers (heterozygous is pink).

There are a number of different methods to represent the alleles for incomplete and co-dominance. For example, in incomplete dominance for flower colour in snapdragons the following can be used:

(i) R - red R' - white
(ii) F^R - red F^w - white
(iii) R - red W - white

For co-dominance, blood type may be represented as follows:
(i) I^A - type A I^B - type B
(ii) A - type A B - type B

Students should be able to solve dihybrid crosses involving one trait that is completely dominant with one other trait that is not (co-dominance, incomplete dominance, multiple alleles). Teachers should use multiple resources to find genetics problems of this type.

Teachers could consider using blood type data of their student population, local office of Canadian Blood Services, or local hospitals. This data can be used in graphs with population size to generate questions regarding the patterns that exist.

It is impossible to determine the genotype of an organism that is expressing the dominant trait simply by looking at its appearance. Teachers should pose the question, "How would you determine the unknown genotype?" Teachers should note that the absence of the homozygous recessive trait in the offspring does not confirm that the unknown parent is homozygous dominant, especially in small samples of offspring.

Genetics: Mendelian *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could solve monohybrid and dihybrid genetics questions prepared for them. In each case they should analyze the data as requested. Assessment should be based on the accurate solution of the problems using appropriate logic and procedures. (315-3)
- Students should analyze the genetic clues presented to them in murder mysteries to determine the name of the murderer. They should write down in point form the logic they used to come to their conclusion. An example is provided on page 561 of the text. (212-4, 214-12, 315-3)

Presentation

- After students have conducted their experiment, they should be asked to present their data and conclusions to the class. They should compile and organize their data using appropriate formats (e.g., numeric tables, graphs). Students should be prepared to explain decisions they may have made during the course of planning and conducting their experiment. (214-12, 215-5)

Resources/Notes

MGH Biology, pp. 541-543

MGH Biology, pp. 533-534

Genetics: Modern Ideas

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• summarize the main scientific discoveries that lead to the modern concept of the gene (315-1)	This section could be introduced by re-emphasizing Mendel's conclusions and how the behaviour of Mendel's traits parallel chromsome behaviour.
• describe and illustrate the role of the chromosomes in the transmission of hereditary information from one cell to another (315-2)	
– explain how the work of Gregor Mendel and Walter Sutton led to the chromosome theory of inheritance	Teachers should explain how the behavior of the chromosomes observed by Sutton during meiosis accounts for Mendel's observations and conclusions concerning segregation and independent assortment.
– state and explain the chromosome theory of inheritance	
– describe Morgan's experiments with *Drosophila* and explain how his observations supported the chromosome theory of inheritance	Morgan's experiments restated Mendel's Law of Independent Assortment by including crossing over.
– explain the concepts of gene linkage (linked genes) and crossing-over.	Crossing over was introduced in Unit 2. The emphasis in this unit is on how crossing over breaks gene linkages and creates variation. Diagrams and simulations may be useful in illustrating these concepts.
– outline, in general terms, the gene-chromosome theory of inheritance	Genes exist on specific sites on chromosomes. When pairs of homologous chromosomes separate during gamete formation, they form two gametes. Each gamete will contain a separate allele for each trait. During fertilization, chromosomes from one gamete will combine with another gamete.
– explain how the discovery of gene linkage affected man's understanding of Mendel's Law of Independent Assortment	
– state the Law of Independent Assortment in modern terms	The Law of Independent Assortment in modern terms includes gene linkage and crossing over.

Genetics: Modern Ideas

Suggested Assessment Strategies	Resources/Notes
Paper and Pencil	*MGH Biology, pp.* 545-548
• Students could predict the general location or arrangement of genes within a chromosome from the analysis of crossing over data with which they have been provided. (214-5, 315-2)	
Journal	
• Is there a relationship between the number of chromosomes and the average mass of individuals in a species? Explain. (214-5)	
• Is there a relationship between the number of chromosomes and the complexity of the species? Explain. (214-5)	*MGH Biology, pp.* 545-547
	MGH Biology, p. 545
	MGH Biology, pp. 545-547
	MGH Biology, pp. 546-547
	MGH Biology, p. 546
	MGH Biology, pp. 546-547

Genetics: Modern Ideas *(continued)*

Outcomes

Students will be expected to

- summarize the main scientific discoveries that lead to the modern concept of the gene (315-1)
  - define sex-linkage
  - explain why sex-linked defects are more common in males than females
  - distinguish between genotypes and phenotypes evident in autosomal and sex-linked inheritance
  - explain the influence of polygenic traits on inheritance patterns.
- interpret patterns and trends in genetic data (214-5)
  - predict the outcome of monohybrid and dihybrid crosses involving sex-linked traits

Suggested Learning and Teaching Strategies

Students should be introduced to the concept of the inheritance of certain characteristics (red-green colour blindness, hemophilia, muscular dystrophy) through the sex chromosomes. Colour blindness analysis charts are useful to illustrate this sex-linked characteristic.

Students should be aware that autosomal inheritance typically involves pairs of genes, with gender being irrelevant to gene expression. Sex-linked inheritance involves pairs of genes on the X chromosome in the female, and a single gene on the X in the male. In this case, gender is important in gene expression and gender must be considered a part of the phenotype.

This is also known as multiple gene inheritance. Skin colour and eye colour are examples of polygenic inheritance where traits are determined by a number of different contributing genes present at different locations and expression depends on the sum of the influences of all of these. Other examples include animal and plant traits selected by breeders for improving livestock and crops, as well as human characteristics such as susceptibility to cardiovascular disease and athletic ability.

Students should solve genetic problems that involve sex-linked traits. In these problems they should predict the genotypes, phenotypes and ratios among offspring and compare specific genotypes and phenotypes for males and females. Students should be able to solve dihybrid crosses involving one trait that is completely dominant with one other trait that is sex-linked. Teachers should use multiple resources to find genetic problems of this type.

Genetics: Modern Ideas *(continued)*

Suggested Assessment Strategies	Resources/Notes
Journal • Students could reflect and respond to the following statement: "True or False: Males are biologically stronger than females". They should defend their position. (315-3)	
Paper and Pencil • Students could solve sex-linked genetics questions prepared for them. In each case, they should analyze the data as requested. Students could analyze the pedigree charts provided and determine the mechanism of inheritance. They should determine the unknown genotypes and phenotypes for the indicated individuals. Assessment should be based on the accurate solution of the problems using appropriate logic and procedures. (212-4, 214-12, 315-3)	*MGH Biology, pp.* 546-547 *MGH Biology, pp.* 558-559 *MGH Biology, pp.* 546-548, 555-559 *MGH Biology, p.* 549 *MGH Biology, pp.* 546-547

