Biology 20 ▮ 30
Program of Studies

Biology 20	is approved with interim status for the 1993–1994 school year.
Biology 30	is in field validation for the 1993–1994 school year.

Curriculum Branch

Alberta
EDUCATION

BIOLOGY 20–30

A. PROGRAM RATIONALE AND PHILOSOPHY

Biology is the study of life and living systems from the molecular level to the biosphere. Through the study of biology, the 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. Meaningful 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 biology 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, problem-solving activities 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 of the discipline 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; teachers act as collaborators or guides. 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 approximatley 125 hours, teachers are encouraged to modify the amount of instructional time to meet the individual needs of students. Some students will require more than 125 hours, while others will require less.

GOALS

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

- to develop in students an understanding of the big 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 attitudes, knowledge and skills 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 attitudes, knowledge and skills 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.

B. GENERAL LEARNER EXPECTATIONS

The general learner expectations outline the many facets of scientific awareness and serve as the foundation for specific learner expectations. The general learner expectations are developed through the study of individual units in Biology 20–30 and, though listed sequentially, are not meant to be developed sequentially or separately.

ATTITUDES

Students will be encouraged to develop:

- an enthusiasm for, and a continuing interest in, science
- the effective 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 skills involving mathematics, problem solving and process skills
- open-mindedness and respect for the points of view of others
- a sensitivity to the living and non-living environment
- an appreciation for 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 non-living 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. These processes involve many skills that are to be developed within the context of the program content.

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 appears to be non-linear and recursive. Students should be able to access skills and strategies flexibly; select and use a skill, process or technology that is appropriate to the task, and monitor, modify or replace it with a more effective strategy.

- 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
- Collecting and Recording
  - carry out the procedure and modify, if necessary
  - organize and correctly use apparatus and materials to collect reliable experimental data
  - accurately observe, gather and record data or information 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 more effectively, using mathematical and statistical calculations, where necessary
  - express measured and calculated quantities to the appropriate number of significant digits, using SI units 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
  - formulate further testable hypotheses supported by the knowledge and understanding generated
  - identify further problems or issues to be investigated
  - identify alternatives 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 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
- suggest alternatives and consider improvements to experimental technique and design
- evaluate and assess ideas, information and alternatives

Further Reading

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

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 interrelationship of science, technology and society, including:

- the central role of experimental evidence in the accumulation of knowledge, and the way in which 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 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 further reading on integrating science, technology and society into the classroom, refer to the Alberta Education publication: *STS Science Education: Unifying the Goals of Science Education* (1990).

C. SPECIFIC LEARNER EXPECTATIONS

LEARNING CYCLE

The specific learner expectations consist of the attitudes, knowledge and skills 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 hypothesis, 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 teachers to evaluate student progress toward achieving the educational objectives.

In biology, students examine phenomena in a variety of topics to show the relationships among 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, systems,* and as they relate to biology. These themes provide a means of showing the connections between the units of study in both courses of the program, and provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of the 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 concepts developed in this course are *energy, equilibrium, matter* and *systems*. *Change* and *diversity* are subordinate themes that are also addressed. 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: Cellular Matter and Energy Flows
Unit 3: Matter and Energy Exchange in Ecosystems
Unit 4: Matter and Energy Exchange by the Human Organism.

Unit 1 focuses on the dynamic *equilibria* that exist for *matter* and *energy* 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 characteristics of some of the *ecosystems* that go to make up the biosphere, and the interactions of the organisms mediating the flow of *matter* and *energy* 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 *matter* and *energy* exchanges with the environment is examined in Unit 4, along with its biotic interactions with pathogenic organisms.

BIOLOGY 30

The major science themes developed in this course are *change, diversity, equilibrium* and *systems*. *Matter* and *energy* are subordinate themes that are also addressed. 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.

Unit 1 focuses on chemical and electrical *systems* that regulate *change* to maintain *equilibria*, 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 *diversity* and *change* run through Unit 3 as the mechanisms for passing on genetic information and causing variation, and are examined at a range of organizational levels. Finally, Unit 4 looks at *change* as illustrated by the genetics of populations, and at the community *systems* in which populations exist.

