Biology 2201

Curriculum Guide 2020

Newfoundland Labrador

Education and Early Childhood Development

Department of Education and Early Childhood Development Mission Statement

The Department of Education and Early Childhood Development will improve provincial early childhood learning and the K-12 education system to further opportunities for the people of Newfoundland and Labrador.

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Acknowledgements

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Section One: Newfoundland and Labrador Curriculum

Introduction

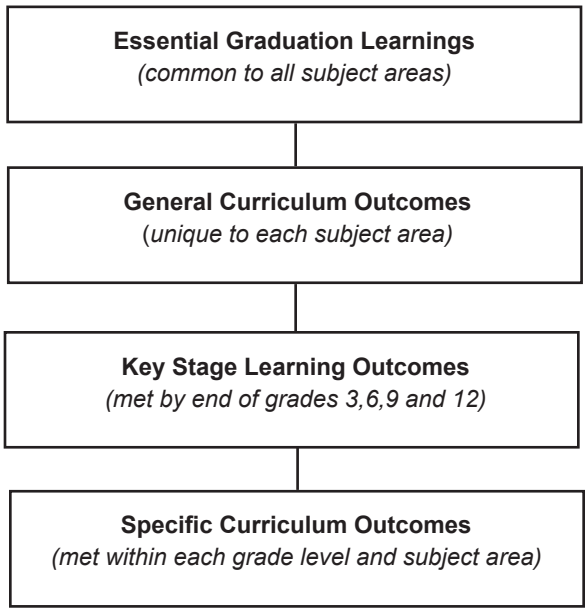
There are multiple factors that impact education: technological developments, increased emphasis on accountability, and globalization. These factors point to the need to consider carefully the education students receive.

The Newfoundland and Labrador Department of Education and Early Childhood Development believes that curriculum design with the following characteristics will help teachers address the needs of students served by the provincially prescribed curriculum:

- Curriculum guides must clearly articulate what students are expected to know and be able to do by the time they graduate from high school.
- There must be purposeful assessment of students' performance in relation to the curriculum outcomes.

Outcomes Based Education

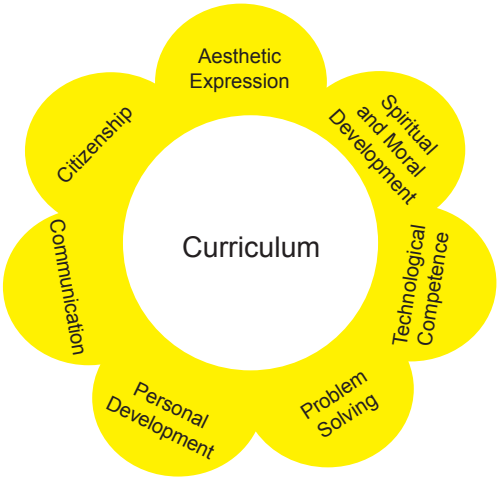
The K-12 curriculum in Newfoundland and Labrador is organized by outcomes and is based on *The Atlantic Canada Framework for Essential Graduation Learning in Schools* (1997). This framework consists of Essential Graduation Learnings (EGLs), General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs) and Specific Curriculum Outcomes (SCOs).



Essential Graduation Learnings

EGLs provide vision for the development of a coherent and relevant curriculum. They are statements that offer students clear goals and a powerful rationale for education. The EGLs are delineated by general, key stage, and specific curriculum outcomes.

EGLs describe the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the EGLs will prepare students to continue to learn throughout their lives. EGLs describe expectations, not in terms of individual subject areas, but in terms of knowledge, skills, and attitudes developed throughout the K-12 curriculum. They confirm that students need to make connections and develop abilities across subject areas if they are to be ready to meet the shifting and ongoing demands of life, work, and study.



Aesthetic Expression – Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship – Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication – Graduates will be able to use the listening, viewing, speaking, reading and writing modes of language(s), and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.

Problem Solving – Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts.

Personal Development – Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Spiritual and Moral Development – Graduates will demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct.

Technological Competence – Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

Curriculum Outcomes

Curriculum outcomes are statements that articulate what students are expected to know and be able to do in each program area in terms of knowledge, skills, and attitudes.

Curriculum outcomes may be subdivided into General Curriculum Outcomes, Key Stage Curriculum Outcomes, and Specific Curriculum Outcomes.

