BIOLOGY 20–30

A. PROGRAM OVERVIEW

RATIONALE AND PHILOSOPHY

Biology is the study of life and living systems from the molecular level to the biosphere. Through the study of biology, learners are given an opportunity to explore and understand the natural world and to become aware of the profound influence of biology in their lives. Learning is facilitated by relating the study of biology to what the learners already know, deem personally useful and consider relevant. Learning proceeds best when it originates from a base of concrete experiences presenting an authentic view of science in the context of biology. In Biology 20–30, students learn biology in relevant contexts and engage in meaningful activities. This facilitates the transfer of knowledge to new contexts. Students are encouraged to participate in lifelong learning about biology and to appreciate it as a scientific endeavour with practical impact on their own lives and on society as a whole.

Biology, as with all sciences, is an experimental discipline requiring creativity and imagination. Methods of inquiry characterize its study. In Biology 20–30, students further develop their ability to ask questions, investigate and experiment; to gather, analyze and assess scientific information; and to test scientific laws and principles and their applications. In the process, students exercise their creativity and

develop their critical thinking skills. Through experimentation, and problem-solving activities that include the integration of technology and independent study, students develop an understanding of the processes by which scientific knowledge evolves.

The Biology 20–30 program places students at the centre. Students are active learners and will assume increased responsibility for their learning as they work through the program. A thorough study of biology is required to give students an understanding that encourages them to make appropriate applications of scientific concepts to their daily lives and prepares them for future studies in biology. Students are expected to participate actively in their own learning. An emphasis on the key concepts and principles of biology provides students with a more unified view of the sciences and a greater awareness of the connections among them.

These science learnings will take varying amounts of time to acquire, depending on the individual learning styles and abilities of students. While each course is designed for approximately 125 hours, instructional time can be modified to meet the individual needs of students. Some students will require more than 125 hours, while others will require less.

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BIOLOGY 20–30

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GOALS

The major goals of the Biology 20–30 program are:

- to develop in students an understanding of the interconnecting ideas and principles that transcend and unify the natural science disciplines
- to provide students with an enhanced understanding of the scientific world view, inquiry and enterprise
- to help students attain the level of scientific awareness essential for all citizens in a scientifically literate society
- to help students make informed decisions about further studies and careers in science
- to provide students with opportunities for acquiring knowledge, skills and attitudes that contribute to personal development.

Biology 20–30 is an academic program that helps students better understand and apply fundamental concepts and skills. The focus is on helping students understand the biology principles behind the natural events they experience and the technology they use in their daily lives. The program encourages enthusiasm for the scientific enterprise and develops positive attitudes about biology as an interesting human activity with personal meaning. It develops in students the knowledge, skills and attitudes to help them become capable of, and committed to, setting goals, making informed choices and acting in ways that will improve their own lives and life in their communities.

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B. LEARNER EXPECTATIONS

GENERAL LEARNER EXPECTATIONS

The general learner expectations outline the many facets of scientific awareness and serve as the foundation for the specific learner expectations covered in section C. The general learner expectations are developed in two categories: *program* expectations and *course* expectations.

PROGRAM GENERAL LEARNER EXPECTATIONS

The *program* general learner expectations are broad statements of science attitudes, knowledge, skills and science, technology and society (STS) connections that students are expected to achieve in all of the senior high school science programs. These *program* general learner expectations are further refined through the *course* general learner expectations and then developed in specific detail through the study of individual units in each of Biology 20 and Biology 30. All expectations follow a progression from Science 10 through to Biology 30, and though listed separately, are meant to be developed in conjunction with one another, within a context.

ATTITUDES

Students will be encouraged to develop:

- enthusiasm for, and a continuing interest in, science
- affective attributes of scientists at work; such as, respect for evidence, tolerance of uncertainty, intellectual honesty, creativity, perseverance, cooperation, curiosity and a desire to understand
- positive attitudes toward scientific and technological skills involving process skills, mathematics, and problem solving
- open-mindedness and respect for the points of view of others
- sensitivity to the living and nonliving environment
- appreciation of the roles of science and technology in our understanding of the natural world.

KNOWLEDGE

Science Themes

Students will be expected to demonstrate an understanding of themes that transcend the discipline boundaries, and show the unity among the natural sciences, including:

- **Change:** how all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled
- **Diversity:** the array of living and nonliving forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns
- **Energy:** the capacity for doing work that drives much of what takes place in the Universe through its variety of interconvertible forms
- **Equilibrium:** the state in which opposing forces or processes balance in a static or dynamic way
- **Matter:** the constituent parts, and the variety of states of the material in the physical world
- **Systems:** the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

SKILLS

Students will be expected to develop an ability to use thinking processes associated with the practice of science for understanding and exploring natural phenomena, problem solving and decision making. Students will also be expected to use teamwork, respect the points of view of others, make reasonable compromises, contribute ideas and effort, and lead when appropriate to achieve the best results. These processes involve many skills that are to be developed within the context of the program content.

Students will also be expected to be aware of the various technologies, including information technology, computer software and interfaces that can be used for collecting, organizing, analyzing and communicating data and information.

The skills framework presented here assumes that thinking processes often begin with an unresolved problem or issue, or an unanswered question. The problem, issue or question is usually defined and hypotheses formulated before information gathering can begin. At certain points in the process, the information needs to be organized and analyzed. Additional ideas may be generated—for example, by prediction or inference—and these new ideas, when incorporated into previous learning, can create a new knowledge structure. Eventually, an outcome, such as a solution, an answer or a decision is reached. Finally, criteria are established to judge ideas and information in order to assess both the problem-solving process and its outcomes.

The following skills are not intended to be developed sequentially or separately. Effective thinking is nonlinear and recursive. Students should be able to access skills and strategies flexibly; select and use skills, processes or technologies that are appropriate to the tasks; and monitor, modify or replace them with more effective strategies.

- Initiating and Planning

- identify and clearly state the problem or issue to be investigated
- differentiate between relevant and irrelevant data or information
- assemble and record background information
- identify all variables and controls
- identify materials and apparatus required
- formulate questions, hypotheses and/or predictions to guide research
- design and/or describe a plan for research, or to solve a problem
- prepare required observation charts or diagrams, and carry out preliminary calculations

- Collecting and Recording

- carry out the procedure and modify, if necessary
- organize and correctly use apparatus and materials to collect reliable data
- observe, gather and record data or information accurately according to safety regulations; e.g., Workplace Hazardous Materials Information System (WHMIS), and environmental considerations

- Organizing and Communicating

- organize and present data (themes, groups, tables, graphs, flow charts and Venn diagrams) in a concise and effective form
- communicate data effectively, using mathematical and statistical calculations, where necessary
- express measured and calculated quantities to the appropriate number of significant digits, using SI notation for all quantities
- communicate findings of investigations in a clearly written report

- Analyzing
 - analyze data or information for trends, patterns, relationships, reliability and accuracy
 - identify and discuss sources of error and their affect on results
 - identify assumptions, attributes, biases, claims or reasons
 - identify main ideas
- Connecting, Synthesizing and Integrating
 - predict from data or information, and determine whether or not these data verify or falsify the hypothesis and/or prediction
 - formulate further, testable hypotheses supported by the knowledge and understanding generated
 - identify further problems or issues to be investigated
 - identify alternative courses of action, experimental designs, and solutions to problems for consideration
 - propose and explain interpretations or conclusions
 - develop theoretical explanations
 - relate the data or information to laws, principles, models or theories identified in background information
 - propose solutions to a problem being investigated
 - summarize and communicate findings
 - decide on a course of action
- Evaluating the Process or Outcomes
 - establish criteria to judge data or information
 - consider consequences and biases, assumptions and perspectives
 - identify limitations of the data or information, and interpretations or conclusions, as a result of the experimental/research/project/design process or method used
 - evaluate and suggest alternatives and consider improvements to the experimental technique and design, the decision-making or the problem-solving process
 - evaluate and assess ideas, information and alternatives

CONNECTIONS AMONG SCIENCE, TECHNOLOGY AND SOCIETY

Science, Technology and Society (STS)

Students will be expected to demonstrate an understanding of the processes by which scientific knowledge is developed, and of the interrelationships among science, technology and society, including:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the functioning of processes or products based on scientific principles
- the ways in which science advances technology and technology advances science
- the use of technology to solve practical problems
- the limitations of scientific knowledge and technology
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

FURTHER READING

For a more detailed discussion on how to integrate thinking and research skills into the science classroom, refer to the publications: *Teaching Thinking: Enhancing Learning*, 1990 and *Focus on Research: A Guide to Developing Students' Research Skills*, 1990.

For further reading on integrating science, technology and society into the classroom, refer to the publication: *STS Science Education: Unifying the Goals of Science Education*, 1990.

COURSE GENERAL LEARNER EXPECTATIONS

The *course* general learner expectations are specific to each of Biology 20 and Biology 30 providing a bridge between the *program* general learner expectations and the specific learner expectations for each unit of study.

The attitudes expectations refer to those predispositions that are to be fostered in students. These expectations encompass attitudes toward science, the role of science and technology, and the contributions of science and technology toward society. The knowledge expectations are the major biology concepts in each course. The skills expectations refer to the thinking processes and abilities associated with the practice of science, including understanding and exploring natural phenomena, and problem solving. The connections among science, technology and society expectations focus on: the processes by which scientific knowledge is developed; the interrelationships among science, technology and society; and links each course to careers, everyday life and subsequent studies of biology.

Although itemized separately, the attitudes, knowledge, skills and STS connections are meant to be developed together within one or more contexts.