BIOLOGY 20

UNIT 1
THE BIOSPHERE

OVERVIEW

Science Themes: *Energy, Matter, Equilibrium* 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: Matter and Energy 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 a *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 *matter* and *energy* 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 experimental evidence in the accumulation of knowledge, and the way in which 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 the human 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 CONCEPTS	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 re-radiated back into space, by extending from Science 10, Unit 1, the Sun's role in heating the 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
2. The cycling of matter through the biosphere perpetuates its steady state equilibrium.	• specific chemical elements are cycled through the biosphere along characteristic pathways, by: • describing the biogeochemical cycles for carbon, nitrogen and phosphorous • explaining how water is cycled through the biosphere along characteristic pathways by extending, from Science 10, Unit 1, the hydrologic cycle • identifying the unique properties of water that are relevant to the hydrologic cycle.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• performing an experiment to demonstrate, quantitatively, solar energy storage by plants • measuring the amount of solar radiation in the area of their learning centre, and comparing this with solar radiation data of other areas of the province and the country	• evaluating the influence of ice and snow on the storage of solar energy, hypothesizing about consequences of fluctuations for biological systems • explaining why metabolic heat release from harvested grain can be reduced by drying the grain prior to storage • assessing the energy savings achieved by recycling metabolic heat in the overall energy requirements of large office buildings
• using science processes to predict 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 area of their learning centre, and comparing this with precipitation and evaporation data of other areas of the province and 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.	• analyzing the greenhouse effect in terms of the biogeochemical cycle of carbon • discussing the influence of agriculture on the biogeochemical cycle of phosphorous and nitrogen • evaluating the implications of the greenhouse effect for the hydrologic cycle and the water balance of agricultural systems.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. The balance of energy and matter exchange in the biosphere, as a system, maintains its steady state equilibrium.	• air composition is influenced by the activities of organisms, by:
	  • describing how the balance 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 photosynthic and cellular respiratory activities.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• 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.	• discussing how the dynamic equilibrium of the atmosphere is influenced by human activity • examining the influence of decreased atomospheric ozone levels on plants and animals • evaluating the significance of changes in atmospheric composition, with respect to CO_2, from the past to the present.

UNIT 2
CELLULAR MATTER AND ENERGY FLOWS

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 Kreb's cycles.

This unit builds on the students' prior learning in Science 10, Unit 2: Matter and Energy in Living Systems, and Biology 20, Unit 1: The Biosphere. This unit provides an introduction to the exchange of *matter* and *energy* within *ecosystems* as described in Unit 3, and within organisms 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 Biology 30, 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 *matter* and *energy* 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 experimental evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the functioning or 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 CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. Photosynthesis stores energy in organic compounds.	• light energy is stored in plants when photosynthesis uses light energy to synthesize carbohydrates, by extending their learning from Science 10, Unit 2, and by: • explaining, in general terms, how pigments absorb light, transfer that energy to reducing power and to adenosine triphosphate (ATP) by chemiosmosis, and where those processes occur; and understanding that in describing the processes involved, specific detailed knowledge of the biochemistry of the reactions is not required • explaining, in general terms, how the products of the light reactions are used to reduce carbon in the Calvin–Benson cycle and where that process occurs in the cell; and understanding that in describing the processes involved, specific detailed knowledge of the biochemistry of the reactions is not required
2. Respiration releases potential energy from organic compounds.	• cellular respiration involves the release of stored energy from carbohydrates, among other organic molecules, by extending their learning from Science 10, Unit 2, and by: • explaining, in general terms, how carbohydrates are oxidized by glycolysis and Krebs cycle to produce reducing power and ATP, and where in the cell those processes occur; and understanding that in describing the processes involved, specific detailed knowledge of the biochemistry of the reactions is not required • explaining, in general terms, how chemiosmosis converts reducing power to ATP, and where in the cell that process occurs; and understanding that in describing the processes involved, specific detailed knowledge of the biochemistry of the reactions is not required • explaining the role of oxygen in cellular respiration • describing the role of ATP in metabolism; e.g., synthesis, movement • explaining how environmental pollutants like cyanide or hydrogen sulfide influence cellular respiration.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• 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 by active solar generating systems	• analyzing the role of photosynthesis as the biological basis of agriculture and forestry • researching and analyzing the effect of herbicides on the biochemistry of photosynthesis
• 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.	• discussing how specific compounds released into the environment may have precise metabolic effects, and the desirability of regulating their release • assessing the impact of cellular biochemistry on athletic training strategies • 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.