Genetics: Molecular

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• summarize the main scientific discoveries that led to the modern concept of the gene (315-1)	Students may research and produce a historical timeline to illustrate the most significant scientific discoveries leading to the concept of the gene.
• explain the role of evidence, theories, and paradigms in the development of the gene concept (114-2)	
– describe the contributions of the following to the understanding of the structure and function of DNA (i) Mendel (ii) Sutton & Boveri (iii) Levene (iv) Griffith (v) MacLeod, McCarty & Avery (vi) Chargaff (vii) Franklin & Wilkins (viii) Hershey and Chase (ix) Watson and Crick (x) McClintock	The depth of treatment for the work of these scientists should be limited to their contribution to the understanding of the structure and function of DNA. The intent of this outcome is to show the progression of scientific understanding by building on the results of previous research. An approach to making historical timelines more meaningful is to relate the time frame to an event that has some relevance to the student. Examples: – 1953 – Watson & Crick discover the structure of DNA – 1953 – the year of the birth of the student's mother/father
• explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3)	Students can brainstorm ideas about DNA and discuss their preconceptions, organize their ideas and, based on their current level of understanding, show the interrelationships between them on a concept web. Students should be aware of and be able to explain how knowledge of the structure, function and replication of DNA revolutionized the understanding of heredity. Students may design and/or construct models of DNA to illustrate the general structure and base arrangement of the molecule.
– describe the Watson and Crick double helix model of DNA	

Genetics: Molecular

Suggested Assessment Strategies

Laboratory Activities

- Students could design and construct a three-dimensional model of a DNA molecule following these structural guidelines:
  - include a minimum number of six base pairs
  - show all possible base pair combinations
  - make the model self-supporting
  - include a key for part identification

  They will be assessed on accuracy and completeness of their model. (315-4)

Paper and Pencil

- Students will be provided with the name of a scientific investigator and/or an achievement that has contributed historically to the concept of the gene. They will prepare a brief summary of the date, names of appropriate individuals and the contributions made on a large index card and present this information to the class. Following this, they could add their information card to the chronological timeline at the front of the classroom. Assessment can be based on the accuracy and completeness of the information collected. (115-3, 315-1)

Journal

- Students could give an example of how the discovery of one technology broadened the circle of knowledge for other areas of science. (115-3, 315-1)

Resources/Notes

MGH Biology, p. 545

MGH Biology, pp. 566-574

MGH Biology, pp. 574-575

MGH Biology, pp. 574-575

Genetics: Molecular *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• identify and describe the structure and function of important biochemical compounds such as nucleic acids (DNA and RNA) (314-3) – compare and contrast the structure of DNA and RNA	Students should describe, in general, how genetic information is contained in a DNA molecule (chromosome); how each DNA molecule replicates itself during cell division; how information is transcribed into the base sequences of RNA molecules and is finally translated into the sequence of amino acids in cell proteins. Students may perform simulations to demonstrate the replication of DNA and the transcription and translation of its information. Students could investigate the rarity of mistakes made during replication of DNA by discussing the role of DNA polymerase and its 'proofreading' mechanism and the influence of DNA repair enzymes.
• explain the semi-conservative model of DNA replication (315-5) – describe the four steps of DNA replication. Include: (i) initiation (ii) elongation (iii) termination (iv) proofreading and correction	Students should realize that DNA replication is a process in which a molecule of DNA is made containing one strand of parental DNA and one strand of new DNA. Students should understand that DNA replication is a four step process. During initiation the DNA molecule unwinds and unzips. Elongation involves the addition of complementary nucleotides to the original DNA strand. Termination is the completion of elongation. During proofreading and correction DNA polymerase detects and corrects any errors that may have occurred in elongation.
• evaluate and select appropriate models for collecting evidence and appropriate processes for inquiring and decision making (212-8)	The Laboratory outcomes 212-8, 215-2 and, in part, 315-5 are addressed by completing *DNA Structure and Replication* CORE LAB #6A.
• select and use appropriate symbolic modes of representation to communicate ideas and results (215-2)	The Laboratory outcomes 213-5, 213-7, 214-18, 215-2 and, in part, 315-4 are addressed by completing *Simulating Protein Synthesis* CORE LAB #6B.
• explain the role of DNA and RNA (mRNA, tRNA, rRNA) in proten synthesis (315-4) Include: (i) transcription (ii) translation	Analogies may be useful in illustrating how the amino acids in foreign proteins can be reorganized into a variety of human proteins (for example, the rearrangement of the letters of the alphabet into different words, or Lego™ blocks into different structures.) Teachers should note the error relating to transcription on page 591 of text. The anti-sense strand is the strand of the DNA molecule that transcribed the mRNA. The anti-sense strand is also referred to as the DNA template. See Teacher's Resource p. 209, section 17.4 (#'s 4-5).

Genetics: Molecular *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Using the processes of transcription and translation, students could convert the DNA strand given into its resulting protein. (314-3, 315-4)

Performance

- Using model kits, students could construct various organic compounds including proteins and nucleic acids. (314-3)
- As an independent project, students may research, design and perform an experiment to demonstrate the effect of environmental factors on inheritance. Their experiment must be approved before it is attempted. (214-5)

Laboratory Activities

- Students could extract DNA experimentally from the source provided, following the guidelines given in the laboratory. Assessment should be based upon observation of the group activity and the answering of appropriate questions. (315-4)

Journal

- Students could discuss the role of carbon as a versatile building block for all organic compounds. (314-3)
- If two sets of identical twins marry and have children, what is the genetic relationship among the cousins? (214-5)
- Vast quantities of human DNA appear to be non-functional. One theory suggests these are ancient archival genes, dormant DNA. What implications does this suggest about our ancestry? (214-5, 214-12)

Resources/Notes

MGH Biology, pp. 574-576

MGH Biology, pp. 582-588

Core Lab #6A: *"DNA Structure and Replication", pp.* 586-587

Core Lab #6B: *"Simulating Protein Synthesis", pp.* 594-595

MGH Biology, pp. 589-594

Genetics: Molecular *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• explain the role of DNA and RNA (mRNA, tRNA, rRNA) in proten synthesis (315-4) (**Cont'd**)	
– discuss the influence of hormonal and environmental factors on gene expression	Students should be aware that environmental factors might cause a change in the expression of some genetic information of an organism (e.g., the two colour pattern of the Siamese cat involves one hair colour gene producing a temperature sensitive enzyme; the enzyme is active and produces dark pigment only on cooler areas of the body - feet, snout, tip of tail, ears; temperature). Sex may also play a role (e.g., baldness gene is only dominant in males). Other examples of the effects of the environment on gene expression include differences in identical twins and the color of fur in Arctic foxes or hares.
• predict the effects of mutations on protein synthesis, phenotypes, and heredity (315-7)	In particular, students could discuss the dangers of UV radiation as a carcinogenic agent. Students can hypothesize how an alteration may ultimately affect the individual involved. Students may investigate and discuss sources of embryo deforming (teratogenic) chemicals found in the environment (thalidomide, alcohol) and the responsibility of society, science and technology to ensure all children have a good quality of life.
– explain the meaning of mutation and what causes it	
– explain what is meant by a gene mutation and predict, in general, its effect on protein synthesis	Students should draw the connection between mutations in genetic information and how they may be expressed through human conditions (e.g., cancer, sickle cell anemia, human thallesemia). The critical role of proteins as the link between gene and the human condition should be emphasized.
– distinguish between somatic and germ mutation and compare the inheritability of each	Somatic mutations occur in somatic cells (body cells) and thus cannot be passed on to offspring. Germ mutations occur during meiosis (gamete production) and thus such mutations can be passed on to the offspring.
– distinguish between the two types of point mutations (gene mutations) Include: (i) substitution -silent -mis-sense -nonsense (ii) frame shift -insertion -deletion	A point mutation is considered a gene mutation because it involves a change in a nucleotide and usually only affects a single gene. Two types of point mutations are substitutions and frame shift mutations.