Biology 20–30

Attitudes

Students will be encouraged to:

- appreciate the role of empirical evidence and models in science, and accept the uncertainty in explanations and interpretations of observed phenomena
- value the curiosity, openness to new ideas, creativity, perseverance and cooperative hard work required of scientists, and strive to develop these same personal characteristics
- appreciate the role of science and technology in advancing our understanding of the natural

world, be open-minded and respectful of other points of view when evaluating scientific information and its applications, and appreciate that the application of science and technology by humankind can have beneficial as well as harmful effects and can cause ethical dilemmas

- show a continuing interest in science, appreciate the need for computational competence, problem-solving and process skills when doing science, and value accuracy and honesty when communicating the results of problems and investigations
- appreciate the complexity of our planet and its diversity of ecosystems, value all organisms and the role they play, appreciate the relationship between humans and their natural environment, and take responsibility toward environmental use within the limits of sustainable development.

Biology 20

Students will be able to:

Knowledge

- explain how equilibrium in the biosphere is maintained by the flow of energy from the Sun through the chemical processes of photosynthesis and cellular respiration, and by the cycling of matter through the biogeochemical cycles; and describe the influence of human activities on the equilibrium of energy and matter exchange and atmospheric composition
- explain the role of structure, function and regulatory mechanisms of the digestive, respiratory, excretory and circulatory systems in energy and matter exchange; and describe blood cellular components, and explain the role of the immune system in protecting the human organism and maintaining internal equilibrium
- explain how solar energy and matter are converted by cellular photosynthetic processes to ATP or stored in organic compounds as

potential chemical energy, and how this potential energy can be converted by cellular respiration to ATP; and describe the influence of oxygen, carbon dioxide and environmental toxins on these processes

- differentiate ecosystems on the basis of the energy and matter exchange of their biotic and abiotic components, by performing field studies on terrestrial and aquatic ecosystems; and explain, quantitatively and qualitatively, the trophic structure of ecosystems, using models, such as food webs, chains and pyramids
- list the direct and indirect evidence that supports the evolution of modern species from ancestral forms; and explain the theory of natural selection and how inherited variability within populations causes evolutionary change and speciation
- explain why populations are the basic components of an ecosystem; and describe the direct and indirect evidence of inherited and acquired variation in population gene pools, and explain the basis for the range of this variation found within individual species of a population

Skills

- perform investigations and tasks of their own and others' design that have a few variables and yield direct or indirect evidence; and provide explanations based upon scientific theories and concepts
- collect, verify and organize data into tables of their own design, and graphs and diagrams of others' design, using written and symbolic forms; and describe findings or relationships, using scientific vocabulary, notation, theories and models
- analyze and interpret data that yield straight- and curved-line graphs; and use appropriate SI notation, fundamental and derived units, and formulas; and calculate slopes of, and areas

under, straight-line graphs; and derive mathematical relationships among variables

- use mathematical language of ratio and proportion, simple equations, and unit analysis to solve single- and multi-step problems; and to communicate scientific relationships and concepts

Connections Among Science, Technology and Society

- apply cause and effect reasoning to formulate simple relationships for a given instance in which scientific evidence shapes or refutes a theory; and describe the limitations of science and technology in answering all questions and solving all problems, using appropriate and relevant examples
- describe and explain the design and function of technological solutions to practical problems, using scientific principles; and relate the ways in which biology and technology advance one another, using appropriate and relevant examples
- explain for a given instance how science and technology are influenced and supported by society, and the responsibility of society, through biology and technology, to protect the environment and use natural resources wisely
- identify subject-related careers and apply the knowledge and skills acquired in Biology 20 to everyday life and to related and new concepts in subsequent studies of biology.

Biology 30

Students will be able to:

Knowledge

- describe the structure and explain the function of nervous and hormonal control systems that enable the human organism to maintain internal equilibrium among its systems while simultaneously interacting and maintaining equilibrium with the external environment; and explain the role of selected hormones in metabolism and homeostasis
- describe mitosis and the cell cycle; and compare mitosis with meiosis and explain the significance to a species of chromosome number reduction and crossing over during meiosis; and describe gametogenesis, fertilization, fetal development and reproductive technologies in humans; and compare and contrast alternation of generations in a range of vascular plants and animals
- describe the anatomy and physiology of single neurons in relation to the initiation, formation and transmission of electrochemical impulses; and explain how sensory receptors, such as the eye and ear, act as energy converters
- describe the anatomy of human reproductive systems; and explain the hormonal control and maintenance of reproductive systems in adults; and describe how sexually transmitted diseases interfere with system function; and describe and explain the physiological events in the fetus that result in the formation of male and female genitalia
- explain heredity; describe direct and indirect evidence for chromosomes, genes, alleles and the influence of crossing over and sex chromosomes, and explain the role of this evidence in formulating the principles of inheritance; and explain the molecular basis of inheritance by describing DNA structure, expression and mutation; and explain the

significance of genomes to species and the influence of biotechnology on genes and genomes

- explain the significance of the Hardy-Weinberg equilibrium to gene pools, and the significance of gene pool change over time; and describe the chaos theory and explain and analyze, quantitatively, the factors and strategies that influence population growth

Skills

- perform and evaluate investigations and tasks of their own and others' design that have multiple variables and yield direct or indirect evidence; and provide explanations and interpretations, using scientific theories and concepts
- collect, verify and organize data into tables, graphs and diagrams of their own design, using written and symbolic forms; and describe findings or relationships and make predictions, using scientific vocabulary, notation, theories and models
- analyze, interpret and evaluate data that yield straight- and curved-lined graphs; and use appropriate SI notation, fundamental and derived units, and formulas; and calculate slopes of, and areas under, straight-line graphs; and derive mathematical relationships among variables
- use mathematical language of ratio and proportion, equations, simple probability and unit analysis to solve single- and multi-step problems; and communicate scientific relationships and concepts

Connections Among Science, Technology and Society

- apply cause and effect reasoning to formulate relationships for a range of instances in which scientific evidence shapes or refutes a theory; and explain the limitations of science and technology in answering all questions and solving all problems, using appropriate and relevant examples
- describe and evaluate the design and function of technological solutions to practical problems, using scientific principles or theories; and relate the ways in which biology and technology advance one another, using appropriate and relevant examples
- explain and evaluate for a given instance, and from a variety of given perspectives, how science and technology are influenced and supported by society; and assess the ability and responsibility of society, through biology and technology, to protect the environment and use natural resources wisely
- identify subject-related careers and apply the knowledge and skills acquired in Biology 30 to everyday life and to related and new concepts in post-secondary studies of biology.

SPECIFIC LEARNER EXPECTATIONS

LEARNING CYCLE

The specific learner expectations consist of the knowledge, skills and attitudes that are to be addressed in Biology 20–30. The use of the learning cycle allows students to progress, from:

- an introduction framing the lesson in an STS connection relevant to the lives of the learners, and makes connections between past and present learning experiences, as well as anticipates activities to focus students' thinking on the learning outcomes of the activity

TO

- the experiential exploration of new content that provides students with a common base of experiences within which they identify and develop key concepts, processes and skills

THROUGH

- a hypothesis-building phase where concepts are developed to describe a particular aspect of their experiential exploration, and opportunities are provided to communicate their conceptual understanding, or demonstrate their skills or behaviours

TO

- an elaboration phase that extends understanding of key concepts and allows further opportunities to practise desired skills and problem-solving strategies

TO

- an application phase where the hypotheses, vocabulary and patterns previously developed are applied to new situations and related to key concepts and principles of science

TO

- a final evaluation of the significance of the new learning in an STS context to assess their understanding and abilities, and provide opportunities for evaluation of student progress toward achieving the curriculum standards.

In Biology 20–30, students examine phenomena in a variety of topics to show the relationships among all the sciences. Wherever possible, examples should be framed in the context of the learners' own experiences to enable them to make the connections between scientific knowledge and the society around them, the technology that societies have developed, and the nature of science itself.

PROGRAM OVERVIEW

The Biology 20–30 program emphasizes the science themes: *change, diversity, energy, equilibrium, matter* and *systems* as they relate to biology. These themes provide a means of showing the connections among the units of study in both courses of the program, and provide a framework for students to learn how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of fundamental science concepts and principles, Biology 20–30 has the goal of educating students about the nature of science and technology, and the interaction between biology and technology. Students must be aware of the tremendous impact of biology and associated technology on society, but at the same time, they must be aware of the roles and limitations of the biological sciences, science in general, and of technology in problem solving in a societal context.

BIOLOGY 20

The major science themes developed in this course are *diversity, energy, equilibrium, matter* and *systems*.

The major concepts allow connections to be drawn among the four units of the course and among all eight units in the two courses in the program.

Biology 20 consists of four units of study:

- Unit 1: The Biosphere
- Unit 2: Energy Flows and Cellular Matter
- Unit 3: Energy and Matter Exchange in Ecosystems
- Unit 4: Energy and Matter Exchange by the Human Organism.

Unit 1 focuses on the dynamic *equilibria* that exist for *energy* and *matter* in the biosphere, and the *systems* that regulate those *equilibria*. In Unit 2, *energy* from the environment is traced through photosynthetic and cellular respiratory *systems* with the associated cycling of *matter* in the form of carbon. Unit 3 examines the *diversity* in

characteristics of some of the *ecosystems* that make up the biosphere, and the interactions of the organisms mediating the flow of *energy* and *matter* through those *ecosystems*. The unit closes with a discussion of how organisms evolve to fill available niches in *ecosystems*. The particular case of the human organism *system* and its *energy* and *matter* exchanges with the environment is examined in Unit 4, along with its biotic interactions with pathogenic organisms and the maintenance of *equilibrium* with its environment.