General Curriculum Outcomes (GCOs)

Each program has a set of GCOs which describe what knowledge, skills, and attitudes students are expected to demonstrate as a result of their cumulative learning experiences within a subject area. GCOs serve as conceptual organizers or frameworks which guide study within a program area. Often, GCOs are further delineated into KSCOs.

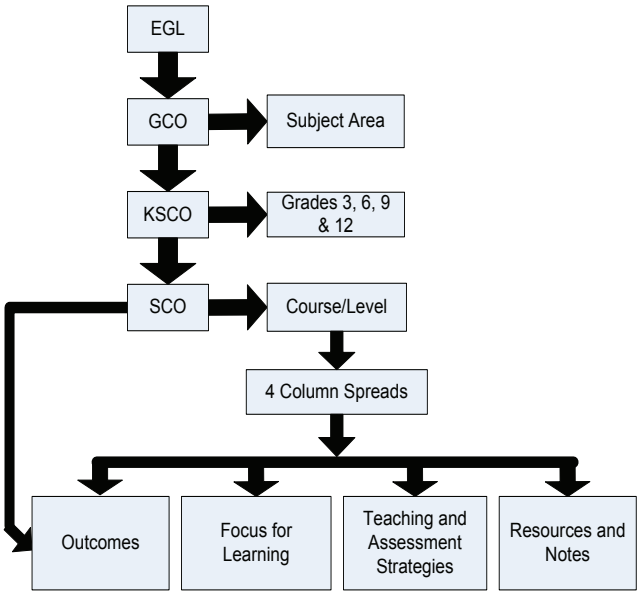
Key Stage Curriculum Outcomes (KSCOs)

Key Stage Curriculum Outcomes (KSCOs) summarize what is expected of students at each of the four key stages of grades three, six, nine, and twelve.

Specific Curriculum Outcomes (SCOs)

SCOs set out what students are expected to know and be able to do as a result of their learning experiences in a course, at a specific grade level. In some program areas, SCOs are further articulated into delineations. *It is expected that all SCOs will be addressed during the course of study covered by the curriculum guide.*

EGLs to Curriculum Guides



Context for Teaching and Learning

Teachers are responsible to help students achieve outcomes. This responsibility is a constant in a changing world. As programs change over time so does educational context. Several factors make up the educational context in Newfoundland and Labrador today: inclusive education, support for gradual release of responsibility teaching model, focus on literacy and learning skills in all programs, and support for education for sustainable development.

Inclusive Education

All students need to see their lives and experiences reflected in their school community. It is important that the curriculum reflect the experiences and values of all genders and that learning resources include and reflect the interests, achievements, and perspectives of all students. An inclusive classroom values the varied experiences and abilities as well as social and ethno-cultural backgrounds of all students while creating opportunities for community building. Inclusive policies and practices promote mutual respect, positive interdependencies, and diverse perspectives. Learning resources should include a range of materials that allow students to consider many viewpoints and to celebrate the diverse aspects of the school community.

Valuing Equity and Diversity

Effective inclusive schools have the following characteristics: supportive environment, positive relationships, feelings of competence, and opportunities to participate. (The Centre for Inclusive Education, 2009)