Genetics: Molecular *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could investigate the effects on the developing human embryo of exposure to a specific environmental influence. The following are suggestions:
  - thalidomide
  - alcohol (Fetal Alcohol Syndrome)
  - tobacco/tobacco smoke
  - DES (diethylstilbesterol)
  - radiation
  - drugs such as cocaine, LSD, marijuana
  - viruses (Rubella/German measles, HIV)
  - caffeine
  - antibiotics (Streptomycin, acne drugs)
  - streptococcus bacteria

  Assessment should be based on accuracy and relevance of information gathered and completeness of research shown during class presentation. (315-6, 315-7)
- Using the processes of transcription and translation, students could convert the DNA strand given into its resulting protein. They should investigate what effect a change in one base in the DNA sequence might have on the resulting protein. (314-3, 315-4, 315-7)

Performance

- Students could design an experiment to investigate the effect of influences such as chemicals or radiation (e.g., microwave, ultraviolet) on the germination of seeds. Once the experiments have been designed and the design approved, there is opportunity for assessing how students actually perform the activities. Do they follow the design, use correct and safe techniques, troubleshoot as required? (315-7)

Resources/Notes

MGH Biology, pp. 594-596

MGH Biology, pp. 596, 598-600

MGH Biology, pp. 596-597

MGH Biology, pp. 596-598

Genetics: Molecular *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• describe factors that may lead to mutations in a cell's genetic information (315-6) – discuss how McClintock's jumping genes contribute to genetic variation – distinguish among the different types of chromosome mutations Include: (i) deletion (ii) duplication (iii) inversion (iv) translocation (v) nondisjunction (monosomy, trisomy)	Students may wish to compare variation in jumping genes to variation in crossing over.
• identify in general terms the impact of genetic diseases on the homeostasis of an organism (317-4) – describe several examples of human genetic diseases caused by chromosomal mutations. Include: (i) Down syndrome (ii) Turner syndrome (iii) Klinefelter syndrome (XXY syndrome) (iv) Jacobs syndrome (XYY syndrome) (v) Triple X syndrome	Students could apply their knowledge of nondisjunction by completing a thinking lab (page 552). This would help reinforce the concepts involved in nondisjunction. Students should explore the severity of chromosomal mutations compared to that of gene mutations. Chromosomal mutations are more serious because they involve a larger portion of genetic material. Students may also explore why there are relatively few syndromes in the human population involving nondisjunction. Most cases of nondisjunction prove to be fatal.
• interpret patterns and trends in genetic data (215-5) – analyze and interpret models of human karyotypes • state a prediction based on available evidence and background information (212-4) • explain how data support or refute the prediction (214-12)	The Laboratory outcomes 212-4, 214-12 and, in part, 214-5 are addressed by completing *Karyotype Lab* CORE LAB #7 (Appendix B of guide). Teachers should note that the lab includes three chromosome sets for karyotyping. Students are only required to complete two karyotypes. Teachers can choose any two of these chromosome sets so that the lab can be varied from year to year. Teachers can also create their own abnormal karyotypes if they wish to have further variations.

Genetics: Molecular *(continued)*

Suggested Assessment Strategies	Resources/Notes
Journal	
• Is it possible for a person born with a chromosomal abnormality, such as, Down Syndrome, to have a "normal" child?	*MGH Biology, pp.* 597-598
• Using their answer from above, students could discuss the statement, "Given the high cost of health care, forced sterilization should be mandatory for individuals with genetic diseases." (315-6)	*MGH Biology, pp.* 597, 550-553
Paper and Pencil	
• Using various sources, students could conduct research on the many hypotheses regarding the role of transposons in the human genome. (315-6, 213-7)	
Presentation	
• After students have completed their research on transposons, they may present their findings to the class. This could be done as a multimedia project to incorporate technology and improve computer skills. (315-6, 215-2, 213-7)	*MGH Biology, pp.* 550-553
Laboratory Activities	
• Teachers could provide students with a selection of human karyotypes. They should pair and arrange the chromosomes in the manner of a karyotype. Students should analyze the resulting karyotype for any inherent abnormalities and provide a brief written summary as to causes of the abnormality and what its possession means to the individual involved. Assessment should be based on accuracy and completeness of exercise. (214-18, 215-2, 313-2)	*MGH Biology, p.* 553 *MGH Biology, pp.* 553-560 **Core Lab #7**: *"Karyotype Lab",* Appendix B

Genetics: Implications

Outcomes

Students will be expected to

- identify in general terms the impact of genetic diseases on the homesostasis of an organism and explain the circumstances that lead to genetic diseases (317-4, 315-8) Include:
  - (i) autosomal recessive inheritance (Tay Sachs, PKU)
  - (ii) co-dominant inheritance (Sickle Cell Anemia)
  - (iii) autosomal dominant inheritance (Progeria, Huntington's)
  - (iv) incomplete dominant inheritance (FH)
  - (v) x-linked recessive inheritance (color blindness, Muscular Dystrophy, Hemophilia)
- describe and evaluate the design of technological solutions and the way they function, using genetic principles (116-6)
- construct arguments to support a decision concerning the use of genetic engineering, using evidence and recognizing various perspectives (118-6)
- analyze and describe examples where genetics-based technologies were developed and based on scientific understanding (116-4)
- analyze, from a variety of perspectives, the risks and benefits of applying the scientific knowledge gained through the genetic research (118-2)

Suggested Learning and Teaching Strategies

There are many current and relevant issues within the realm of biotechnology. Students can evaluate the data on genetic research obtained from Internet web sites. Students can evaluate, from a variety of perspectives (e.g., counsellor, prospective parents, potential patient) the role of genetic counselling and gene testing for the identification and treatment of potentially debilitating genetic conditions (e.g., Tay Sachs, PKU, Huntington disease, Alzheimer's). Students could discuss the personal and ethical considerations faced by individuals as the identification of genes, possibility of prenatal diagnoses and predictive ability for particular disorders increases. Questions such as the following could be considered:

– Would you, as an individual, want to know if you will suffer from a disabling disease later in life? Do you have a right to know?

– Do insurance companies have a right to accept/reject you for insurance coverage based on the results of voluntary and confidential genetic testing predicting your future health?

– Do employers have a right to know your genetic status determined from voluntary genetic testing? For example, suppose you are a heterozygous carrier for sickle cell anemia; you know there is a belief within the airline industry that carriers are more sensitive to a decrease in cabin air pressure. Do you inform the airline of your genetic status before accepting a job? As genetic testing becomes more common, and increases in availability, will potential employers have a right to know of your genetic status as a preliminary to hiring?

The CORE STSE component of this unit incorporates a broad range of Biology 3201 outcomes. More specifically, it targets (in whole or in part) 116-4, 116-6, 117-7, 118-2, 118-6, 315-6, 315-7, 315-8 and 315-9. The STSE component, *Genetics Research in Newfoundland and Labrador*, can be found in Appendix C.