BIOLOGY 30

The major science themes developed in this course are *change, diversity, equilibrium* and *systems*.

The major concepts allow connections to be drawn among the four units of the course and among all eight units in the two courses in the program.

Biology 30 consists of four units of study:

- Unit 1: Systems Regulating Change in Human Organisms
- Unit 2: Reproduction and Development
- Unit 3: Cells, Chromosomes and DNA
- Unit 4: Change in Populations and Communities.

Biology 30 expands upon the concepts and skills introduced in Science 10 and Biology 20. Unit 1 focuses on chemical and electrical *systems* that regulate body processes to maintain *equilibrium*, and the processes of reproduction and development as *systems* for bringing about *change* are examined in Unit 2. Both of these units use the human organism as a model system. The themes of *change* and *diversity* run through Unit 3 as the mechanisms for passing on genetic information and causing variation, and are examined for a range of organizational levels. Finally, Unit 4 looks at *change* as illustrated by the genetics of populations, at equilibrium in populations, and at the community *systems* in which populations exist.

BIOLOGY 20

UNIT 1 THE BIOSPHERE

OVERVIEW

Science Themes: *Energy, Equilibrium, Matter and Systems*

In Unit 1, students investigate the *matter* and *energy equilibrium* between photosynthetic activity and the cellular respiratory activity of living *systems*. The nature of water and other forms of *matter* as substrata for life is discussed during a survey of the hydrologic cycles and the biogeochemical cycles of several significant elements, and an examination of the roles of living *systems* in that cycling. The unit closes with a discussion of the impact of living *systems* on the *equilibrium* of atmospheric composition.

This unit builds on Science 10, Unit 1: Energy from the Sun, and Unit 2: Energy and Matter in Living Systems. It provides students with a foundation for the study of the nature of *energy* and *matter* flow at the cellular level in Unit 2, the *ecosystem* level in Unit 3, and the organism level in Unit 4.

The three **major concepts** developed in this unit are:

- the biosphere is maintained by a constant flow of *energy*
- the cycling of *matter* through the biosphere perpetuates its steady state *equilibrium*
- the balance of *energy* and *matter* exchange in the biosphere, as an open *system*, maintains its steady state *equilibrium*.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities related to *energy* and *matter* research on the biosphere
- collecting and recording environmental data

- organizing and communicating research results
- connecting, synthesizing and integrating data or information, and interpretations related to the biosphere as a *system*.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the use of technology to solve practical problems
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- appreciate the complexity of our planet
- develop an awareness of one's personal role in the preservation of the environment
- develop a sense of responsibility toward use of our environment
- develop optimism about humankind's ability to learn to function within the limits of sustainable development
- develop an open-mindedness concerning the views and values of others
- develop an attitude of participation in planning and shaping the future
- develop an awareness of global issues and the contribution of local activity to the resolution of global problems.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. The biosphere is maintained by a constant flow of *energy*.
 - most of the energy used in the biosphere comes from the Sun and is either stored or reradiated back into space, by extending from Science 10, Unit 1, the Sun's role in heating Earth, and by:
 - explaining how energy storage in the biosphere, as a system, can be visualized as a balance between photosynthetic and cellular respiratory activities
 - describing how stored biological energy in the biosphere, as a system, is eventually lost as heat; e.g., muscle heat generation, decomposition.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- performing an experiment to demonstrate, quantitatively, solar energy storage by plants
- measuring the amount of solar radiation in the local area, and comparing this with solar radiation data of other areas of the province and/or the country.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that the biosphere is maintained by solar energy that flows through photosynthesis and respiration and is lost as heat; and by measuring and comparing solar energy variations; and performing experiments that demonstrate plant energy storage, within the context of:

- evaluating the evidence for the influence of ice and snow on the storage of solar energy; i.e., albedo effect, hypothesizing about consequences of fluctuations for biological systems

OR

- explaining how metabolic heat release from harvested grain can be reduced by drying processes prior to grain storage by explaining the scientific principles involved in this technology

OR

- assessing the energy savings achieved in the overall requirements of large office buildings by using thermal energy recycling technologies to capture metabolic heat and the influence of the needs, interests and financial support of society in the development of these technologies

OR

- any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
<p>2. The cycling of <i>matter</i> through the biosphere perpetuates its steady state <i>equilibrium</i>.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p>
	<ul style="list-style-type: none"> • specific chemical elements are cycled through the biotic and abiotic components of the biosphere, by extending from Science 10, Unit 1, the hydrologic cycle, and by: • summarizing and explaining the biogeochemical cycles for carbon, nitrogen and phosphorous • explaining how water is cycled through the biosphere along characteristic pathways • identifying the properties of water and explaining their relevance to the hydrologic cycle; e.g., freezing point, hydrogen bonding, specific heat, density.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • predicting disruptions in nitrogen and phosphorous cycles caused by human activities • hypothesizing how alterations in the carbon cycle, as a result of the burning of fossil fuels, might influence other cycling phenomena • measuring the rates of precipitation and evaporation in the local area; and comparing this with precipitation and evaporation data of other areas of the province and/or the country • designing an experiment to compare carbon dioxide production by plants with that of animals • measuring the rates of water consumption and loss in plants and animals. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding that biosphere cycling of matter perpetuates its steady state; and by predicting and hypothesizing the human influence in these cycles; and by measuring and comparing precipitation and water movement; and designing matter exchange experiments with plants and animals, within the context of: • analyzing how society affects the biogeochemical cycle of carbon, which in turn influences the greenhouse effect <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • discussing the influence of agricultural products or processes on the biogeochemical cycle of phosphorous and nitrogen; e.g., feedlot operations, composting, commercial fertilizer applications <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • evaluating the implications of the greenhouse effect on the hydrologic cycle and the water requirements of society and its agricultural systems <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. The balance of *energy* and *matter* exchange in the biosphere, as an open *system*, maintains its steady state *equilibrium*.

- air composition is influenced by the activities of organisms, by extending from Science 10, Unit 2, how energy and matter are exchanged between living systems and their environment, and by:
 - explaining how the equilibrium between gas exchanges in photosynthesis and cellular respiration influences atmospheric composition
 - describing how human activities can have a disrupting influence on the balance, in the biosphere, of photosynthetic and cellular respiratory activities; e.g., fossil fuel combustion, forest destruction.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • predicting the effect of changes in carbon dioxide and oxygen concentration on the atmospheric equilibrium by a significant reduction of photosynthetic organisms through human activities • designing a model of a closed biological system in equilibrium with respect to carbon dioxide, water and oxygen exchange; e.g., space station, Biosphere II. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding the balance of energy and matter exchange in the biosphere and the influence of human activities on this equilibrium; and by predicting atmospheric equilibrium changes and designing models of closed systems in equilibrium, within the context of: • discussing how the dynamic equilibrium of the atmosphere is influenced by human activity <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • examining the influence of changes to atmospheric ozone levels on society, agriculture, plants and animals <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • evaluating, from the past to the present, the evidence for changes in atmospheric composition, with respect to carbon dioxide and its significance to current biosphere equilibrium <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • evaluating the technology of a closed system; e.g., space station, Biosphere II <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

UNIT 2

ENERGY FLOWS AND CELLULAR MATTER

OVERVIEW

Science Themes: *Energy, Matter and Systems*

In Unit 2, students study photosynthesis as the process that obtains *energy* from the environment, and cellular respiration as the process that releases it again to do useful work in cellular *systems*. The associated cyclical fluxes of carbon and other forms of *matter* within the cellular *system*, between cells or between organisms, as *systems*, are outlined in general. It is not the intent of this unit that students learn the molecular details of the Calvin–Benson and Krebs cycles.

This unit builds on prior learning in Science 10, Unit 2: Energy and Matter in Living Systems. It provides an introduction to the exchange of *energy* and *matter* within *ecosystems* as described in Unit 3, and within organisms as described in Unit 4. It also prepares students for an examination of the role of *energy* in supporting the *systems* discussed in Biology 30, Unit 1: Systems Regulating Change in Human Organisms, and Unit 2: Reproduction and Development.

The two **major concepts** developed in this unit are:

- photosynthesis stores *energy* in organic compounds
- respiration releases potential *energy* from organic compounds.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities that demonstrate *energy* and *matter* exchange
- collecting and recording data on photosynthetic and respiratory activity
- connecting, synthesizing and integrating cellular biochemical phenomena.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the ways in which science advances technology and technology advances science
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- appreciate that *energy* and *matter* may flow at very different levels of organization
- appreciate that events at the molecular level support the functioning of living *systems*
- appreciate that biologists can pursue careers involving work at very different levels of biological organization
- appreciate the contributions that the other fields of natural science can make to the biological sciences
- value the maintenance of a healthy environment to prevent the malfunctioning of the basic processes of life.