UNIT 3
MATTER AND ENERGY EXCHANGE IN ECOSYSTEMS

OVERVIEW

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

In Unit 3, students examine the biotic and abiotic factors that characterize *matter* and *energy* 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 the selection of organisms better adapted for the roles they play in their *ecosystem*.

This unit builds on Biology 20, Unit 1 and Unit 2, by providing a linkage between the biosphere and the cellular phenomena discussed previously, by examining *matter* and *energy* flow in *ecosystems*. This unit provides the general context in which exchange between organisms and their environment may be studied in the next unit. It also 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 variety of *ecosystems* 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 abiotic and biotic *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 experimental evidence in the accumulation of knowledge, and the way in which 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
- develop an interest in 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 in the limitations of the theory
- respect and tolerate the personal and religious beliefs of others.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. The biosphere is composed of a variety of ecosystems each with distinctive biotic and abiotic factors.	• the biosphere is composed of biomass each with many different ecosystems characterized by physiographic, climatic, edaphic (soil) and biotic factors, by: • describing how energy and matter exchange contribute to the existence of the biosphere's major biomes • describing how the biotic and abiotic factors influence an aquatic and a terrestrial ecosystem in the region of their learning centre; e.g., stream or lake and prairie, boreal forest, vacant lot or sports field.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• performing a field study and measuring, quantitatively, appropriate abiotic factors such as temperature, precipitation, light intensity, pH, hardness and oxygen content in an aquatic and terrestrial ecosystem, and presenting their data in a form, such as graphs, tables and charts, that describes, 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 their data in a form that describes, in general terms, the biotic structure of the ecosystem chosen • evaluating the dependability of resources used for evaluation, assessment or analysis, and identifying their degree of bias • evaluating the dependability of technologies used for measurement, and identifying their degree of accuracy • gathering both quantitative and qualitative data on the nature of snow and ice as abiotic factors, and hypothesizing about their ecological role • 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.	• evaluating the possible impact that modern human activity has had or could have on the ecosystems chosen • analyzing the factors that may influence the natural quality of water used for human consumption • discussing the impact of "slash and burn" or "clear-cutting" practices on ecosystem stability and energy flow • assessing the environmental consequences of the introduction of new species to isolated, established ecosystems.

MAJOR CONCEPTS	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: • analyzing, quantitatively and qualitatively, the structure of ecosystem trophic levels, using models, such as food chains and webs • analyzing, quantitatively and qualitatively, the energy and matter exchange in ecosystems, using models, such as pyramids
3. Populations are basic components of ecosystem structure.	• there is a great deal of variation with populations, by: • describing the nature of variation in 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 species; e.g., blood groups, enzymes • describing some lines of evidence to support the evolution of modern species from ancestral forms; e.g., hominoids, horses • explaining how natural selection acts on the variability within populations to cause evolutionary change.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• collecting information and building a model depicting the food web of a chosen ecosystem • evaluating, quantitatively, the energy matter exchange in a chosen ecosystem, using a pyramid of mass or numbers	• discussing the impact of the draining of wetlands for "reclamation" • analyzing the interrelationship between heavy metals and their introduction into the environment and natural food webs/chains • researching the effect single-crop monoculture has on food webs and species diversity
• designing and performing an experiment to measure inherited variation in an animal or plant population • formulating hypotheses about the adaptive significance of the variations in a range of homologous structures in extant and extinct organisms • gathering and analyzing data on one species of plant or animal to demonstrate how that organism's morphology has evolved over time.	• discussing the nature of science as a way of knowing, compared with other ways of knowing; e.g., natural selection • describing how paleontology has provided invaluable data on variation over time • comparing the views of society at present with those of Darwin's era with respect to variation and change in species • researching the contributions of Charles Lyell, Thomas Malthus and Alfred Wallace, among others, to Darwin's understanding of change and to the eventual formulation of his concept of natural selection.

UNIT 4
MATTER AND ENERGY EXCHANGE BY THE HUMAN ORGANISM

OVERVIEW

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

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*. *Matter* and *energy* 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 2: Matter and Energy in Living Systems, and the other units in this course. This unit 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 *matter* and *energy* with the environment
- the human organism's excretory *system* is responsible for maintenance of internal homeostasis
- the human organism's circulatory *system* maintains *equilibrium* between the body *systems* as well as 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 *matter* and *energy* 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 information from models, simulations and research to demonstrate how *equilibrium* is maintained with respect to *matter* and *energy* exchange.