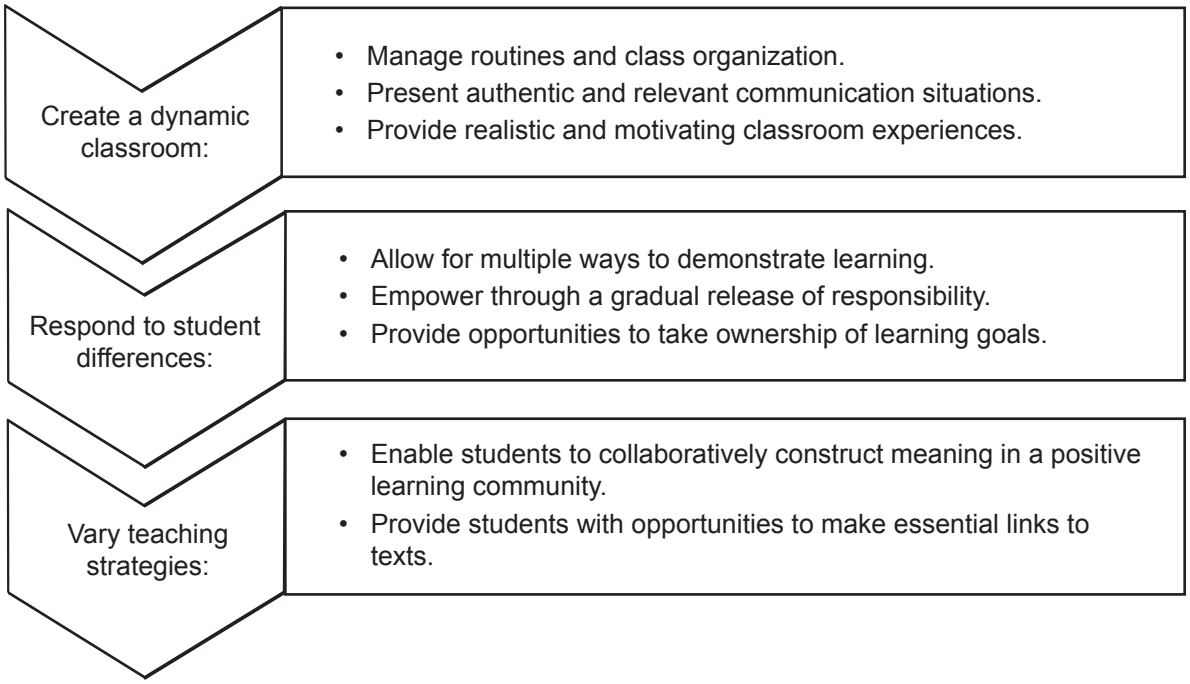
Differentiated Instruction

Differentiated instruction is a teaching philosophy based on the premise that teachers should adapt instruction to student differences. Rather than marching students through the curriculum lockstep, teachers should modify their instruction to meet students' varying readiness levels, learning preferences, and interests. Therefore, the teacher proactively plans a variety of ways to 'get it' and express learning. (Carol Ann Tomlinson, 2008)

Curriculum is designed and implemented to provide learning opportunities for all students according to abilities, needs, and interests. Teachers must be aware of and responsive to the diverse range of learners in their classes. Differentiated instruction is a useful tool in addressing this diversity.

Differentiated instruction responds to different readiness levels, abilities, and learning profiles of students. It involves actively planning so that the process by which content is delivered, the way the resource is used, and the products students create are in response to the teacher's knowledge of whom he or she is interacting with. Learning environments should be flexible to accommodate various learning preferences of the students. Teachers continually make decisions about selecting teaching strategies and structuring learning activities that provide all students with a safe and supportive place to learn and succeed.

Planning for Differentiation



Differentiating the Content

Differentiating content requires teachers to pre-assess students to identify those who require prerequisite instruction, as well as those who have already mastered the concept and may therefore apply strategies learned to new situations. Another way to differentiate content is to permit students to adjust the pace at which they progress through the material. Some students may require additional time while others will move through at an increased pace and thus create opportunities for enrichment or more indepth consideration of a topic of particular interest.

Teachers should consider the following examples of differentiating content:

- Meet with small groups to reteach an idea or skill or to extend the thinking or skills.
- Present ideas through auditory, visual, and tactile means.
- Use reading materials such as novels, websites, and other reference materials at varying reading levels.

Differentiating the Process

Differentiating the process involves varying learning activities or strategies to provide appropriate methods for students to explore and make sense of concepts. A teacher might assign all students the same product (e.g., presenting to peers) but the process students use to create the presentation may differ. Some students could work in groups while others meet with the teacher individually. The same assessment criteria can be used for all students.

Teachers should consider flexible grouping of students such as whole class, small group, or individual instruction. Students can be grouped according to their learning styles, readiness levels, interest areas, and/or the requirements of the content or activity presented. Groups should be formed for specific purposes and be flexible in composition and short-term in duration.

Teachers should consider the following examples of differentiating the process:

- Offer hands-on activities for students.
- Provide activities and resources that encourage students to further explore a topic of particular interest.
- Use activities in which all learners work with the same learning outcomes but proceed with different levels of support, challenge, or complexity.

Differentiating the Product

Differentiating the product involves varying the complexity and type of product that students create to demonstrate learning outcomes. Teachers provide a variety of opportunities for students to demonstrate and show evidence of what they have learned.