MAJOR CONCEPT	KNOWLEDGE
<p><i>Students should be able to demonstrate an understanding that:</i></p>	
<p>1. Photosynthesis stores <i>energy</i> in organic compounds.</p>	<ul style="list-style-type: none"> • light energy is stored in plants when photosynthesis uses light energy to synthesize carbohydrates, by extending from Science 10, Unit 2, the structure and function of membranes, and by: • explaining, in general terms, how pigments absorb light, transfer that energy as reducing power in nicotinamide adenine dinucleotide, reduced form (NADH), and to chemical potential in ATP by chemiosmosis, describing where those processes occur • explaining, in general terms, how the products of the light reactions, NADH and ATP, are used to reduce carbon in the Calvin–Benson cycle, describing where the process occurs in the cell.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • using chromatography techniques to demonstrate that plant leaves contain a range of pigments • using experimental data to demonstrate, quantitatively, that plant leaves produce starch in the presence of light • drawing analogies between the storage of energy by photosynthesis and the storage of energy by active solar generating systems. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding how light energy from the Sun is stored in organic compounds by photosynthesis; and by using chromatography technology to demonstrate, quantitatively, energy storage in plants; and by drawing analogies between biological energy storage and active solar storage, within the context of: • analyzing the role of photosynthesis as the biological basis of agriculture and forestry <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • researching and analyzing the effects of herbicides on the biochemistry of photosynthesis <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
2. Respiration releases potential <i>energy</i> from organic compounds.	<p><i>Students should be able to demonstrate an understanding that:</i></p>
	<ul style="list-style-type: none"> cellular respiration involves the release of stored energy from carbohydrates, as well as other organic molecules, by extending from Science 10, Unit 2, growth in living systems, and by: explaining, in general terms, how carbohydrates are oxidized by glycolysis and Krebs cycle to produce reducing power in NADH and flavin adenine dinucleotide, reduced form (FADH), and chemical potential in ATP, describing where in the cell those processes occur; and understanding that specific detailed knowledge of the biochemistry of the reactions is not required explaining, in general terms, how chemiosmosis converts the reducing power of NADH and FADH to the chemical potential of ATP, describing where in the cell the process occurs; and understanding that specific detailed knowledge of the biochemistry of the reactions is not required explaining the role of oxygen in cellular respiration; e.g., aerobic, anaerobic summarizing and explaining the role of ATP in metabolism; e.g., synthesis, movement, active transport explaining how environmental pollutants, like cyanide or hydrogen sulfide, inhibit cellular respiration.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • designing and performing an experiment to demonstrate that a byproduct of respiration in both autotrophs and heterotrophs is heat • demonstrating that respiration causes oxidation and an exchange of gases • using experimental methods to demonstrate, quantitatively, the oxygen consumption of an animal • drawing analogies between the role of ATP in a cell and money in an economic system • investigating the action of metabolic toxins, such as hydrogen sulfide, on cellular respiration. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding that potential energy stored in organic compounds is released by cellular metabolic processes, the role of oxygen and ATP, and environmental influences on these processes; and by demonstrating, experimentally, heterotroph gas exchange; designing and performing metabolic experiments and investigating the action of metabolic toxins, within the context of: <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • discussing how specific compounds released into the environment, by society, may have precise metabolic effects on humans, plants and animals, and the desirability of regulating such releases <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • assessing the impact of research in cellular biochemistry on athletic training strategies <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • researching the technology of methane gas production from organic waste, and assessing the potential impact of this technology on the societies of less developed countries <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

UNIT 3

ENERGY AND MATTER EXCHANGE IN ECOSYSTEMS

OVERVIEW

Science Themes: *Diversity, Energy, Matter and Systems*

In Unit 3, students examine the biotic and abiotic factors that characterize *energy* and *matter* exchange in aquatic and terrestrial *ecosystems*. The unit closes by reviewing the process of organic evolution by natural selection. That process provides a model *system* to explain how the production of *diversity* allows for the selection of organisms better adapted to the roles they play in their *ecosystem*.

This unit builds on Biology 20, Unit 1: The Biosphere, and Unit 2: Energy Flows and Cellular Matter, providing a linkage between the biosphere and cellular phenomena by examining *energy* and *matter* flow in *ecosystems*. The unit provides the general context in which exchange between organisms and their environment are studied, and prepares students for analysis of populations and communities in Biology 30, Unit 4: Change in Populations and Communities.

The three **major concepts** developed in this unit are:

- the biosphere is composed of a *diversity* of biomes, each with distinctive biotic and abiotic factors
- *ecosystems* have characteristic structures determined by their *energy* and *matter* exchange
- populations are basic components of *ecosystem* structure.

In this unit, *students will develop* an ability to use the skills and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning *ecosystem* research activities
- collecting and recording relevant data on the biotic and abiotic *ecosystem* components
- analyzing quantitative data on organism *diversity* and abiotic factors of *ecosystems*

- connecting, synthesizing and integrating the *energy* and *matter* exchange in *ecosystems* and predicting the future outcomes of those *ecosystems*.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- appreciate the *diversity* of *ecosystems*
- value the knowledge that all organisms have an important role in maintaining the life of the planet
- develop an awareness of one's personal role in the preservation of the environment
- develop a sense of responsibility toward use of the environment
- appreciate the multidimensional nature of science, technology and society issues
- appreciate the contributions and limitations of scientific and technological knowledge to societal decision making
- value the necessity of being adaptable to *changes* in the environment
- appreciate the explanatory value of the modern synthesis of the Darwinian theory of evolution to all aspects of biology at all organizational levels, as well as appreciate the limitations of the theory
- respect and tolerate the personal and religious beliefs of others.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. The biosphere is composed of a *diversity* of biomes, each with distinctive biotic and abiotic factors.
 - the biosphere is composed of biomes, each with many different ecosystems, characterized by physiographic, climatic, edaphic (soil) and biotic factors, by extending from Biology 20, Unit 1, energy and matter exchange in the biosphere, and by:
 - describing how energy and matter exchange contribute to the existence of the biosphere's major biomes; e.g., tundra, taiga, deciduous forest, rain forest
 - identifying ecosystem biotic and abiotic factors and explaining their influence in an aquatic and a terrestrial ecosystem in a local region; e.g., stream or lake, prairie, boreal forest, vacant lot, sports field.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- performing a field study and measuring, quantitatively, appropriate abiotic factors, such as temperature, precipitation, snow depth, ice thickness, light intensity, pH, hardness and oxygen content in an aquatic and a terrestrial ecosystem; and presenting the data in a form, such as graphs, tables or charts, that describe, in general terms, the abiotic structure of the ecosystem chosen
- performing a field study and gathering and analyzing both quantitative and qualitative data on the diversity of plant, animal and decomposer species in the ecosystem chosen; and presenting the data in a form that describe, in general terms, the biotic structure of the ecosystem chosen
- hypothesizing the ecological role of biotic and abiotic factors; e.g., albedo effect, competition
- evaluating the dependability of resources, including technologies, used for measurement, assessment or analysis; and identifying the degree of bias in a field study.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that the biosphere is composed of biomes and ecosystems, each distinctly characterized by their energy and matter exchange; and by performing field studies measuring, gathering and analyzing biotic and abiotic data; evaluating resource and technology dependability; hypothesizing the ecological roles of snow and ice; and predicting future outcomes of ecosystems, within the context of:

- evaluating the impact that human activity has had, or could have, on the ecosystems chosen

OR

- analyzing the needs and interests of society that may influence the natural quality of water used for human consumption

OR

- discussing the impact of “slash and burn” or “clear-cutting” practices of societies on the stability and energy flow of the ecosystem involved

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. *Ecosystems* have characteristic structures determined by their *energy* and *matter* exchange.

- the structure of ecosystems can be described, by extending from Biology 20, Unit 2, the relationship between photosynthesis and respiration, and by:
 - explaining, quantitatively, the structure of ecosystem trophic levels, using models, such as food chains and webs
 - explaining, quantitatively, the energy and matter exchange in ecosystems, using models, such as pyramids.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- collecting information and building a model depicting the food web of a chosen ecosystem
- evaluating, quantitatively, the energy and matter exchange in a chosen ecosystem, using a pyramid of mass or numbers
- analyzing data on the diversity of plants, animals and decomposers that make up the biotic component of a specific endangered ecosystem; and predicting the future outcome of that ecosystem.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding how the nature of energy and matter exchange determines ecosystem structure and representing this information in models; and by collecting and analyzing energy and matter exchange information, and building models from this information, within the context of:

- discussing the impact of the draining of wetlands for reclamation and society's responsibility to use natural resources judiciously

OR

- analyzing the interrelationship between the introduction of heavy metals into the environment and matter exchange in natural food chains/webs, and the impact of this on quality of life

OR

- researching the effect single-crop monoculture has on food webs and species diversity in the ecosystem, and the influence of the needs and interests of society on this practice

OR

- assessing the environmental consequences of the introduction of new species to isolated, established ecosystems and the responsibility of society, through science and technology, to protect the environment

OR

- any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
<p>3. Populations are basic components of <i>ecosystem</i> structure.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p>
	<ul style="list-style-type: none"> • there is a great deal of variation within populations, by: <ul style="list-style-type: none"> • describing, in general terms, the nature of variation within populations; e.g., inherited versus acquired, continuous versus discontinuous • explaining how populations are adapted to their environment; e.g., drug resistance, cold tolerance • explaining, in general terms, how a great range of variation exists within individual populations; e.g., blood groups, enzymes • summarizing and describing lines of evidence to support the evolution of modern species from ancestral forms; e.g., hominids, horses • describing natural selection and explaining its action on future populations leading to evolutionary change.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • designing and performing an experiment to measure inherited variation in a plant or animal population • formulating hypotheses about the adaptive significance of the variations in a range of homologous structures in extant (still existing) and extinct organisms • gathering and analyzing data, actual or simulated, on plants or animals to demonstrate how morphology evolves over time; e.g., corn, Darwin's finches, pepper moths. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding that populations are the basic component of ecosystem structure, including range of variation, environmental adaptation and evidence supporting evolutionary change; and by designing and performing experiments to measure variation, hypothesizing adaptive significance of variations; and analyzing morphology changes over time, within the context of: • discussing the nature of science as a way of knowing, compared with other ways of knowing; e.g., origin of life <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • describing how paleontology and the role of evidence in the accumulation of knowledge has provided invaluable data for theories explaining observable variations in organisms over time <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • comparing society's interpretation of variations within populations and change over time with those of Darwin's era; and realizing the inability of science to provide complete answers <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • researching the contributions of Charles Lyell, Thomas Malthus and Alfred Wallace, among others, to Darwin's understanding of species change, the role of evidence in the accumulation of knowledge, and the eventual formation of Darwin's concept of natural selection and origin of species <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

UNIT 4

ENERGY AND MATTER EXCHANGE BY THE HUMAN ORGANISM

OVERVIEW

Science Themes: *Energy, Equilibrium, Matter and Systems*

In Unit 4, students use the human organism as a model *system* to examine the processes that mediate the interactions between organisms and their environment. These processes maintain metabolic *equilibrium*. *Energy* and *matter* are exchanged between humans and their environment during the processes of respiration, digestion and excretion. These processes are carried out with the aid of a circulatory *system* that is also part of a defence *system*. Regulation of the interactions between pathogens and the human organism help maintain metabolic *equilibrium*.