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

- the central role of experimental evidence in the accumulation of knowledge, and the way in which 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 HIV 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 CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. The human organism's digestive and respiratory systems exchange matter and energy with the environment.	• human organisms, like other organisms, must exchange matter and energy, by extending their learning from Science 10, Unit 2, on the concepts of diffusion, osmosis and active transport, and by: • describing the intake of matter from the environment, its processing through the digestive system and the return of the remaining material to the environment • describing how gases and heat are exchanged between the human organism and its environment.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• observing the principle features of the digestive and respiratory systems of a mammal, using models, computer simulations or dissected organisms, and identifying, accurately, the structures from drawings of those systems • performing an experiment 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 • designing and performing experiments to investigate the influence of enzyme concentration, temperature and pH on the activity of enzymes; e.g., pepsin, pancreatin • performing an experiment to demonstrate the action of digestive enzymes from animal and plant tissue; e.g., potato, liver • designing and performing experiments to investigate the mechanics of breathing.	• discussing the role of food additives; e.g., antioxidants • evaluating the role of irradiation in preventing food spoilage • explaining the biological basis of nutritional deficiencies • evaluating how diet can adversely affect the equilibrium of other body systems; e.g., anorexia nervosa • assessing the physiological effect of legal drugs, such as alcohol and nicotine, on digestive and respiratory functions • comparing and contrasting the societal and scientific definitions of death • evaluating the ethical implications of organ transplants.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

2. The human organism's excretory system is responsible for maintenance of internal homeostasis.	• human organisms, like other organisms, must maintain an equilibrium with respect to their internal environment, by:
	  • explaining the role of the kidney in excreting metabolic wastes from the body and expelling them to the environment
	  • explaining how the excretory system maintains internal homeostasis with respect to water and ions.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• performing an experiment to investigate simulated urine composition, analyzing the data and summarizing the role of the kidney in homeostatic regulation of pH, water 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., ingestion of large amounts of tea or caffeine soft drinks) or where the sodium ion intake was excessive; e.g., anchovy pizza, cheese.	• identifying specific pathologies of the digestive, excretory, respiratory and circulatory systems, and the technology used to ease or cure the problems • examining the relationships that exist among lifestyle, hypertension and kidney function.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
3. The human organism's circulatory system maintains equilibrium between the body systems as well as its external environment.	• human organisms must maintain an internal equilibrium with respect to organs and organ systems as well as with their external environment, by: • describing the role of the circulatory system in aiding the digestive, excretory and respiratory systems' exchange of matter and energy with the environment • explaining the role of the body surface in maintenance of organism equilibrium; e.g., temperature regulation, pathogen protection • describing the main cellular components of blood that are involved in resisting the influence of pathogens • explaining main cellular and non-cellular characteristics of the human immune system; e.g., macrophage, helper T cell, B cell, killer T cell, suppressor T cell, memory T cell.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• observing the principle features of the circulatory and excretory systems of a mammal, using models, computer simulations or dissected organisms, and identifying, accurately, 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 • observing blood flow in the capillaries of a living organism • performing, quantitatively, experiments that demonstrate human venous pressure in quantitative terms • 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 human immune system.	• researching the disruption to human circulatory equilibrium that is caused by severe burns • analyzing how the circulatory system can assist in the delivery of prescription drugs to their sites of action • describing how vaccinations maintain an internal equilibrium with respect to pathogens • evaluating methods of preventing the spread of disease-causing organisms like *Staphylococcus*, smallpox virus and the human immunodeficiency virus.

BIOLOGY 30

UNIT 1
SYSTEMS REGULATING CHANGE IN HUMAN ORGANISMS

OVERVIEW

Science Themes: *Systems* and *Equilibrium*

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 Biology 20, Unit 4: Matter and Energy 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 the next unit, and to post-secondary studies.