Teachers should give students options to demonstrate their learning (e.g., create an online presentation, write a letter, or develop a mural). This will lead to an increase in student engagement.

Differentiating the Learning Environment

The learning environment includes the physical and the affective tone or atmosphere in which teaching and learning take place, and can include the noise level in the room, whether student activities are static or mobile, or how the room is furnished and arranged. Classrooms may include tables of different shapes and sizes, space for quiet individual work, and areas for collaboration.

Teachers can divide the classroom into sections, create learning centres, or have students work both independently and in groups. The structure should allow students to move from whole group, to small group, pairs, and individual learning experiences and support a variety of ways to engage in learning. Teachers should be sensitive and alert to ways in which the classroom environment supports their ability to interact with students.

Teachers should consider the following examples of differentiating the learning environment:

- Develop routines that allow students to seek help when teachers are with other students and cannot provide immediate attention.
- Ensure there are places in the room for students to work quietly and without distraction, as well as places that invite student collaboration.
- Establish clear guidelines for independent work that match individual needs.
- Provide materials that reflect diversity of student background, interests, and abilities.

The physical learning environment must be structured in such a way that all students can gain access to information and develop confidence and competence.

Meeting the Needs of Students with Exceptionalities

All students have individual learning needs. Some students, however, have exceptionalities (defined by the Department of Education and Early Childhood Development) which impact their learning. The majority of students with exceptionalities access the prescribed curriculum. For details of these exceptionalities see www.gov.nl.ca/edu/k12/studentsupportservices/exceptionalities.html

Supports for these students may include

1. Accommodations
2. Modified Prescribed Courses
3. Alternate Courses
4. Alternate Programs
5. Alternate Curriculum

For further information, see Service Delivery Model for Students with Exceptionalities at www.cdli.ca/sdm/

Classroom teachers should collaborate with instructional resource teachers to select and develop strategies which target specific learning needs.

Meeting the Needs of Students who are Highly Able

(includes gifted and talented)

Some students begin a course or topic with a vast amount of prior experience and knowledge. They may know a large portion of the material before it is presented to the class or be capable of processing it at a rate much faster than their classmates. All students are expected to move forward from their starting point. Many elements of differentiated instruction are useful in addressing the needs of students who are highly able.

Teachers may

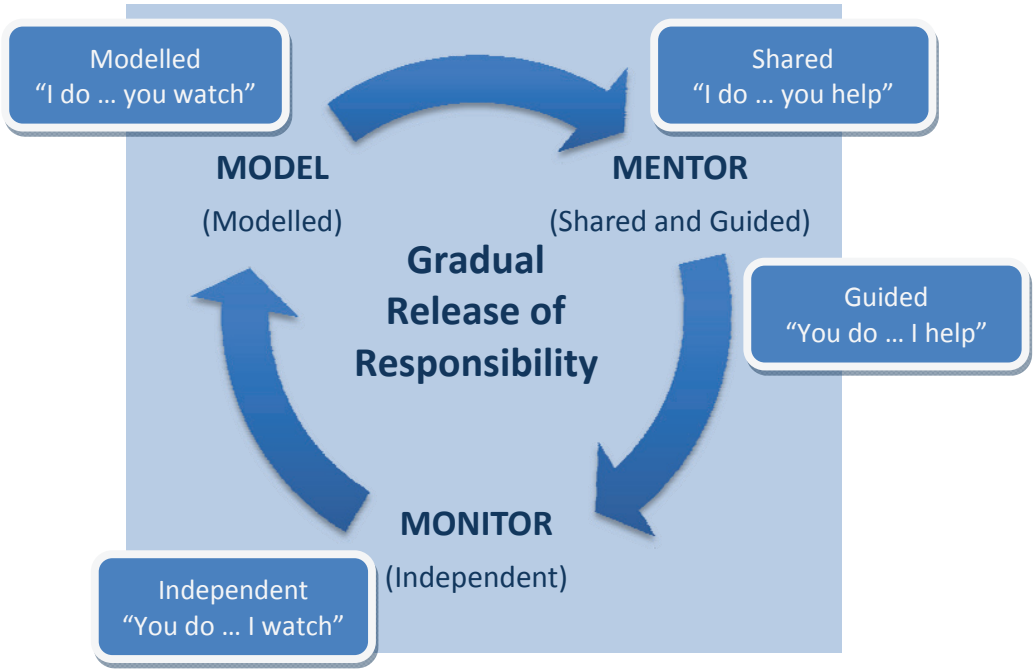
- assign independent study to increase depth of exploration in an area of particular interest;
- compact curriculum to allow for an increased rate of content coverage commensurate with a student's ability or degree of prior knowledge;
- group students with similar abilities to provide the opportunity for students to work with their intellectual peers and elevate discussion and thinking, or delve deeper into a particular topic; and
- tier instruction to pursue a topic to a greater depth or to make connections between various spheres of knowledge.