This unit builds on learning from Science 10, Unit 1, Energy from the Sun, and Unit 2: Energy and Matter in Living Systems, and the other three units in this course. It provides a structural and functional context in which control *systems* can be studied in Biology 30, Unit 1: Systems Regulating Change in Human Organisms.

The three **major concepts** developed in this unit are:

- the human organism's digestive and respiratory *systems* exchange *energy* and *matter* with the environment
- the human organism's excretory *system* exchanges *energy* and *matter* with the environment
- the human organism's circulatory *system* transports *energy* and *matter* to maintain *equilibrium* among the body *systems* as well as between the organism and its external environment.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities to investigate the role of selected human organ *systems* in *energy* and *matter* exchange
- collecting and recording relevant biochemical data from a variety of physiological processes
- analyzing data and information from a variety of biochemical and physiological experiments
- connecting, synthesizing and integrating by drawing analogies among villi, alveoli, nephrons and capillaries; and by integrating information from models, simulations and research to demonstrate how *equilibrium* is maintained with respect to *energy* and *matter* exchange.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the ways in which science advances technology and technology advances science
- the use of technology to solve practical problems
- the limitations of scientific knowledge and technology
- the influence of the needs, interests and financial support of society on scientific and technological research.

ATTITUDES

Students will be encouraged to:

- appreciate the importance of the relationship between the human organism and its environment in maintaining homeostasis
- appreciate the hierarchical organization of the human organism
- foster a curiosity about the structure and function of the human organism's *systems*, and their role in maintaining *equilibrium* with the environment
- appreciate how the digestive, respiratory, excretory, transport and defence *systems* are closely linked to cellular respiration
- develop a commitment to learning about the function of organs and *systems* in the human organism and the importance of maintaining personal health
- appreciate the complex and precise nature of the immune *system* and its sensitivity to factors like stress and infection
- appreciate the interactive nature of science and technology in developing products and processes that promote or inhibit the functioning of the human organism's *systems*
- appreciate the ethical dilemmas that may arise as a result of science and technology being used to influence the functioning of the human organism.

MAJOR CONCEPT	KNOWLEDGE
<p>1. The human organism's digestive and respiratory <i>systems</i> exchange <i>energy</i> and <i>matter</i> with the environment.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p> <ul style="list-style-type: none"> • human organisms, like other organisms, must exchange energy and matter by extending from Science 10, Unit 1, systems and Unit 2, concepts of surface area to volume ratio and membrane transport, and by: • describing the intake of matter from the environment, its chemical and physical processing through the digestive system into the blood stream and the return of the remaining material to the environment • explaining how gases and heat are exchanged between the human organism and its environment.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- observing the principal features of the digestive and respiratory systems of a mammal, using models, computer simulations or dissected organisms; and identifying the structures from drawings of those systems; e.g., villi, alveoli
- performing experiments to detect the presence, in food, of organic molecules, such as carbohydrates, lipids and proteins, using qualitative chemical tests
- designing and performing a calorimetry experiment to determine, quantitatively, the potential energy of carbohydrates and fats in foods
- performing an experiment to demonstrate the action of digestive enzymes from plant or animal tissue; e.g., potato, liver
- designing and performing experiments to investigate the influence of enzyme concentration, temperature and pH on the activity of enzymes; e.g., pepsin, pancreatin
- designing and performing experiments to investigate the mechanics of breathing; e.g., lung volume, breathing rate.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that human digestive and respiratory systems exchange energy and matter with the environment; and by observing system structure and function; designing and performing experiments identifying matter exchanged, quantifying energy exchanged, investigating enzyme function and gas exchange mechanisms, within the context of:

- discussing and evaluating the role of food additives to solve the problems of food spoilage; e.g., antioxidants, irradiation technology

OR

- explaining the biological basis of nutritional deficiencies; and evaluating how diet can adversely affect the equilibrium of other body systems; e.g., anorexia nervosa

OR

- assessing the physiological effect of such legal drugs as alcohol and nicotine on digestive and respiratory functions

OR

- evaluating the ethical implications of organ transplants in terms of the needs, interests and financial support of society on scientific and technological research in this field; e.g., societal and scientific definitions of death

OR

- any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
2. The human organism's excretory system exchanges <i>energy</i> and <i>matter</i> with the environment.	<i>Students should be able to demonstrate an understanding that:</i>
	<ul style="list-style-type: none"> human organisms, like other organisms, must maintain an equilibrium with respect to their internal environment, by:
	<ul style="list-style-type: none"> explaining the role of the kidney in excreting metabolic wastes from the body and expelling them into the environment explaining how the excretory system maintains internal equilibrium with respect to water, pH and ions.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> performing an experiment to investigate simulated urine composition, analyzing the data and summarizing the role of the kidney in homeostatic regulation of water, pH and ionic substances researching the human excretory system and designing a flow chart model to describe how the human organism maintains homeostasis with respect to water and ions in a situation where either the water intake was high; e.g., tea, coffee, soda pop, or where the sodium ion intake was excessive; e.g., anchovy pizza, cheese making analogies between kidney function and renal and peritoneal dialysis. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> understanding the role of the human excretory system in excretion of wastes and balance of water and ions; and by performing simulated urine composition experiments, analyzing data to summarize the role of the kidney; and researching the human excretory function for the purpose of designing models of kidney function, within the context of: identifying specific pathologies of the digestive, excretory, respiratory and circulatory systems, and the technology used to ease or cure the problems <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> examining the relationships that exist among lifestyles, hypertension and kidney function <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. The human organism's circulatory system transports *energy* and *matter* to maintain *equilibrium* among the body *systems* as well as between the organism and its external environment.
- human organisms must maintain an internal equilibrium with respect to organs and organ systems, as well as equilibrium with their external environment, by:
 - explaining the role of the circulatory system in aiding the digestive, excretory and respiratory systems' exchange of energy and matter with the environment
 - explaining the role of the body surface in maintenance of organism equilibrium; e.g., temperature regulation, protection from pathogens
 - describing the main components of blood and their role in transport, and their role in resisting the influence of pathogens; e.g., erythrocytes, leucocytes, platelets, plasma
 - listing main cellular and noncellular components of the human immune system and describing their role; e.g., macrophage, helper T cell, B cell, killer T cell, suppressor T cell, memory T cell.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- observing the principal features of the circulatory and excretory systems of a mammal, using models, computer simulations or dissected organisms; and identifying the structures from drawings of those systems
- summarizing, from models, computer simulations or a dissected organ, the structures and direction of blood flow through a mammalian heart
- using a microscope to observe blood flow in the capillaries of a living organism; e.g., goldfish
- performing experiments that measure venous pressure in humans
- measuring and interpreting their own blood pressure; and investigating the role of exercise in influencing blood pressure
- using a microscope to examine prepared slides of human blood to observe the morphology and relative abundance of the cellular components of the blood
- researching and designing a simulation or model of the functioning of the main components of the human immune system.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that the human circulatory system maintains an equilibrium among systems and with the external environment, exchanging thermal energy, and providing pathogen protection through the immune system and its cellular components; and by observing circulatory and excretory system morphology and capillary flow, measuring system pressure; and researching and designing immune system models, within the context of:

- researching experimental evidence on disruptions to human circulatory equilibrium caused by severe burns

OR

- analyzing how technological advances assist the circulatory system in the delivery of prescription drugs to their sites of action

OR

- describing how biotechnology can assist in the maintenance of internal equilibrium with respect to pathogens

OR

- evaluating the needs, interest and financial support society has on preventing the spread of disease-causing organisms, like *Staphylococcus*, smallpox virus and the human immunodeficiency virus (HIV)

OR

- any other relevant context.

BIOLOGY 30

UNIT 1 SYSTEMS REGULATING CHANGE IN HUMAN ORGANISMS

OVERVIEW

Science Themes: *Equilibrium and Systems*

Unit 1 uses the human organism as a model *system* to study that *equilibrium* between an organism's internal environment and its external environment can be maintained by metabolic or behavioural means. Endocrine glands and other *systems* maintain physiological *equilibrium* mediated by hormones. A study of the interaction between the neural and endocrine *systems* leads to an examination of the functioning of the central and peripheral nervous *systems* and their ability to sense the environment and respond to it. That ability is important in maintaining organism *equilibrium*.

This unit builds on Science 10, Unit 1: Energy from the Sun, Unit 2: Energy and Matter in Living Systems; and Biology 20, Unit 4: Energy and Matter Exchange by the Human Organism, by examining the biological processes that mediate the interactions between organisms and their environment to maintain a desirable *equilibrium*. This unit leads to further study of control *systems* in Unit 2, and to post-secondary studies.