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

- humans regulate their physiological processes, using electrochemical control *systems*
- humans maintain 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 experimental evidence in the accumulation of knowledge, and the way in which 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 CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. Humans regulate their physiological processes, using electrochemical control systems.	• the human organism, like other organisms, maintains control over its internal environment with neural systems, by extending from Biology 20, Unit 4, the biological systems that maintain the organism's equilibrium with the environment, and by: • describing the structure of a neuron, the formation of an action potential and the transmission of a signal across a synapse or neuromuscular junction and the main chemical transmitters involved • describing the structures of the central and peripheral nervous systems and their functioning in regulating the voluntary and involuntary systems of the human organism • describing some of the systems (organs) that allow human organisms to sense their environment and their spatial orientation in it; e.g., auditory, visual, sensory receptors, olfactory, proprioceptors.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• observing neurons and neuromuscular junctions on prepared microscope slides • designing and performing experiments to investigate the physiology of reflex arcs • observing the principle features of the mammalian brain, using models, computer simulations or dissected mammalian brains, and identifying, accurately, the major structures from drawings of that organ • observing the principle features of the mammalian eye, using models, computer simulations or dissected mammalian eyes, and identifying, accurately, the major structures from drawings of that organ • designing and performing experiments to investigate their heat, cold, pressure and touch receptors and their abilities to sense their environment • performing experiments to measure their ability to discriminate objects visually and to hear a range of sounds.	• analyzing the influence of anesthetics, drugs and chemicals from the environment on the functioning of the nervous system • discussing the biological basis of neurological diseases like Alzheimer's or Parkinson's • discussing how advances in technology have increased our access to the world beyond our normal sensory limit • evaluating the application of biological knowledge in developing offensive and defensive military capabilities • defining "quality of life" and evaluating the effect of technology on longevity and quality of life • discussing current addiction theories related to the use of prescription and non-prescription drugs • evaluating the impact of photoperiod and light wavelength on the human organism • evaluating the impact of sound waves (duration and intensity) on the equilibrium of the human organism.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

2. Humans maintain homeostasis through the use of complex chemical control systems.	• endocrine systems coordinate other organ systems to maintain internal homeostasis as well as the organism's equilibrium with the environment, by:
	  • describing the main endocrine glands, the hormones they produce and the metabolic roles of those hormones
	  • describing how the endocrine system allows human organisms to sense their internal environment and respond appropriately to it
	  • explaining how the endocrine and neural control systems act together.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• 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/or investigating the role of insulin in the regulation of blood sugar, using a computer simulation • inferring the role of aldosterone and vasopressin in the maintenance of homeostasis of water and ions, by the analysis and interpretation of data on blood and urine composition • designing an experiment to demonstrate how an environmental factor, such as ultraviolet light, can be detected and responded to by the human organism • researching, identifying and summarizing the main hormonal and nervous components of the "general adaptation syndrome".	• evaluating the use of hormones produced by biotechnology in the control of problems like diabetes and dwarfism, and in increasing milk yields from cows • comparing the nature of control mechanisms in technological systems to those in organisms • assessing the impact of biochemical control systems research in biology, on athletics • explaining the relationship between ultraviolet light, O_3 depletion and pigment deposition within skin cells • discussing the use of hormone therapy in the treatment of humans; e.g., growth hormone and aging, steroids and sports.

UNIT 2
REPRODUCTION AND DEVELOPMENT

OVERVIEW

Science Themes: *Systems* and *Change*

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 those processes by hormonal *systems* is examined. The *systems* associated with parturition and lactation are regulated hormonally.

This unit builds upon the learning of biological control *systems* from the preceding unit, and leads to a more detailed study of gametogenesis and genetics in the next unit, and to post-secondary studies.

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

- humans and other organisms have complex reproductive *systems* to ensure the survival of the species
- reproductive success is regulated by chemical control *systems*
- cell differentiation and organism development are regulated by a combination of genetics and environmental influence.