Highly able students require the opportunity for authentic investigation to become familiar with the tools and practices of the field of study. Authentic audiences and tasks are vital for these learners. Some highly able learners may be identified as gifted and talented in a particular domain. These students may also require supports through the Service Delivery Model for Students with Exceptionalities.

Gradual Release of Responsibility

Teachers must determine when students can work independently and when they require assistance. In an effective learning environment, teachers choose their instructional activities to model and scaffold composition, comprehension, and metacognition that is just beyond the students' independence level. In the gradual release of responsibility approach, students move from a high level of teacher support to independent work. If necessary, the teacher increases the level of support when students need assistance. The goal is to empower students with their own learning strategies, and to know how, when, and why to apply them to support their individual growth. Guided practice supports student independence. As a student demonstrates success, the teacher should gradually decrease his or her support.

Gradual Release of Responsibility Model



Literacy

"Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society". To be successful, students require a set of interrelated skills, strategies and knowledge in multiple literacies that facilitate their ability to participate fully in a variety of roles and contexts in their lives, in order to explore and interpret the world and communicate meaning. (The Plurality of Literacy and its Implications for Policies and Programmes, 2004, p.13)

Literacy is

- a process of receiving information and making meaning from it; and
- the ability to identify, understand, interpret, communicate, compute, and create text, images, and sounds.

Literacy development is a lifelong learning enterprise beginning at birth that involves many complex concepts and understandings. It is not limited to the ability to read and write; no longer are we exposed only to printed text. It includes the capacity to learn to communicate, read, write, think, explore, and solve problems. Individuals use literacy skills in paper, digital, and live interactions to engage in a variety of activities:

- Analyze critically and solve problems.
- Comprehend and communicate meaning.
- Create a variety of texts.
- Make connections both personally and inter-textually.
- Participate in the socio-cultural world of the community.
- Read and view for enjoyment.
- Respond personally.

These expectations are identified in curriculum documents for specific subject areas as well as in supporting documents, such as *Cross-Curricular Reading Tools* (CAMET).

With modelling, support, and practice, students' thinking and understandings are deepened as they work with engaging content and participate in focused conversations.

Reading in the Content Areas

The focus for reading in the content areas is on teaching strategies for understanding content. Teaching strategies for reading comprehension benefits all students as they develop transferable skills that apply across curriculum areas.

When interacting with different texts, students must read words, view and interpret text features, and navigate through information presented in a variety of ways including, but not limited to

Advertisements	Movies	Poems
Blogs	Music videos	Songs
Books	Online databases	Speeches
Documentaries	Plays	Video games
Magazine articles	Podcasts	Websites

Students should be able to interact with and comprehend different texts at different levels.

There are three levels of text comprehension:

- Independent level – Students are able to read, view, and understand texts without assistance.
- Instructional level – Students are able to read, view, and understand most texts but need assistance to fully comprehend some texts.
- Frustration level – Students are not able to read or view with understanding (i.e., texts may be beyond their current reading level).

Teachers will encounter students working at all reading levels in their classrooms and will need to differentiate instruction to meet their needs. For example, print texts may be presented in audio form, physical movement may be associated with synthesizing new information with prior knowledge, or graphic organizers may be created to present large amounts of print text in a visual manner.

When interacting with information that is unfamiliar to students, it is important for teachers to monitor how effectively students are using strategies to read and view texts:

- Analyze and think critically about information.
- Determine importance to prioritize information.
- Engage in questioning before, during, and after an activity related to a task, text, or problem.
- Make inferences about what is meant but not said.
- Make predictions.
- Synthesize information to create new meaning.
- Visualize ideas and concepts.