Genetics: Implications

Suggested Assessment Strategies

Paper and Pencil

- Students could use a case study to investigate one of the inherited diseases studied. (315-8)

Presentation

- Students could debate the merits of mandatory testing for genetic diseases as a means of reducing the health care cost versus a person's right to privacy. Assessment should be based on accuracy and relevance of information gathered and completeness of the research shown during class presentation. (317-4, 315-8, 118-2)

Resources/Notes

MGH Biology, pp. 555-559

Core STSE #3: *"Genetics Research in Newfoundland and Labrador"*, Appendix C

Genetics: Implications *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• interpret patterns and trends in genetic data (214-5) – draw and interpret the patterns of inheritance shown on pedigree charts	Students should draw and interpret pedigree charts from data on human single and multiple allele inheritance patterns. They should be able to analyze inheritance data and infer the method of inheritance (dominant, recessive, sex-linked). Students should compare pedigree charts for the inheritance of non sex-linked and sex-linked conditions. The pedigree of the hemophilia within Queen Victoria's bloodline is readily available and serves to provide a biological/historical cross-curricular link. Student groups may design procedures, collect data and prepare family pedigrees to demonstrate the inheritance of autosomal traits determined by single and multiple alleles, and sex-linked traits. Simulations of forensic investigations or murder mysteries involving clues based on genetic traits (blood type, freckles, etc.) and pedigree information that require students to "solve" a crime based on the information provided are an interesting way to enhance student knowledge and interest in genetic analysis.
• describe and evaluate the design of technological solutions and the way they function, using genetic principles (116-6) – discuss the importance of genetic counselling – describe the various methods of detecting genetic disorders such as: (i) amniocentesis (ii) CVS (chorionic villi sampling) (iii) fetoscopy (iv) genetic markers (linked marker and gene specific marker)	Genetic counsellors study the medical histories of couples and their families and help parents-to-be by advising them of the frequencies of genetic disorders within affected families and by helping them to determine the probable risk factors associated with their particular case. It is suggested that Department of Health & Community Services sources be explored and appropriate literature be examined for additional information on this concept. Teachers should make a connection from Core Lab #7 (Karyotyping) which discusses methods of detecting genetic disorders. Teachers should note that amniocentesis, CVS and fetoscopy have already been completed in Unit 2.
– describe the various methods of treating genetic disorders such as: (i) screening and prevention (ii) surgery (iii) environmental control (iv) gene therapy	Students should research and discuss both the potential and the ethics of biotechnology and somatic cell gene replacement therapy in the treatment of human genetic disorders. What might be the implications of gene therapy on germ or sex cells? Students could discuss the role of gene banks for the preservation of endangered species and genotypes and whether society has the right or responsibility to preserve these species in this way for future generations.

Genetics: Implications *(continued)*

Suggested Assessment Strategies

Presentation

- Teachers could invite a genetics counsellor/geneticist to discuss the merits of genetics counselling. (116-6, 315-8)

Journal

- You are a genetics counsellor. What advice would you give a couple who just found out that their unborn child has a 49% chance of having a serious kidney disease? (116-6, 315-8, 215-5)

Paper and Pencil

- Students could analyze pedigree charts provided and determine the mechanism of inheritance. They should determine the unknown genotypes and phenotypes for the indicated individuals. Assessment should be based on the accurate solution of the problems using appropriate logic and procedures. (212-4, 214-12, 315-3)
- Students may design pedigree charts to show the inheritance of certain characteristics such as freckles, handidness, etc., in their family. Sample pedigree charts may be found on the Internet and provided to students as examples. (214-5, 215-2)
- Students could research the use of gene therapy in the treatment of certain genetic diseases, such as cystic fibrosis. (116-6, 213-7)

Resources/Notes

MGH Biology, pp. 544, 558, 560-562

MGH Biology, p. 606

MGH Biology, pp. 606-608

MGH Biology, pp. 609-611

Genetics: Implications *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• demonstrate an understanding of genetic engineering, using knowledge of DNA (315-9)	Genetic engineering can be defined as the manipulation of an organism's genetic material to modify the proteins it produces.
– define genetic engineering	
– describe the tools and techniques used in genetic engineering. Include: (i) restriction enzymes (ii) recombinant DNA (iii) DNA amplification - bacterial vectors - viral vectors - Polymerase Chain Reaction (iv) gel electrophoresis (v) DNA sequencing	The use of restriction enzymes or biological scissors in DNA fingerprinting can be effectively demonstrated using paper activities. Students could perform simulations to demonstrate the use of restriction enzymes in the creation of new DNA sequences (e.g., recombinant DNA). DNA sequencing can be compared to completing a puzzle, tying together the clues in a murder mystery, reconstructing remains in archaeology.
• explain the importance of the Human Genome Project and why it was initiated (315-10, 117-2)	
– describe the Human Genome Project	Students should know what the Human Genome Project is, how and why it was conducted and what the implications of decoding the entire human genome are.
– describe the major findings of the project	The two major findings of this project are that 99.9% of all human DNA is identical and that there are approximately 35 000 different genes in the human population. Individual students or student groups could be assigned an individual human chromosome for which they investigate its mapping. They could prepare a large cardboard model of this structure labelled with its identified genes and the characteristics for which they code. Students could make a presentation on their chromosome as the class builds a human genome to be displayed within the classroom or school.

Genetics: Implications *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Within assigned groups, students could be asked to research and report to the class on one of the tools or techniques currently available to study genetics. Areas that may be considered include the polymerase chain reaction (PCR) process, DNA 'fingerprinting' and gel electrophoresis, gene probes, recombinant DNA, cloning, genetic markers and gene mapping. (118-6, 118-2)
- Students could analyze the simulation of DNA fingerprinting presented to them and determine which suspect was in the vicinity of the crime scene. They should write down in point form the logic used to come to their conclusion . (212-4, 315-2, 315-8, 315-10)
- Students could be assigned one chromosome from the human genome to research and map. They could prepare, to the assigned scale, a cardboard model of this chromosome, with its most significant genes clearly labelled. They could present to the class information about their chromosome and it could be mounted as part of a common genome either within the classroom or as a bulletin board display for the school. (212-4, 315-2, 315-8, 315-10)

Journal

- The Human Genome Project raises a number of important issues that might be considered. Students could reflect on these questions and develop, present, and defend their position based on scientific thinking.
  - Recently a Canadian futurist, Frank Ogden, applied to the U.S. Patent and Trademark office to have his DNA trademarked, in an effort to protect himself and his identity. He feels that his application is important because it paves the way for others to do the same, especially if they have a talent that may interest researchers wishing to study their DNA, the building blocks of life. Do you think Frank Ogden should be successful? Why or why not?
  - Is it ethical for private biotechnology companies to use research information gained through public funding for private profit? Should the individuals whose DNA was used for public research in the Human Genome Project be compensated for their contribution? (114-2, 117-2, 118-2, 118-6, 215-5, 315-9, 315-10)

Resources/Notes

MGH Biology, p. 604

MGH Biology, pp. 613-618

MGH Biology, pp. 613-614

MGH Biology, pp. 614-616, 125

MGH Biology, pp. 615-617
MGH Biology, pp. 616-618

MGH Biology, pp. 618-620

Genetics: Implications *(continued)*

Outcomes

Students will be expected to

- analyze, from a variety of perspectives, the risks and benefits to society of applying the scientific knowledge gained through the Human Genome Project (118-2)
  - Risks:
    - (i) privacy
    - (ii) financial
    - (iii) ethical
  - Benefits:
    - (i) knowledge of predisposition to disease
    - (ii) analysis, prevention and treatment of disease
- select and integrate information from various sources on genetically modified organisms and genetically modified foods (213-7)
- analyze from a biological, social, ethical and environmental perspective the risks and benefits of the development of GMFs and GMOs (118-2)
  - define GMOs and GMFs
  - give examples of GMOs or GMFs and its major significance. Include:
    - (i) herbicide - resistant plants
    - (ii) BST-producing bacteria
    - (iii) golden rice
    - (iv) transgenic salmon
    - (v) insulin-producing bacteria
    - (vi) PCB-eating bacteria
    - (vii) oil-eating bacteria

Suggested Learning and Teaching Strategies

The completion of the Human Genome Project presents potential risks and benefits to society. Students could brainstorm relevant issues and subsequently research, analyze and discuss a selection of these.