The two **major concepts** developed in this unit are:

- the human organism regulates physiological processes, using electrochemical control *systems*
- the human organism maintains homeostasis through the use of complex chemical control *systems*.

In this unit, *students will develop* an ability to use the skills and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities demonstrating the human response to a variety of environmental stimuli to maintain its *equilibrium*
- collecting and recording neural and hormonal data from observations and published research

- analyzing physiological data
- connecting, synthesizing and integrating data from activities that predict the role of control *systems* in the maintenance of organism *equilibrium*
- evaluating the processes or outcomes of neural and hormonal research and identifying their limitations.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the ways in which science advances technology and technology advances science
- the use of technology to solve practical problems
- the limitations of scientific knowledge and technology
- the influence of the needs, interests and financial support of society on scientific and technological research.

ATTITUDES

Students will be encouraged to:

- foster curiosity about the structure and function of the human organism's endocrine and neural control *systems* and their role in maintaining homeostasis
- appreciate the complexity and precise nature of the neural and endocrine *systems* and the importance of their integrating functions in maintaining *equilibrium*
- develop a commitment to learning about the functioning of the neural and endocrine *systems* and the importance of maintaining personal health
- appreciate the interactive nature of science and technology in developing products and processes that promote or inhibit the functioning of the human organism's *systems*
- appreciate the ethical dilemmas that may arise as a result of science and technology being used to influence the functioning of the human organism.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. The human organism regulates physiological processes, using electrochemical control *systems*.

- the human organism, like other organisms, maintains control over its internal environment with neural systems, by extending from Science 10, Unit 1, energy systems, Science 10, Unit 2, cell processes and Biology 20, Unit 4, the biological systems that maintain the organism's equilibrium with the environment, and by:
 - describing the structure and function of a neuron and myelin sheath, explaining the formation and transmission of an action potential and the transmission of a signal across a synapse or neuromuscular junction and the main chemicals and transmitters involved; i.e., norepinephrine, acetylcholine and the enzyme that breaks them down
 - describing the composition and function of a simple reflex arc and the organization of neurons into nerves
 - identifying the principal structures of the central and peripheral nervous systems and explaining their functions in regulating the voluntary (somatic) and involuntary (autonomic) systems of the human organism; e.g., cerebral hemispheres, cerebellum, pons, medulla, hypothalamus, pituitary, spinal cord, sympathetic and parasympathetic nervous systems
 - explaining how human organisms sense their environment and their spatial orientation in it; e.g., auditory, visual, skin receptors, olfactory, proprioceptors.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- observing neurons and neuromuscular junctions on prepared microscope slides
- designing and performing experiments to investigate the physiology of reflex arcs
- observing the principal features of the mammalian brain, using models, computer simulations or dissected mammalian brains; and identifying the major visible structures from drawings or models of that organ
- observing the principal features of the mammalian eye and ear, using models, computer simulations or dissected mammalian eyes; and identifying the major visible structures from drawings or models of those organs
- designing and performing experiments to investigate heat, cold, pressure and touch receptors, and the ability to sense environment
- performing experiments to measure the ability to discriminate objects visually and to hear a range of sounds.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding how human physiological processes are regulated by electrochemical control systems, describing the structure and function of neurons, the central and peripheral nervous systems, and sensory input transducers; and/or by observing the principal features of a neuron, mammalian brain and eye; and designing and performing experiments to investigate reflex arcs and sensory input, within the context of:

- analyzing experimental evidence for the influence of anesthetics, drugs and chemicals, natural and synthetic, on the functioning of the nervous system, and their relationship to addiction theories

OR

- discussing the biological basis of neurological diseases, like Alzheimer's or Parkinson's

OR

- discussing how advances in science and technology have increased access to the world beyond normal sensory limits

OR

- evaluating the application of biological knowledge in developing offensive and defensive military capabilities

OR

- discussing and evaluating the effect of science and technology on longevity and quality of life

OR

- evaluating the impact of photoperiod, light wavelength and duration on the human organism

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. The human organism maintains homeostasis through the use of complex chemical control systems.

- endocrine systems coordinate other organ systems through feedback to maintain internal homeostasis as well as the organism's equilibrium with the environment, by extending from Biology 20, Unit 4, the maintenance of metabolic equilibrium, and by:
 - identifying the principal endocrine glands of the human organism; e.g., the hypothalamus/pituitary complex, thyroid and adrenal glands, pancreas islet cells
 - describing the hormones of the principal endocrine glands; i.e., TSH/thyroxine, ACTH/cortisol glucagon/insulin, HGH, ADH, epinephrine, norepinephrine, aldosterone
 - explaining the metabolic roles hormones play in homeostasis; i.e., thyroxine to metabolism, insulin to blood sugar regulation, HGH to growth, ADH to water regulation
 - explaining how the endocrine system allows human organisms to sense their internal environment and respond appropriately; e.g., sugar metabolism
 - comparing the endocrine and neural control systems and explaining how they act together; e.g., stress and the adrenal gland
 - describing, using an example, the physiological consequences of hormone imbalances.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- inferring the role of insulin in the regulation of blood sugar, by performing an experiment to investigate the presence of reducing sugars in simulated urine; and comparing the results with urinalysis data; and/or investigating the role of insulin in the regulation of blood sugar, using a computer simulation
- inferring the role of ADH and aldosterone in the maintenance of homeostasis of water and ions, by the analysis and interpretation of data on blood and urine composition
- formulating hypotheses from published data on an environmental factor that can be detected and responded to by the human organism; e.g., ultraviolet light and pigment deposition, diet and thyroid function
- researching, identifying and summarizing the main hormonal and nervous components in stress management; i.e., “general adaptation syndrome.”

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that homeostasis of organs and organ systems is regulated, in part, by chemical control systems; and describing the main components and hormones of the human endocrine system, their metabolic role, and their interaction with the nervous system; and by inferring and interpreting from data, the role of insulin, ADH and aldosterone; and evaluating the components of the “general adaptation syndrome”, within the context of:

- evaluating the use of biotechnology to solve practical hormone problems; e.g., hormone synthesis for diabetes, dwarfism, milk yields in cows

OR

- comparing the function of technological control systems with electrochemical control systems in organisms; e.g., computer control systems for car emissions

OR

- assessing the impact on athletics of research into biochemical control systems

OR

- explaining the relationship among ultraviolet light, ozone depletion and pigment deposition within skin cells

OR

- discussing the use of hormone therapy in the treatment of humans; e.g., growth hormone and aging, steroids and sports

OR

- any other relevant context.

UNIT 2 REPRODUCTION AND DEVELOPMENT

OVERVIEW

Science Themes: *Change* and *Systems*

Unit 2 studies the concept that species must reproduce themselves to ensure their survival. The processes associated with reproduction and development are reviewed here to illustrate their physiological regulation by using the human organism as a model *system*. *Change* can be induced in the reproductive and other *systems* of organisms by hormones from a variety of glands. *Change* also occurs as gametes are produced, fuse to form zygotes and undergo development. The regulation of these processes by hormonal *systems* is examined. The *systems* associated with parturition and lactation are regulated hormonally.

This unit builds upon Biology 20, Unit 4: Energy and Matter Exchange by the Human Organism; on the learning of biological control *systems* from Unit 1; and leads to a more detailed study of gametogenesis and genetics in Unit 3, and to post-secondary studies.

The three **major concepts** developed in this unit are:

- humans and other organisms have complex reproductive *systems* that ensure the survival of the species
- reproductive success of organisms is regulated by chemical control *systems*
- cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental influences.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning
- collecting and recording reproductive data
- analyzing research information on hormonal data and physiological events

- connecting, synthesizing and integrating, from research information, the influence of internal and environmental factors on life span development
- evaluating the processes or outcomes of knowledge about research in human reproduction and the consequences or limitations of this research.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the ways in which science advances technology and technology advances science
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- appreciate that there are biological and societal aspects to the study of reproduction
- appreciate the association among health, reproduction and development
- appreciate the ethical dilemmas that may arise from the application of scientific research and/or technological developments to reproductive and developmental processes
- appreciate the multidimensional nature of science, technology and society issues
- respect and tolerate the personal and religious beliefs of others.