Learning Skills for Generation Next

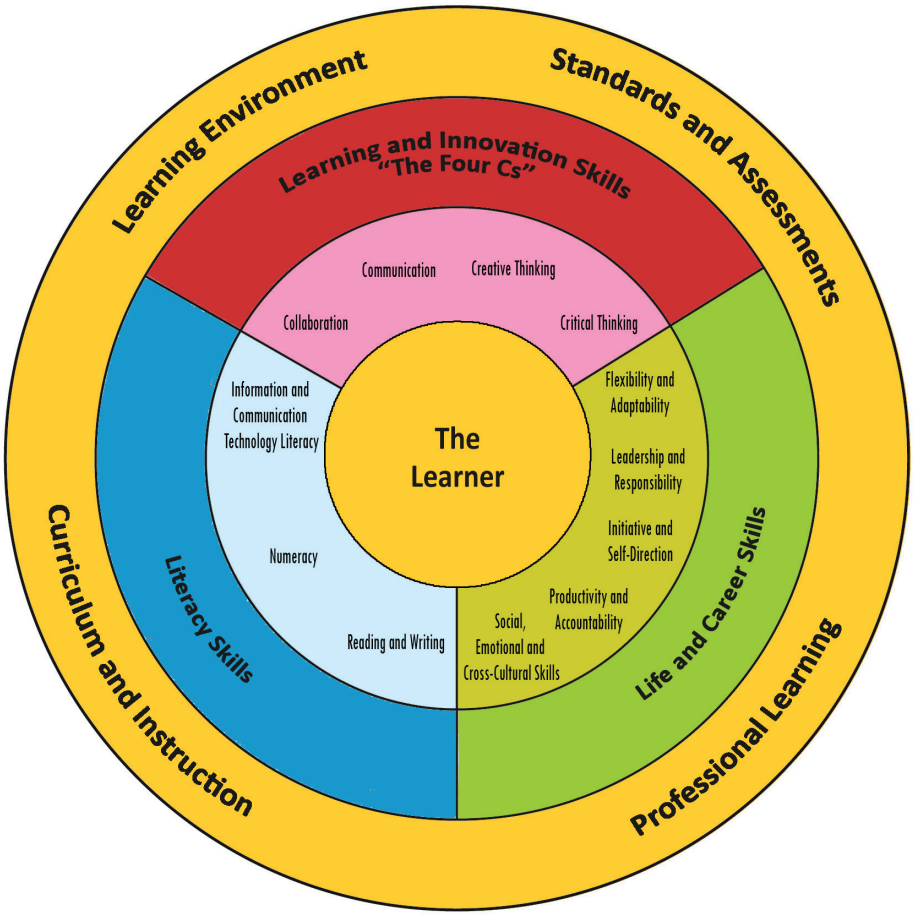
Generation Next is the group of students who have not known a world without personal computers, cell phones, and the Internet. They were born into this technology. They are digital natives.

Students need content and skills to be successful. Education helps students learn content and develop skills needed to be successful in school and in all learning contexts and situations. Effective learning environments and curricula challenge learners to develop and apply key skills within the content areas and across interdisciplinary themes.

Learning Skills for Generation Next encompasses three broad areas:

- Learning and Innovation Skills enhance a person's ability to learn, create new ideas, problem solve, and collaborate.
- Life and Career Skills address leadership, and interpersonal and affective domains.
- Literacy Skills develop reading, writing, and numeracy, and enhance the use of information and communication technology.

The diagram below illustrates the relationship between these areas. A 21st century curriculum employs methods that integrate innovative and research-driven teaching strategies, modern learning technologies, and relevant resources and contexts.