Students could investigate and perform a risk/benefit analysis and defend their position on situations such as:

- The use of genetically modified microorganisms (GMO) for drug production, pollution clean-up, environmental monitoring and mining.
- The use of genetically modified food (GMF) in the marketplace. Students should investigate the extent to which genetic manipulation currently pervades the food industry (e.g., processed foods) and how aware or unaware the general public is of this.
- What is the importance of labelling genetically modified foods? What practical issues are involved?

Teachers could use multiple resources to find other examples of GMOs and GMFs.

Genetics: Implications *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could select an area within the topic of biotechnology that is of interest to them and prepare a class presentation and written report which illustrates two differing points of view. Internet web sources provide an extensive database for this exercise. Assessment should be based upon quality of both presentation and written report. Teachers should ensure that at least one individual or group chooses to deal with the Human Genome Project and its implications for human life and health. (116-6, 117-2, 118-2, 118-6, 215-5)
- As a class, students could create a list of world wide web sites useful for information concerning genetics and genetic screening. (213-7)
- Students could create their own webquest that relates to moral and ethical concerns associated with genetics. They could generate ten questions and list a variety of web sites their peers could use to seek answers to the questions. (213-7)

Resources/Notes

MGH Biology, pp. 618-620

MGH Biology, pp. 621, 623-626, 630

Genetics: Implications *(continued)*

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to • analyze from a biological, social, ethical and environmental perspective the risks and benefits of the development of GMFs and GMOs (118-2) **(Cont'd)** – identify and explain the major risks associated with GMOs and GMFs. Include: (i) environmental threats (ii) health effects (iii) social and economic issues	Students could debate the merits of labelling foods that are genetically modified.
• construct arguments to support or oppose the use of GMOs and GMFs in society (118-6) • present and defend a course of action on the use of GMO and GMF, based on findings (215-5)	Students may examine how our new-found ability to move genes around potentially impacts allergenicity levels. The production of "new" foods or organisms could increase the amount of allergens around us.
• analyze from a biological, social, ethical and environmental perspective, the risks and benefits of cloning organisms (118-2) – define cloning – use sheep as an example to describe the cloning process – identify and explain the major benefits and risks associated with cloning. • identify and describe science-based careers related to the field of biotechnology Include: (117-7) (i) cytogeneticist (ii) medical geneticist (iii) genetic engineer	This would be an ideal time to do a role-play concerning these arguments. Students could do research on the topic and set up a debate. Cloning was covered in Unit 2. It is expanded in this section. Students could use Dolly the sheep as an example of the cloning process. The benefits and risks associated with cloning include: (i) speed of reproduction (ii) elimination of disease (iii) manipulation of traits (iv) reducing genetic variability (v) embyro use and destruction (vi) loss of individuality

Genetics: Implications *(continued)*

Suggested Assessment Strategies

Presentation

- Students could debate the pros and cons of producing genetically modified foods. For example,

  "We will be conducting a debate in which you will be required to display the results of your research and "argue" against other stakeholders concerning the merits of the use of the technology for the production of genetically modified foods or any other aspect of relevant biotechnology. You will represent various sectors of society, depending on the issues selected. They may include individuals such as farmers, politicians, Greenpeace activists, consumers, or representatives of development agencies involved in underdeveloped countries."

  Teachers could assess the participation of students, preparation of the argument and thoroughness of the research done. (116-6, 117-2, 118-2, 118-6, 215-5)

Paper and Pencil

- Students could research and analyze how the cloning of the sheep Dolly in 1997 influenced our understanding of the potential of biotechnology and how knowledge of the cloning of mammals continues to evolve. (118-6, 118-2)

Portfolio

- Students could investigate (through research or interview) a career of their choice related to this unit on genetics and heredity. Examples include biochemist, genetic counsellor, laboratory technologist, geneticist, oncologist, etc. Students could prepare a small poster on the knowledge and skills required in this career. Assessment will be based on the quality of the display prepared. (315-10, 117-2)

Resources/Notes

MGH Biology, pp. 626-627

MGH Biology, pp. 627-631

MGH Biology, pp. 608-609 and STSE #3

Unit 4
EVOLUTION, CHANGE AND DIVERSITY

Suggested Time: 18 Hours

Unit Overview

Introduction

Evolution is a concept in biology that links yesterday with today. This unit focusses on the history, importance and mechanisms of the process of evolution and how a change in the DNA blueprint creates new traits that propel evolution. It builds upon what the students have learned about mutations and genetic variability and shows how these can lead to changes in species based upon natural selection. This unit also outlines evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth.

Focus and Context

By considering questions generated by students and teachers and the discussion of issues raised, various learning and assessment activities will meet specific curriculum outcomes within this section. The main focus of this unit falls within the realm of scientific inquiry and observation as it transposes from a historical to modern perspective on the scientific thought and techniques involving evolution, change and diversity.

Science Curriculum Links

The curricular connections for this unit in Biology 3201 exist at both the elementary and intermediate levels within units dealing with diversity of life. Students at these points within their life science education are asked to compare adaptations of closely related animals that live in different parts of the world and discuss possible reasons for any differences noted. They are then asked to expand their view of this concept by identifying changes that have occurred in animals over the course of time using the fossil record. These considerations provide a framework upon which further discussions can be built.

Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology

114-2 explain the roles of evidence, theories and paradigms in the development of scientific knowledge

114-5 describe the importance of peer review in the development of scientific knowledge

115-7 explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or replaced

Relationships between Science and Technology

116-2 analyse and describe examples where scientific understanding was enhanced or revised as the result of the invention of a technology

Social and Environmental Contexts of Science and Technology

118-6 construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives

Skills

Students will be expected to

Initiating and Planning

212-1 identify questions to investigate that arise from practical problems and issues

212-4 state a prediction and a hypothesis based on available evidence and background information

Performing and Recording

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

213-6 use library and electronic research tools to collect information on a given topic

Analysing and Interpreting

214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-17 identify new questions or problems that arise from what was learned

Communication and Teamwork

215-4 identify multiple perspectives that influence a science-related decision or issue

Knowledge

Students will be expected to

316-1 describe historical and cultural contexts that have changed evolutionary concepts

316-2 evaluate current evidence that supports the theory of evolution and that feeds the debate on gradualism and punctuated equilibrium

316-3 analyse evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction

316-4 outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth

Evolutionary Change: Historical Perspectives

Outcomes

Students will be expected to

- explain how knowledge of evolution theory evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or replaced (115-7)
  - define the terms evolution, adaptation and variation
- draw a timeline illustrating how early life forms evolved into the diverse array of organisms present on Earth today. Include the appearance of: (316-4)
  - (i) single cells
  - (ii) marine worms
  - (iii) clams
  - (iv) fish
  - (v) dinosaurs
  - (vi) small mammals
  - (vii) modern mammals (humans)
- analyze evolutionary mechanisms such as natural selection, and artificial selection (316-3)
  - explain the process of natural selection and artificial selection
  - use the Peppered Moth story as an example of evolution and adaptation

Suggested Learning and Teaching Strategies

Students should be aware that the topic of evolution is based on many different theories. Like all theories, there is no evidence that completely eliminates doubt. Since many of the topics relating to Earth origins, life origins, evolution, etc., may be addressed from various points of view, it is the suggested intent of this biology course to outline the topics from the scientific process approach. Teachers should be aware that many topics in biology, (and in medical research), especially evolution, may be appraised along the lines of personal value judgements, ethical assessments and religious beliefs. It should be emphasized that the purpose of learning about all views is so that the student can intellectually question each and make educated decisions about what s/he believes.