MAJOR CONCEPT	KNOWLEDGE
<p>1. Humans and other organisms have complex reproductive <i>systems</i> that ensure the survival of the species.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p> <ul style="list-style-type: none"> • human organisms have evolved a specialized series of ducts and tubes to facilitate the union of an egg and sperm, by: <ul style="list-style-type: none"> • describing hormonal and chromosomal factors and explaining the physiological events resulting in the formation of the primary (gonads) and secondary (associated structures) reproductive organs in the female and male fetus • identifying the structures and describing their functions in female (e.g., ovaries, fallopian tubes, uterus, cervix, vagina) and male (e.g., testes, epididymus, vas deferens, seminal vesicles, prostate gland, penis) reproductive systems • explaining how sexually transmitted diseases can interfere with the passage of eggs and sperm; e.g., chlamydia, gonorrhea.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- observing the principal features of the human reproductive system, using models or computer simulations; and identifying the major structures from drawings of that organ system
- distinguishing eggs and sperm from their supporting structures, using prepared slides of ovaries and testes; e.g., interstitial cells, follicle, corpus luteum, seminiferous tubules.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding the development of human reproductive organs; and describing the anatomical structures that facilitate gamete union and species survival; and explaining the role of sexually transmitted diseases in this process; and by observing the principal features of human reproductive systems; and identifying eggs, sperm and supporting structures from slides, within the context of:

- evaluating the implications of reproductive technology for human biology

OR

- discussing society's expectations of the scientific community with respect to reproductive technology

OR

- identifying the types of physiological and physical damage caused by exposure to sexually transmitted disease organisms in females and males

OR

- any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
<p>2. Reproductive success of organisms is regulated by chemical control systems.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p> <ul style="list-style-type: none"> • the development of sexual anatomy and sexual functioning is influenced by hormones, by: <ul style="list-style-type: none"> • describing the role of hormones in the regulation of primary and secondary sex characteristics in females and males • identifying the principal reproductive hormones in the female and explaining their interactions in the maintenance and functioning of the female reproductive system; e.g., estrogen, progesterone, LH, FSH, prolactin, oxytocin • identifying the principal reproductive hormones in the male and explaining their interactions in the maintenance and functioning of the male reproductive system; e.g., testosterone, luteinizing hormone (LH), follicle stimulating hormone (FSH) • comparing the cyclical patterns of reproduction in humans with that of nonprimate mammals.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • analyzing blood hormone data and physiological events of a single menstrual cycle, and inferring the roles of the female sex hormones • analyzing blood hormone data and physiological events, and inferring the roles of the male sex hormones. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding that human reproductive success, development of secondary sexual characteristics, formation of gametes and reproductive system maintenance are regulated by hormones; and by analyzing and inferring from data and physiological events the roles of sex hormones, within the context of: • researching and assessing the effects of the medical use of reproductive hormones on humans <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • explaining how reproductive hormone homeostasis is disrupted by the natural aging process <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • researching and assessing the value of producing and using reproductive hormones in domestic animals, such as cattle and horses <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. Cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental influences.
- events following conception are governed by a combination of genetic, endocrine and environmental influences, by extending from Biology 20, Unit 4, the human organism as a system, and by:
 - tracing the processes of fertilization, implantation, extraembryonic membrane formation (e.g., amnion, chorion, yolk sac, placenta), embryo development, parturition and lactation, and the control mechanisms of those events; e.g., progesterone, LH, chorionic gonadotropin, oxytocin, prolactin
 - describing fetal development from implantation to full term in the context of the main physiological events that occur in the development of organ systems during each major stage (trimester) and the influence of environmental factors on the development of these systems; e.g., alcohol, drugs, pathogens
 - describing the physiological or mechanical basis of different reproductive technology methods; e.g., conception control, in vitro fertilization, infertility reversal.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> • observing the stages of embryo development, using preserved material, such as chicken embryos, prepared slides, models or computer simulations; and extrapolating these events to the development of a human fetus • investigating the effects of environmental factors, such as alcohol and nonprescription drugs, on the development of the human fetus • evaluating, from published data, the effectiveness and safety of the various reproductive technology methods • interpreting hormonal data from published investigations; e.g., pregnancy testing. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> • understanding how development from conception is regulated by genetics, hormones and environment; and describing these developmental events and the technologies that influence them; and by observing slides, models or computer simulations of nonhuman embryo development, investigating environmental influences on the embryo/fetus and assessing safety reproductive technology, within the context of: • analyzing the use of technology to solve problems of incompatibility between fetus and mother, and possible solutions to such problems <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • assessing the societal impact of reproductive imaging technologies; e.g., ultrasound, magnetic resonance image ray (MRI), X-rays <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • discussing how knowledge of embryo/fetus development has influenced society's values on human life <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • discussing the societal impact of chemicals and drugs on fetal development; e.g., alcohol and cocaine <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • assessing the effects of hormonal conception control technology on population demographics in developed and underdeveloped countries <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • any other relevant context.

UNIT 3 CELLS, CHROMOSOMES AND DNA

OVERVIEW

Science Themes: *Change and Diversity*

In Unit 3, students examine the cell and molecular biology of mitosis as well as its limitations in providing *diversity*. The significance of meiosis as a way by which organisms can introduce *diversity* into their descendants is introduced. The timing and location of meiosis in the reproductive biology of the human organism is discussed. The studies of classical genetics are reviewed to show how phenotypes may *change* through generations. Classical genetics is extended to a molecular level where the role of DNA in producing RNA, then proteins, is reviewed. The principles of introducing *change* into the sequence of bases in DNA is examined.

This unit builds on Science 10, Unit 2: Energy and Matter in Living Systems, where simple cell division was introduced and Biology 30, Unit 2: Reproduction and Development, where spermatogenesis and oogenesis were introduced. This unit leads to a study of population genetics in Unit 4, and to post-secondary study.

The three **major concepts** developed in this unit are:

- cells divide to increase in number but must reduce their chromosome number before combining at fertilization
- genetic characters are handed down by simple rules
- classical genetics can be explained at a molecular level.

In this unit, *students will develop* an ability to use the **skills and thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities that demonstrate genetic inheritance patterns and environments
- collecting and recording empirical data on single gene inheritance, cell division and information from computer simulations and models
- analyzing published and collected genetic information for trends, patterns and relationships

- connecting, synthesizing and integrating various types of genetic and cellular information.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the ways in which science advances technology and technology advances science
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- be open-minded toward new evidence, and be aware of the *changes* it may promote
- appreciate that extension of learning requires new knowledge, skills, attitudes and risk taking
- value the development of information, science and technology, while continuing to cultivate human values
- appreciate the usefulness of computational competence and the problem-solving skills required by classical genetics
- develop a positive attitude toward mathematical and scientific process skills
- appreciate the ethical dilemmas that may arise from the application of scientific research and/or technological developments as they relate to the field of genetics
- appreciate, and be critical about, current research and theories concerning genetic information.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

1. Cells divide to increase in number but must reduce their chromosome number before combining at fertilization.
 - chromosomes are duplicated before cells divide; that daughter cells get one complete set of chromosomes; that chromosome number must be reduced before fertilization; and that variations in the combination of genes on a chromosome can occur during that reduction, by recalling from Science 10, Unit 2, that growth may involve increasing cell number, and by:
 - explaining, in general, the events of the cell cycle, including cytokinesis, and chromosomal behaviour in mitosis and meiosis
 - describing the processes of spermatogenesis and oogenesis and the necessity for chromosomal number reduction in meiosis
 - describing the processes of nondisjunction and crossing over; and evaluating their significance on organism development
 - comparing the processes of mitosis and meiosis
 - comparing the formation of fraternal and identical offspring in a single birthing event
 - describing the diversity of reproductive strategies by comparing the alternation of generations in a range of plants and animals; i.e., pine, bee, mammal.

SKILLS	STS CONNECTIONS
<p><i>Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:</i></p> <ul style="list-style-type: none"> identifying the stages of the cell cycle; and calculating the duration of each stage from observations of prepared slides of onion root tip cells preparing microscope slides to demonstrate some stages of mitosis and meiosis performing a simulation to demonstrate the behaviour of chromosomes during meiosis researching a range of reproductive strategies in seed plants and animals; and presenting this information in the form of charts, tables or diagrams; e.g., budding, spore production, binary fission preparing and interpreting models of human karyotypes. 	<p><i>Students should be able to demonstrate the interrelationships among science, technology and society, by:</i></p> <ul style="list-style-type: none"> understanding that mitosis results in cell division and genetic continuity, and meiosis results in gamete formation and genetic variation; and by observing actively dividing cells, performing meiosis simulations and researching reproductive strategies in plants and animals, within the context of: <p>OR</p> <ul style="list-style-type: none"> discussing the role of mitosis and biotechnology in regenerating damaged or missing parts of organisms <p>OR</p> <ul style="list-style-type: none"> evaluating how a knowledge of cell division might be applied to the limitation of cancerous growth in plants or animals <p>OR</p> <ul style="list-style-type: none"> discussing the types and sources of various teratogenic compounds found in the environment and the responsibility of society, through science and technology, to ensure quality of life for future generations <p>OR</p> <ul style="list-style-type: none"> evaluating the impact of research in plant and animal reproduction on our understanding of mitosis and meiosis in humans <p>OR</p> <ul style="list-style-type: none"> any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
2. Genetic characters are handed down by simple rules.	<p data-bbox="659 255 1397 316"><i>Students should be able to demonstrate an understanding that:</i></p> <ul data-bbox="659 384 1397 989" style="list-style-type: none"> <li data-bbox="659 384 1397 541">• chromosomes consist of a sequence of genes and their alleles, and that during meiosis and fertilization these genes become combined in new sequences, by extending from Biology 30, Unit 2, fertilization and development in the human organism, and by: <li data-bbox="701 670 1397 766">• describing the evidence for the segregation of genes and the independent assortment of genes on different chromosomes, as investigated by Mendel <li data-bbox="701 799 1397 895">• explaining the influence of crossing over on the assortment of genes on the same chromosome; e.g., gene linkage <li data-bbox="701 927 1397 989">• explaining the significance of sex chromosomes compared to autosomes, as investigated by Morgan.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- performing experiments to investigate the relationships between chance and genetic inheritance
- performing simulations to investigate monohybrid and dihybrid genetic crosses, by using Punnett squares
- designing a procedure and collecting data in peer groups or families to demonstrate the presence of single and multiple alleles in human inheritance
- drawing and interpreting pedigree charts from data on human single allele and multiple allele inheritance patterns; e.g., blood types
- predicting, quantitatively, the probability of inheritance from monohybrid, dihybrid and sex-linked inheritance data
- designing and performing an experiment to demonstrate the inheritance pattern of a trait controlled by a single pair of genes.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding how genetic characters are handed down by simple rules; and describing evidence for gene segregation and explaining the significance of crossing over and sex chromosomes; and by drawing and interpreting pedigree charts; and performing simulations or experiments to predict inheritance patterns, within the context of:

- evaluating, from a variety of perspectives, the needs and interests of society and the role of genetic counselling in the identification and treatment of potentially disabling genetic disorders; e.g., phenylketonuria

OR

- discussing the role of gene banks used to preserve endangered species and genotypes, particularly of plants and animals used in agriculture; and the responsibility of society to protect the environment for future generations

OR

- discussing biotechnology and gene replacement therapy in the treatment of human genetic disorders

OR

- any other relevant context.