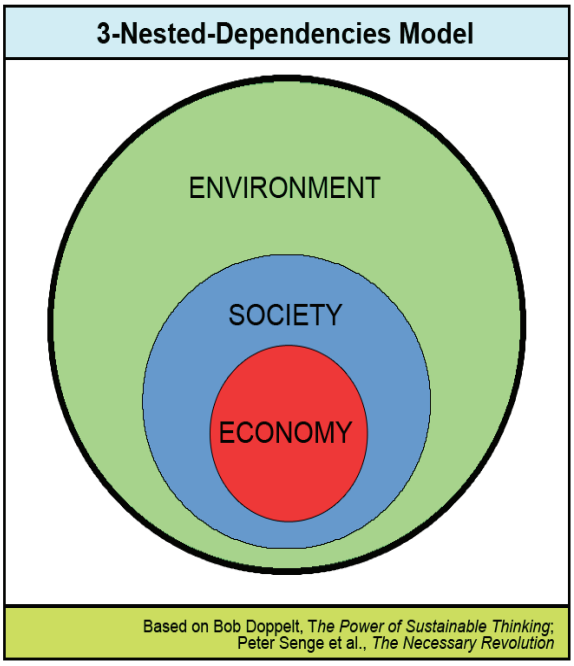
Support for students to develop these abilities and skills is important across curriculum areas and should be integrated into teaching, learning, and assessment strategies. Opportunities for integration of these skills and abilities should be planned with engaging and experiential activities that support the gradual release of responsibility model. For example, lessons in a variety of content areas can be infused with learning skills for Generation Next by using open-ended questioning, role plays, inquiry approaches, self-directed learning, student role rotation, and Internet-based technologies.

All programs have a shared responsibility in developing students' capabilities within all three skill areas.

Education for Sustainable Development

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". (Our Common Future, 43)

Sustainable development is comprised of three integrally connected areas: economy, society, and environment.



As conceived by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) the overall goal of Education for Sustainable Development (ESD) is to integrate the knowledge, skills, values, and perspectives of sustainable development into all aspects of education and learning. Changes in human behaviour should create a more sustainable future that supports environmental integrity and economic viability, resulting in a just society for all generations.

ESD involves teaching *for* rather than teaching *about* sustainable development. In this way students develop the skills, attitudes, and perspectives to meet their present needs without compromising the ability of future generations to meet their needs.

Within ESD, the knowledge component spans an understanding of the interconnectedness of our political, economic, environmental, and social worlds, to the role of science and technology in the development of societies and their impact on the environment. The skills necessary include being able to assess bias, analyze consequences of choices, ask questions, and solve problems. ESD values and perspectives include an appreciation for the interdependence of all life forms, the importance of individual responsibility and action, an understanding of global issues as well as local issues in a global context. Students need to be aware that every issue has a history, and that many global issues are linked.

Assessment and Evaluation

Assessment

Assessment is the process of gathering information on student learning.

How learning is assessed and evaluated and how results are communicated send clear messages to students and others about what is valued.

Assessment instruments are used to gather information for evaluation. Information gathered through assessment helps teachers determine students' strengths and needs, and guides future instruction.

Teachers are encouraged to be flexible in assessing student learning and to seek diverse ways students might demonstrate what they know and are able to do.

Evaluation involves the weighing of the assessment information against a standard in order to make a judgement about student achievement.

Assessment can be used for different purposes:

1. Assessment *for* learning guides and informs instruction.
2. Assessment *as* learning focuses on what students are doing well, what they are struggling with, where the areas of challenge are, and what to do next.
3. Assessment *of* learning makes judgements about student performance in relation to curriculum outcomes.

1. Assessment for Learning

Assessment *for* learning involves frequent, interactive assessments designed to make student learning visible. This enables teachers to identify learning needs and adjust teaching accordingly. Assessment *for* learning is not about a score or mark; it is an ongoing process of teaching and learning:

- Pre-assessments provide teachers with information about what students already know and can do.
- Self-assessments allow students to set goals for their own learning.
- Assessment *for* learning provides descriptive and specific feedback to students and parents regarding the next stage of learning.
- Data collected during the learning process from a range of tools enables teachers to learn as much as possible about what a student knows and is able to do.

2. Assessment as Learning

Assessment *as* learning involves students' reflecting on their learning and monitoring their own progress. It focuses on the role of the student in developing metacognition and enhances engagement in their own learning. Students can

- analyze their learning in relation to learning outcomes,
- assess themselves and understand how to improve performance,
- consider how they can continue to improve their learning, and
- use information gathered to make adaptations to their learning processes and to develop new understandings.

3. Assessment of Learning

Assessment *of* learning involves strategies designed to confirm what students know in terms of curriculum outcomes. It also assists teachers in determining student proficiency and future learning needs. Assessment *of* learning occurs at the end of a learning experience and contributes directly to reported results. Traditionally, teachers relied on this type of assessment to make judgements about student performance by measuring learning after the fact and then reporting it to others. Used in conjunction with the other assessment processes previously outlined, assessment *of* learning is strengthened. Teachers can

- confirm what students know and can do;
- report evidence to parents/guardians, and other stakeholders, of student achievement in relation to learning outcomes; and
- report on student learning accurately and fairly using evidence obtained from a variety of contexts and sources.