A suggestion for introducing the topic of evolution is to develop a time line to help students visualize historical and/or geologic time frames. Another option is to create a timeline that illustrates the geologically recent event of human appearance on Earth. Tape a string along the wall to represent the history of Earth as one single year. Date one end of the string as January 1 (the formation of Earth) and the other end as December 31. Make a set of index cards with each one marking a crucial event. Students could place these on the string where they feel the events first occurred. Then, with a second set of cards, place the events where they actually belong on the string and discuss with the students the discrepancies between their placement and the appropriate location.

Students may examine an organism that has undergone artificial selection. They could explore the value of the trait that has been selected and compare any negative effects of its selection. Examples of organisms that have been artificially selected could include dogs, wheat, apples, roses, cattle, sheep, and so on.

The story of the Peppered Moth was previously covered at the intermediate science level. It is an example of the process of Industrial Melanism.

Evolutionary Change: Historical Perspectives

Suggested Assessment Strategies

Paper and Pencil

- Students could select a career to investigate that relates to this evolutionary unit and prepare a poster on the knowledge and skills required for each profession. Posters should be displayed. Examples include anthropologist, palaeontologist, botanist, physiologist, entomologist, etc. Assessment should be based on the quality of the display prepared. (213-6)
- Students could select a modern animal and investigate the evolutionary evidence that exists for its ancestry. The report on this work may be visual (e.g., videotape, poster, models) or written. Assessment should be based on accuracy and completeness of research and quality of presentation. (115-7, 316-2, 316-4)
- Students could select an organism that has undergone artificial selection. Examine and prepare a report on the value of the traits that were artificially selected and compare to any negative effects that may have resulted from this form of selection. (316-3)

Resources/Notes

www.gov.nl.ca/edu/science_ref/main.htm

MGH Biology, pp. 644-649

MGH Biology, pp. 660-661

MGH Biology, pp. 644-647

MGH Biology, pp. 647-649

Evolutionary Change: Modern Perspectives

Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
• describe historical and cultural contexts that have changed evolutionary concepts (316-1)	Students could begin by discussing some of the cultural aspects that influenced the progression of evolutionary ideas such as the influence of religious beliefs.
• describe the importance of peer review in the development of evolutionary knowledge (114-5) – describe the contributions of the following: (i) Charles Lyell (ii) Thomas Malthus (iii) Alfred Wallace (iv) Charles Darwin (v) Jean Baptiste Lamarck (vi) Georges Cuvier	Students should be aware of the contributions of Charles Lyell, Thomas Malthus, Alfred Wallace and, in particular, Charles Darwin to the historical development of the theory of evolution. Students should recognize that there are many explanations for changes in life forms over time (scientific, religious, philosophical). When students are discussing peer review they might contrast the methodology of Jean Baptiste Lamarck and Charles Darwin. Students could develop a timeline to illustrate historical progression towards the theory of evolution.
• explain the roles of evidence, theories and paradigms in the development of evolutionary knowledge (114-2) – describe the theories put forth by Larmarck and Darwin – compare and contrast Lamarckian and Darwinian evolutionary theories – explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory	The concept of paradigm shift was first dealt with in Science 1206. Students should recognize that a paradigm shift had occurred when the evolution ideas of Lamarck were generally dropped in favour of the ideas of Darwin. Students could examine how a German biologist, August Freidrich Weismann, was able to disprove Lamarck's theory by cutting off the tails of mice and allowing them to reproduce. Weismann showed that after many generations the tails still remained on the offspring and, therefore, disproved that acquired traits could be inherited.
– illustrate how knowledge of Mendelian genetics and mutations supported Darwin's theory	Students could be asked to explain how the work of Mendel provided support for Darwin's theory.
– explain the modern theory of evolution and its importance to biological sciences	Students should make reference to the modern theory as a meshing of Mendel's and Darwin's Theories.

Evolutionary Change: Modern Perspectives

Suggested Assessment Strategies	Resources/Notes
Presentation	*MGH Biology, pp.* 650-658
• Students could use library and electronic research tools to collect information on a topic related to an evolutionary theory and prepare a class presentation and written report. Sample topics may include:	
– contributions of individuals to the theory of evolution	
– types of evolutionary mechanisms	
– types of evidence supporting or contradicting the theory of evolution	
– theories on the origin of life on Earth	*MGH Biology, p.* 655
– gradualism vs. punctuated equilibrium	*MGH Biology, p.* 656 *MGH Biology, p.* 657
– role of viruses in the evolutionary process	*MGH Biology, p.* 652 *MGH Biology, p.* 651
– exobiology	*MGH Biology, p.* 650
• Assessment will be based on the quality of the student presentation and the information researched. (213-6, 214-17)	
Journal	
• Students could compare the theories of Lamarck and Darwin. (114-5, 316-2)	*MGH Biology, pp.* 651-658
	MGH Biology, pp. 674-675

Evolutionary Change: Modern Perspectives (continued)

Outcomes

Students will be expected to

- explain the roles of evidence, theories and paradigms in the development of evolutionary knowledge (114-2) **(Cont'd)**
  - describe current evidence that supports the modern theory of evolution. Include:
    (i) fossil record
    (ii) biogeography
    (iii) comparative anatomy
    - homologous structures
    - analogous structures
    - vestigial structures
    (iv) comparative embryology
    (v) heredity
    (vi) molecular biology
  - discuss the relationship between the relative age of rock sediments and the relative age of fossils contained within the rock layers.
  - compare the processes and accuracy of the methods of dating fossils. Include:
    (i) relative dating
    (ii) absolute dating

Suggested Learning and Teaching Strategies

Students could use multimedia resources to investigate how scientists have used various pieces of evidence to support or refute the theory of evolution. An example of one site is: www.pbs.org/wgbh/evolution/library/04/index.html

Groups of students could videotape and share a story of a chosen organism with the class or do this as part of a written research project.

Teachers should provide students with fossils or pictures of fossils so that they can compare them with each other and living relatives. By observing similarities, students can understand why organisms may be classified together. By observing differences, students can understand how organisms have changed over time, becoming more complex. Comparative anatomy can be demonstrated in a similar way. Students can also research other organisms that have similar anatomy to themselves. They can then use this information to devise a "family tree" showing their findings. When discussing molecular biology, students should explain how nucleic acid sequences in the nucleus, mithochondria and chloroplast are being used to provide evidence for evolutionary relationships among species.

Teachers could refer to the Biology 2201 STSE unit "Classification by Application of Modern Technologies" to remind students how DNA analysis has been used to determine relatedness among organisms.

One analogy that could be used to differentiate between relative dating and absolute dating would be to use "I am older than you, you are older than your sister, etc." for relative dating and "you can tell the age of a tree by counting its rings" for absolute dating.