MAJOR CONCEPT	KNOWLEDGE
<p>3. Classical genetics can be explained at a molecular level.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p>
	<ul style="list-style-type: none"> • genetic information in chromosomes is translated into protein structure; that the information may be manipulated; and that the manipulated information may be used to transform cells, by: <ul style="list-style-type: none"> • summarizing the historical events that led to the discovery of the structure of the DNA molecule, as described by Watson and Crick • describing, in general, how genetic information is contained in the sequence of bases in DNA molecules in chromosomes; how the DNA molecules replicate themselves; how the information is transcribed into sequences of bases in RNA molecules and is finally translated into sequences of amino acids in proteins • explaining, in general, how restriction enzymes and ligases may cut DNA molecules into smaller fragments and reassemble them with new sequences of bases • explaining, in general, how cells may be transformed by inserting new DNA sequences into their genomes • explaining how a random change (mutation) in the sequence of bases provides a source of genetic variability • explaining how information in nucleic acids contained in the nucleus, mitochondria and chloroplasts gives evidence for the relationships among organisms of different species.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- predicting the general arrangement of genes in a chromosome, from analysis of data on crossing over between genes in a single pair of chromosomes
- designing and constructing models of DNA to demonstrate the general structure and base arrangement
- performing simulations to demonstrate the replication of DNA and the transcription and translation of its information
- designing and performing an experiment to demonstrate how an environmental factor can cause a change in the expression of genetic information of an organism
- performing simulations to demonstrate the use of restriction enzymes and ligases in creating new DNA sequences; e.g., electrophoresis
- analyzing and inferring, from published data, the relationship between human activities and changes in genetic information, that lead to inheritable mutations and cancer.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding how DNA structure and function can explain classical genetics; and explaining DNA manipulation, mutations and DNA evidence for organism relationships; and by predicting gene sequences; designing and constructing DNA models; performing experiments to demonstrate DNA expression; and analyzing and inferring the relationship between human activities and mutations, within the context of:

- evaluating the use of genetically engineered organisms in agriculture and forestry; and bioremediation in the natural environment

OR

- debating the societal and scientific definitions of life and the living condition

OR

- discussing the Human Genome Project in terms of the needs, interests and financial support of society

OR

- discussing the implications to society of corporations being able to patent new life forms produced by biotechnology

OR

- assessing the impact of DNA mapping technology on the study of genetic relationships and variations in population ecology

OR

- any other relevant context.

UNIT 4

CHANGE IN POPULATIONS AND COMMUNITIES

OVERVIEW

Science Themes: *Change, Equilibrium and Systems*

Unit 4 introduces students to genetic principles that may be used to analyze population *systems*, and an example is drawn with the Hardy–Weinberg *equilibrium*. The reasons for populations not being in *equilibrium* are reviewed. Population growth and growth strategies are discussed. The interactions of organisms in human or natural *systems*, and the consequences of such interactions for populations and communities in those *systems*, are investigated. Populations of different organisms exist in communities that may *change* over time as a result of natural or artificial events. A review of such successional events completes the unit.

This unit builds on the learning from Biology 20, Unit 3: Energy and Matter Exchange in Ecosystems. This unit, the course and the program, may lead to careers or post-secondary study in the biological sciences.

The three **major concepts** developed in this unit are:

- communities are made up of populations that consist of pools of genes from the individuals of a species
- individuals of populations interact with each other and members of other populations
- population *change* over time can be expressed in quantitative terms.

In this unit, *students will develop* an ability to use the **skills** and **thinking processes** associated with the practice of science, emphasizing:

- initiating and planning activities to demonstrate population growth and *change* over time
- collecting and recording empirical data on population and community *change*

- analyzing published data, collected data and information from computer simulations and models
- connecting, synthesizing and integrating *ecosystem* information from a variety of sources to interpret and explain community *change* and *equilibrium*.

The **STS connections** in this unit illustrate:

- the central role of evidence in the accumulation of knowledge, and the ways proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility of society, through science and technology, to protect the environment and use natural resources judiciously to ensure quality of life for future generations.

ATTITUDES

Students will be encouraged to:

- be open-minded toward new evidence and be aware of the *changes* it may promote
- appreciate the usefulness of computational competence and problem-solving skills required by population genetics
- develop a positive attitude toward mathematical and scientific process skills
- appreciate the *diversity* in populations and communities
- appreciate that *change* occurs in populations and communities over very long and short time scales

- value the knowledge that all organisms have an important role in maintaining the life of the planet
- develop optimism about the human ability to learn to function within the limits of sustainable development
- develop an attitude of participation in planning and shaping the future
- appreciate the contributions and limitations of scientific and technological knowledge to societal decision making.

MAJOR CONCEPT	KNOWLEDGE
<p>1. Communities are made up of populations that consist of pools of genes from the individuals of a species.</p>	<p><i>Students should be able to demonstrate an understanding that:</i></p>
	<ul style="list-style-type: none"> • populations can be defined in terms of their gene pools, by extending from Biology 20, Unit 3, the nature of variation and adaptation in populations, and by: • describing the Hardy–Weinberg principle and explaining its importance to population gene pool stability and the significance of nonequilibrium values; e.g., evolution of a population • describing the conditions that cause the gene pool diversity to change; e.g., random genetic drift, gene migration, differential reproduction • applying, quantitatively, the Hardy–Weinberg principle to observed and published data • describing the molecular basis and significance of gene pool change over time; i.e., mutations.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- calculating and interpreting problem-solving exercises involving the Hardy–Weinberg principle expressed as $p^2 + 2pq + q^2 = 1$
- performing experiments and/or computer simulations to demonstrate population growth and gene pool change.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that communities consist of population-specific gene pools; and explaining the significance of the Hardy–Weinberg principle and the molecular basis of gene pool change over time; and by applying and interpreting the Hardy–Weinberg principle, and performing experiments to demonstrate population growth, within the context of:

- discussing the implications of the introduction of exotic species into an ecosystem where natural predators do not exist, and methods to deal with situations arising therefrom

OR

- debating the role of ecological reserves in preserving our natural heritage

OR

- assessing the role and importance of models in science to explain observable phenomena; e.g., the Hardy–Weinberg principle

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

2. Individuals of populations interact with each other and members of other populations.

- interactions occur among members of the same population of a species as well as among members of populations of different species, by:

- describing the basis of symbiotic relationships, i.e., commensalism, mutualism, parasitism, and interspecific and intraspecific competition and their influences on population changes
- describing the relationships between predator and prey species and their influence on population changes; and explaining the role of defence mechanisms in predation; e.g., mimicry, protective colouration
- explaining how mixtures of populations that define communities may change over time or remain as a climax community; e.g., primary succession, secondary succession.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- summarizing and evaluating the symbiotic relationship between a parasite and its host
- designing and performing an experiment to demonstrate interspecific and/or intraspecific competition
- performing simulations to investigate the relationships between predators and their prey
- designing and performing an experiment to demonstrate succession in a micro-environment, and recording its pattern of succession over time.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that individuals interact with each other and other populations, and that communities and their populations change over time; and by summarizing and evaluating relationships; and by performing predatory-prey simulations; and designing and performing experiments demonstrating biotic interactions, within the context of:

- discussing the implications of the predator-prey relationship for wildlife management in national and provincial parks

OR

- investigating the long-term implications of ecosystem fire control and prevention on population and ecosystem stability and diversity

OR

- analyzing the relationship between parasites and human developmental potential in less developed countries

OR

- any other relevant context.

MAJOR CONCEPT

KNOWLEDGE

Students should be able to demonstrate an understanding that:

3. Population *change* over time can be expressed in quantitative terms.

- populations grow in characteristic ways, and that the changes in population growth can be quantified, by extending from Biology 20, Unit 3, variations within populations, and by:
- describing and explaining, quantitatively, factors that influence population growth; i.e., mortality, natality, immigration, emigration
- describing the growth of populations in terms of the mathematical relationship among carrying capacity, biotic potential and the number of individuals in the population
- explaining, quantitatively, the behaviour of populations, using different growth patterns; i.e., r- and K-strategies, J and S curves
- describing the implications of the chaos theory for the study of biological systems, especially as they relate to population growth patterns.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science, by:

- graphing and interpreting population growth data on a variety of organisms
- designing and performing an experiment to demonstrate the affect of environmental factors on population growth
- researching the chaos theory, and hypothesizing its application to biological systems.

STS CONNECTIONS

Students should be able to demonstrate the interrelationships among science, technology and society, by:

- understanding that populations have characteristic growth patterns, and these changes can be expressed quantitatively; and by graphing and interpreting population growth data; designing and performing experiments demonstrating environmental influence; and researching the chaos theory, within the context of:

- analyzing the growth of human populations and comparing them with the naturally occurring populations of other species

OR

- evaluating the implications for natural systems inherent in the chaos theory

OR

- developing appropriate investigative strategies for dealing further with biological problems; e.g., risk/benefit analysis, cost/benefit analysis

OR

- any other relevant context.

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