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

- 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 experimental evidence in the accumulation of knowledge, and the way in which 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 between 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 CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. Humans and other organisms have complex reproductive systems to ensure the survival of the species.	• human organisms have evolved a specialized series of ducts and tubes to facilitate the union of an egg and sperm, by: • explaining the physiological events resulting in the formation of male and female reproductive organs in the fetus • describing the structures of the human male and female reproductive organs • explaining how sexually transmitted diseases can interfere with the passage of eggs and sperm
2. Reproductive success is regulated by chemical control systems.	• the development of secondary sex characteristics and sexual functioning is influenced by hormones, by: • describing the involvement of hormones in the regulation of primary and secondary sex characteristics • describing the interactions of hormones in the maintenance of the female reproductive system.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• observing the principal features of the human reproductive system, using models or computer simulations, and identifying, accurately, the major structures from drawings of that organ system • identifying sperm, eggs and the supporting structures, using prepared slides of testes and ovaries	• evaluating the implications of reproductive technology for human biology • discussing society's expectations of the scientific community with respect to reproductive technology • identifying the types of physiological and physical damage caused by exposure to sexually transmitted disease organisms in males and females
• analyzing blood hormone data and physiological events, and inferring the roles of the male sex hormones • analyzing blood hormone data and physiological events of a single menstrual cycle, and inferring the roles of the female sex hormones.	• researching the effects of prolonged estrogen and/or progesterone treatment on the health of women • explaining how reproductive hormone homeostasis is disrupted by the aging process.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
3. Cell differentiation and organism development are regulated by a combination of genetics and environmental influence.	• events following conception are governed by a combination of genetics and environmental influences, by: • describing events of fertilization, implantation, extra-embryonic membrane formation, embryo development, parturition and lactation, and the control of those events • describing development from implantation to full term and the main physiological events that occur during each major stage (trimester) of this development • explaining the physiological or mechanical basis of different reproduction technology methods.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• observing the stages of embryo development, using living material, such as chicken embryos, preserved 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 non-prescription drugs, on the development of the human fetus • evaluating, from published data, the effectiveness and safety of the various reproductive technology methods.	• analyzing the problems of incompatibility between fetus and mother, and the possible solutions to such problems • discussing how knowledge of fetal development has affected society's values on life • discussing the societal impact of chemicals and drugs on fetal development; e.g., alcohol and cocaine • assessing the effect of hormonal conception control technology on population demographics in developed and underdeveloped countries.

UNIT 3
CELLS, CHROMOSOMES AND DNA

OVERVIEW

Science Theme: *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: Matter and Energy in Living Systems, where simple cell division was introduced and the previous unit, where spermatogenesis and oogenesis were introduced. This unit leads to a study of population genetics in the next unit, 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 experimental evidence in the accumulation of knowledge, and the way in which 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 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 CONCEPTS	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: • describing, in general, the events of the cell cycle • describing, in general, the reduction of chromosome number in meiosis, paying particular attention to the necessity of reduction in chromosome number and the process of crossing over • comparing and contrasting the process of mitosis and meiosis • comparing and contrasting the alternation of generations in a range of vascular plants and animals.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• identifying the stages of the cell cycle and calculating the duration of each stage from observations of onion root tip cells • preparing microscope slides to enable them to observe some stages of mitosis; e.g., onion root tips • performing a simulation to demonstrate the behaviour of chromosomes during meiosis • researching a range of reproductive strategies in vascular plants and animals and presenting this information in the form of charts, tables or diagrams.	• discussing the role of mitosis in regenerating damaged or missing parts of organisms • evaluating how a knowledge of mitosis might be applied to the limitation of "cancerous" growth in plants or animals • discussing the types and sources of various teratogenic compounds found in the environment • evaluating the impact of research in plant and animal reproduction on our understanding of mitosis and meiosis in humans.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
2. Genetic characters are handed down by simple rules.	• chromosomes consist of a sequence of genes and their alleles, and that during meiosis and fertilization those genes become combined in new sequences, by: • describing the evidence for the segregation of genes and the independent assortment of genes on different chromosomes • explaining the influence of crossing over on the assortment of genes on the same chromosome • explaining the significance of sex chromosomes compared to autosomes.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• 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 their peer groups or families to demonstrate the presence of single allele, and multiple allele inherited human traits • predicting, quantitatively, the probability of inheritance, from monohybrid and dihybrid inheritance data • drawing and interpreting pedigree charts from data on human single allele and multiple allele inheritance patterns • designing and performing an experiment to demonstrate the inheritance pattern of a trait controlled by a single pair of genes.	• evaluating the role of genetic counselling in their society • discussing the role of gene banks used in agriculture to preserve endangered species and genotypes, particularly of plants and animals • discussing the possibility of replacement gene therapy in the treatment of human genetic disorders • discussing the societal impact of the Human Genome Project • evaluating the identification and treatment of potentially disabling genetic disorders from a variety of perspectives; e.g., phenylketonuria.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. Classical genetics can be explained at a molecular level.	• 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:
	  • 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
	  • describing, 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 gives evidence for the relationships between organisms of different species.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• predicting the general arrangement of genes on a chromosome, from analysis of data on crossing over between genes on 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 • performing simulations to demonstrate translation and transcription of a segment of DNA • designing and performing an experiment to demonstrate how an environmental factor can cause a change in the genetic information of an organism • performing simulations to demonstrate the use of restriction enzymes and ligases in creating new DNA sequences • analyzing and inferring, from published data, the relationship between human activities, and changes in the genetic information, that lead to inheritable mutations and cancer.	• evaluating the use of genetically engineered organisms in agriculture, forestry and bioremediation in the natural environment • analyzing the possibilities of the use of genetically engineered organisms in the pharmaceutical industry • debating the societal and scientific definition of life and the living condition • evaluating the potential risks of genetic engineering to life on Earth • discussing the implications of corporations being able to patent new life forms produced by genetic engineering • assessing the impact of modern biochemical technology on the study of variations in populations.