Evolutionary Change: Modern Perspectives (continued)

Suggested Assessment Strategies

Paper and Pencil

- Students could compare the amino acid and protein sequences of different organisms to compare their similarities (e.g., frog, human, chimpanzee, rabbit, cow) (114-2)

Laboratory Activity

- Products are available from biological supply companies that contain simulated blood samples that allow comparison of simulated blood proteins from sources such as human, chimp, frog, chicken. (114-2)
- Teachers could plan a field trip to a fossil site within the province. Students should observe these fossils only; they could take video and photographs but they should not remove any fossils from these sites. (114-2)

Journal

- Students could reflect on this statement and develop, present and defend their position based on scientific thinking.

  "It has been hypothesized that we are in the midst of a 'sixth mass extinction'. Fossil records indicate that global mass extinctions have occurred only five times since complex life emerged, and that each time it was due to a single catastrophic event. It has been said that this apparent 'sixth mass extinction' is not, however, occurring due to a catastrophic event, but due to the activities of a single species, *Homo sapiens*, called the exterminator species!" (118-6, 316-3)

Presentation

- Students could conduct research to examine the evolutionary relationship between snakes and lizards and present their findings to the class. (114-2)
- The Shroud of Turin is a very important artifact for the Christian Religion. The Shroud has been dated through dating technologies. Students could research how it was dated and the controversy it caused. They should present their findings to the class. (212-1)

Resources/Notes

MGH Biology, pp. 659-662
MGH Biology, pp. 663-664
MGH Biology, pp. 664-665

MGH Biology, p. 665

MGH Biology, p. 666

MGH Biology, pp. 666-667

MGH Biology, pp. 659-662

MGH Biology, p. 662 and Thinking Lab "Rocks of Ages"

Evolutionary Change: Modern Perspectives *(continued)*

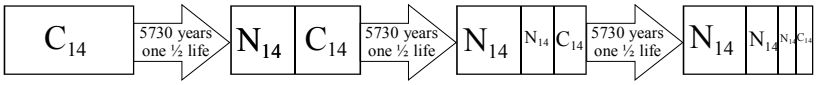
Outcomes

Students will be expected to

- identify questions to investigate that arise from practical problems (212-1)
  - perform calculations involving half-life

Suggested Learning and Teaching Strategies

A good method to introduce absolute dating, in terms of half-life, is by using a series of visual diagrams such as



The diagram indicates that the amount of carbon-14 decreases and the amount of nitrogen-14 (stable daughter) increases over time, however, the carbon-14 never completely disappears.

Half-life calculations should ask students to calculate one of the following, given the other two:

(i) half-life (ii) time of decay in years (i.e., fossil age) (iii) amount of decay

Some examples are found on the next page. More examples are found in the textbook and in most biology resources. Teachers should use multiple resources to find half-life calculation problems of this type.

Teachers may derive the formula below for students to use in these type of problems as an extension to this topic.

$$N_f = N_o\left(\frac{1}{2}\right)^{\frac{t}{h}}$$

Where: N_f = final amount N_o = initial amount

t = time (years) h = half life

- analyze and describe examples where scientific understanding was enhanced or revised as the result of the invention of a technology (116-2)
  - define population genetics, gene pool, allele frequency
  - state the Hardy-Weinberg law and explain its significance in terms of the development of evolutionary theories

Students should understand the conditions necessary to maintain a Hardy-Weinberg equilibrium. A Hardy-Weinberg equilibrium occurs when a population does not change genetically from one generation to the next. Scientists can determine how a real population changes over time by comparing a real population with a hypothetical Hardy-Weinberg population.

  - perform calculations involving Hardy-Weinberg equilibrium

Students should be able to complete problems using the mathematical application of the Hardy-Weinberg Principle. Some examples are found on the next page. Teachers should use multiple resources to find problems of this type.

Evolutionary Change: Modern Perspectives *(continued)*

Suggested Assessment Strategies

Paper and Pencil

- Students could complete the following problems involving half-life calculations.
  - A fossil contains 1/16 of the original carbon-14. How old is the fossil if the half-life of carbon-14 is 5730 years?
  - A rock that is known to be 3.5 billion years old contains 1/32 of the original amount of uranium-235. What is the half-life of uranium-235?
  - What fraction of carbon-14 remains in a fossil that is approximately 17 190 years old? The half-life of carbon-14 is 5730 years. (212-1)
- Students could complete the following Hardy-Weinberg problems.
  - If 16% of a Hardy-Weinberg population expresses a particular recessive trait, calculate the percentage of the population that would have the heterozygous genotype of this trait.
  - For a population in Hardy-Weinberg equilibrium, the frequency of the recessive allele is 0.3. What percentage of the population is heterozygous?
  - The frequency of a dominant allele for a certain trait in a Hardy-Weinberg population is 0.9. What percentage of individuals would be expected to express the dominant trait?
  - If 16% of a Hardy-Weinberg population expresses a recessive trait, what percentage of the population is homozygous for the dominant trait? (116-2)

Journal

- You are a biologist studying the endangered species of pine marten in Newfoundland. Explain how you might use your understanding of population genetics in your work. (116-2)

Resources/Notes

MGH Biology, p. 662

MGH Biology, pp. 646, 677-679, 681

MGH Biology, pp. 681-686

Evolutionary Change: Modern Perspectives *(continued)*

Outcomes

Students will be expected to

- state a prediction based on available evidence and background information (212-4)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)
- compile and display evidence and information in a variety of formats, including diagrams, flow charts, tables, and graphs (214-3)
- analyze evolutionary mechanisms and their effects on biodiversity. Include: (316-3)
  - describe conditions that have the potential to disrupt Hardy-Weinberg equilibrium
    (i) mutations
    (ii) genetic drift
    - bottle neck effect
    - founder effect
    (iii) gene flow
    (iv) non-random mating
    - inbreeding
    - assortative mating
    (v) natural selection
    - stabilizing selection
    - directional selection
    - disruption selection
    (vi) sexual selection

Suggested Learning and Teaching Strategies

The Laboratory outcomes 212-4, 213-5, 214-3 and, in part, 116-2 are addressed by completing *Population Genetics and the Hardy-Weinberg Principle* CORE LAB #8.

Students should understand that a Hardy-Weinberg population does not actually exist because of these evolutionary mechanisms. Students could investigate examples of each of the evolutionary mechanisms listed and present their findings to the class (e.g., breeds of dogs are produced by artificial selection, yet all dogs, including the St. Bernard and Chihuahua, remain members of the same species; natural selection resulting in morphological, behavioural or reproductive adaptations such as the camouflage of the peppered moth; dwindling of the cheetah population due to inbreeding). Familiarity with the concept of artificial selection can come from studies of pedigrees or student experiments. Artificial selection allows the creation of 'breeds' of domestic animals whereas in natural selection, selection is due solely to natural conditions.

Students can use the Internet to access Web sites and collect relevant information on evolution and biodiversity. Students can brainstorm a list of extinctions that have occurred and research and evaluate the causes of each as naturally occurring or as a result of human activity. This discussion can be expanded into one that extrapolates itself to current and future extinctions, their causes, and hypothesizes the implications of this reduced genetic biodiversity.