UNIT 4
CHANGE IN POPULATIONS AND COMMUNITIES

OVERVIEW

Science Themes: *Systems, Equilibrium* and *Change*

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: Matter and Energy Exchange in Ecosystems, and from the previous unit. 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 experimental evidence in the accumulation of knowledge, and the way in which 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 CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
1. Communities are made up of populations that consist of pools of genes from the individuals of a species.	• 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: • explaining the significance of the Hardy–Weinberg equilibrium and the significance of non-equilibrium values • describing the molecular basis and significance of gene pool change over time
2. Individuals of populations interact with each other and members of other populations.	• interactions occur between members of the same population of a species in addition to interactions between members of populations of different species, by: • describing the basis of symbiotic relationships, like commensalism, mutualism and parasitism, and different types of competition and their influence on populations • explaining the relationships between predator and prey species, and the role of mimicry in predation and their influence on populations • 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	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• calculating and interpreting problem-solving exercises involving the Hardy–Weinberg equilibrium • performing experiments and computer simulations to demonstrate the growth of populations of organisms	• discussing the implications of the introduction of exotic species in an ecosystem where natural predators do not exist, and methods of dealing with the situations arising therefrom • debating the role of ecological reserves in preserving our natural heritage • assessing the role of importance of models in science to explain observable phenomena; e.g., the Hardy–Weinberg equilibrium
• summarizing and evaluating the symbiotic relationship between a parasite and its host • designing and performing an experiment to demonstrate interspecific competition • performing simulations to investigate the relationships between predators and their prey • designing and performing an experiment to demonstrate succession in a microenvironment and recording its pattern of succession over time.	• discussing the implications of the predator–prey relationship for wildlife management in national and provincial parks • discussing the long-term implications of ecosystem fire control and prevention on population and ecosystem stability and diversity • analyzing the relationship between parasites and human developmental potential in less developed countries.

MAJOR CONCEPTS	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:
	  • describing the factors that influence population growth
	  • describing the growth of populations up to the carrying capacity of their environments and the behaviour of populations, using different growth patterns (r- and K-strategies)
	  • describing the application of the "chaos theory" to the study of biological systems, especially as it relates to population growth patterns.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationships of science, technology and society by; among other activities:*
• graphing and interpreting population growth data on a variety of organisms • designing and performing an experiment to demonstrate the effect of environmental factors on population growth • performing computer simulations to illustrate the application of the chaos theory.	• analyzing the growth of human populations in comparison with natural populations of other species • evaluating the implications for natural systems inherent in theories of chaos • developing appropriate investigative strategies for dealing further with biological problems; e.g., risk benefit analysis, cost benefit analysis.

D. BASIC LEARNING RESOURCES

Biology 20 and Biology 30

Galbraith, Don et al. *Biology Directions*. Toronto, ON: John Wiley & Sons Canada Limited, 1993.

ISBN 0471795127

Ritter, Bob et al. *Nelson Biology*. Scarborough, ON: Nelson Canada, 1993.

ISBN 0176038604

Basic learning resources for the 1984 Biology 30 program, as listed in the Learning Resources Distributing Centre *Buyers Guide*, are to be withdrawn August 31, 1994.