Evolutionary Change: Modern Perspectives *(continued)*

Suggested Assessment Strategies

Journal

- Students describe which mechanisms would be at work for a small tribe of humans in a remote part of the world that has not had contact with the outside world. How might these people be different from other humans? At what point might they no longer remain *Homo sapiens*? (316-3)

Presentation

- Students could conduct research on the nucleic acid sequences of different animal species. They could use their findings to describe evolutionary relationships. (316-3)

Resources/Notes

Core Lab #8: *"Population Genetics and the Hardy Weinberg Principle", MGH Biology, pp.* 684-685

MGH Biology, pp. 687-696

MGH Biology, p. 688
MGH Biology, pp. 689-692

MGH Biology, p. 692
MGH Biology, pp. 692-693

MGH Biology, pp. 693-694

MGH Biology, pp. 695-696

Evolution: Implications

Outcomes

Students will be expected to

- analyze evolutionary mechanisms and their effects on biodiversity. (316-3) (**cont'd**)
  - define speciation
  - describe two general pathways that lead to the formation of a new species (transformation, divergence)
  - explain the conditions under which speciation may occur
  - describe how geographic isolation may contribute to speciation
  - demonstrate how biological barriers to reproduction may contribute to speciation. Include:
    (i) pre-zygotic barriers
    - behavioural isolation
    - habitat isolation
    - temporal isolation
    - mechanical isolation
    - gametic isolation

    (ii) post-zygotic barriers
    - hybrid inviability
    - hybrid sterility
    - hybrid breakdown
  - describe adaptive radiation as a mechanism for speciation
  - distinguish between convergent and divergent evolution and explain its occurrence in certain groups of organisms
  - explain the process of coevolution

Suggested Learning and Teaching Strategies

Examples of transformation are the peppered moth or antibiotic resistant microbes. An example of divergence is the finches from Galápagos Islands.

The rapid appearance of new antibiotic-resistant microbes and the development of pesticide-resistant insects can be considered studies in microevolution - rapid evolution due to intense selection. Students could investigate the causes of the appearance of these new strains and the environmental and societal implications they present. Students may discuss questions such as the following:

- If mutations play an important role in evolution, why are many scientists concerned about the mutagenic effects of X-rays, radiation from nuclear power plants, chemicals, etc?
- What would be the effect on the offspring if DNA polymerase were absolutely infallible in its proofreading capacity? What would be the long-term effect on biological evolution?
- What are the implications of the cloning process, if any, on evolution?

Students can investigate the evolutionary evidence that exists for the ancestry of a modern animal, such as the horse, cat, dog (and/or other household pet or domesticated animal used in agriculture). This may involve (in the example of the horse) looking at things such as the following:

- tracing the ancestry of the modern horse from *Eohippus* to *Equus* to determine the historical changes required in its evolution from a small woodland browser to a large, plains-dwelling grazer.
- examining illustrations (drawings, photos, art) that compare possible changes in anatomy such as size, leg and tooth anatomy that would allow them to evaluate evidence for the theory of evolution. Examination of the diagrams could lead to the question, "How are dietary changes linked to changes in tooth anatomy?"
- asking and discussing questions such as, "What advantages would a tall horse have as a plains-dweller?", "Why would running be necessary for a plains-dweller?", "How did changes in the environment result in an evolutionary adaptation?"

Evolution: Implications

Suggested Assessment Strategies

Journal

- Students could explain, using modern evolutionary theory, the recent appearance of antibiotic-resistant bacteria populations. (316-3)
- Students could explain, using modern evolutionary theory the recent appearance of pesticide-resistant insect populations. (118-6, 316-3)
- Students could conduct research into the debate on the extinction of the *Homo neanderthalis*. They should evaluate the two main competing theories: extinction due to competition with *Homo sapiens* or extinction due to interbreeding with *Homo sapiens*. (316-3)

Laboratory Activities

- Thinking lab, "Leopard Frogs - One Species or Seven?", deals with pre-zygotic barriers. Additional web research beyond the given link in the lab exercise would be advantageous. (316-3)

Resources/Notes

MGH Biology, pp. 708-709

MGH Biology, pp. 709-710

MGH Biology, pp. 710-711

MGH Biology, pp. 720-723

Evolution: Implications *(continued)*

Outcomes

Students will be expected to

- compare the views on gradualism and punctuated equilibrium and discuss how evidence for evolution fuels the debate between them (316-2)
  - (i) Gould
  - (ii) Eldridge
- identify multiple perspectives that influence a science-related decision or issue (215-4)
- outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth (316-4)
  - (i) chemical evolution
    - Oparin-Haldane theory
    - Miller-Urey theory
  - (ii) heterotroph hypothesis
  - (iii) symbiogenesis
  - (iv) panspermia theory
  - (v) GAIA theory
  - (vi) intelligent design theory
- use research tools to collect information on a given topic (213-6)
- explain the role of evidence, theories and paradigms in the development of evolutionary knowledge (114-2)
- explain how knowledge of evolution evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or replaced (115-7)
- construct arguments to support a judgment (118-6)
- identify new questions that arise from what was learned (214-17)

Suggested Learning and Teaching Strategies

Students could research the published work of Stephen J. Gould and Niles Eldridge with regard to punctuated equilibrium. Charts can illustrate the differences between these two views. Students could investigate and answer the questions, "How would a scientist who supports gradualism or punctuated equilibrium explain gaps in the fossil record?" and "What sort of evidence would you need to be convinced to accept gradualism rather than punctuated equilibrium, or vice versa?"

Students should research, interpret and evaluate data concerning theories on the origin and development of life (e.g., Gaia, symbiosis theory of eukaryotic cell origins, heterotroph hypothesis, mass extinction theories, organic spontaneous origin or chemical evolution (Oparin-Haldane/ Miller-Urey) under early conditions. Students could research the conditions on a planet in our solar system and, using the Haldane-Oparine Theory, determine whether life may or may not exist (today or in the future).

Teaching evolution to students is a very controversial exercise. By including "Intelligent Design" as a theory for the origin of life, teachers can show students that there are many different beliefs about the beginning of life on Earth. This may help students who, because of religious beliefs, do not believe in the scientific view of evolution. It can be emphasized that the purpose of learning about all views is so that the student can intellectually question each and make educated decisions about what s/he believes.

The CORE STSE component of this unit incorporates a broad range of Biology 3201 outcomes. More specifically, it targets (in whole or in part) 213-6, 114-2, 115-7, 118-6, 214-14 and 316-4. The STSE component, *Extraterrestrial Life: Myth or Realitys*, can be found in Appendix C.

Evolution: Implications *(continued)*

Suggested Assessment Strategies

Presentation

- Students could debate the two opposing viewpoints - gradualism versus punctuated equilibrium. Students would need to research both points of view to argue points and counter points. (316-2)
- Teachers could divide the class into five groups and assign each group one theory of evolution to research. Students could then debate the pros and cons of each theory as they are presented. (316-2)
- Students could use library and electronic research to collect information on each theory or a selected theory. Students should prepare individual written reports and give a class presentation on theory or theories. (316-2, 316-4)
- Based on the information found from their research, students could prepare a chart that outlines the major ideas of each theory of evolution. (316-2, 316-4)

Journal

- In Quebec there is a cult known as the Raelians. They believe that humankind developed from aliens. Students could discuss how examination of nucleic acid sequences could be used to refute or support the Raelians. (115-7, 116-2)

Resources/Notes

MGH Biology, pp. 723-725

MGH Biology, pp. 727-730

Core STSE #4: *"Extraterrestrial Life: Myth or Reality",* Appendix C