Involving Students in the Assessment Process

Students should know what they are expected to learn as outlined in the specific curriculum outcomes of a course as well as the criteria that will be used to determine the quality of their achievement. This information allows students to make informed choices about the most effective ways to demonstrate what they know and are able to do.

It is important that students participate actively in assessment by co-creating criteria and standards which can be used to make judgements about their own learning. Students may benefit from examining various scoring criteria, rubrics, and student exemplars.

Students are more likely to perceive learning as its own reward when they have opportunities to assess their own progress. Rather than asking teachers, "What do you want?", students should be asking themselves questions:

- What have I learned?
- What can I do now that I couldn't do before?
- What do I need to learn next?

Assessment must provide opportunities for students to reflect on their own progress, evaluate their learning, and set goals for future learning.

Assessment Tools

In planning assessment, teachers should use a broad range of tools to give students multiple opportunities to demonstrate their knowledge, skills, and attitudes. The different levels of achievement or performance may be expressed as written or oral comments, ratings, categorizations, letters, numbers, or as some combination of these forms.

The grade level and the activity being assessed will inform the types of assessment tools teachers will choose:

Anecdotal Records	Photographic Documentation
Audio/Video Clips	Podcasts
Case Studies	Portfolios
Checklists	Presentations
Conferences	Projects
Debates	Questions
Demonstrations	Quizzes
Exemplars	Role Plays
Graphic Organizers	Rubrics
Journals	Self-assessments
Literacy Profiles	Tests
Observations	Wikis

Assessment Guidelines

Assessments should measure what they intend to measure. It is important that students know the purpose, type, and potential marking scheme of an assessment. The following guidelines should be considered:

- Collect evidence of student learning through a variety of methods; do not rely solely on tests and paper and pencil activities.
- Develop a rationale for using a particular assessment of learning at a specific point in time.
- Provide descriptive and individualized feedback to students.
- Provide students with the opportunity to demonstrate the extent and depth of their learning.
- Set clear targets for student success using learning outcomes and assessment criteria.
- Share assessment criteria with students so that they know the expectations.

Evaluation

Evaluation is the process of analyzing, reflecting upon, and summarizing assessment information, and making judgements or decisions based on the information gathered. Evaluation is conducted within the context of the outcomes, which should be clearly understood by learners before teaching and evaluation take place. Students must understand the basis on which they will be evaluated and what teachers expect of them.

During evaluation, the teacher interprets the assessment information, makes judgements about student progress, and makes decisions about student learning programs.

Section Two: Curriculum Design

Rationale

The vision of science education in Newfoundland and Labrador is to develop scientific literacy.

> *Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem solving, and decision making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them.*

To develop scientific literacy, students require diverse learning experiences which provide opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, careers, and futures.

Science education which strives for scientific literacy must engage students in science inquiry, problem solving, and decision making.

Science Inquiry

Science inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as "the" scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analyzing data, and interpreting data are fundamental to engaging in science. These skills are often represented as a cycle which involves the posing of questions, the generation of possible explanations, and the collection of evidence to determine which of these explanations is most useful in accounting for the phenomenon under investigation. Teachers should engage students in science inquiry activities to develop these skills.

Problem Solving

Problem solving involves seeking solutions to human problems. It may be represented as a cycle consisting of the proposing, creating, and testing of prototypes, products, and techniques in an attempt to reach an optimum solution to a given problem. The skills involved in this cycle facilitate a process which has different aims and procedures from science inquiry. Students should be given opportunities to propose, perform, and evaluate solutions to problem solving or technological tasks.

Decision Making

Decision making involves determining what we should do in a particular context or in response to a given situation. Increasingly, the types of problems that we deal with, both individually and collectively, require an understanding of the processes and products of science and technology. The process of decision making involves identification of the problem or situation, generation of possible solutions or courses of action, evaluation of the alternatives, and a thoughtful decision based on the information available. Students should be actively involved in decision making situations. While important in their own right, decision making situations also provide a relevant context for engaging in science inquiry and/or problem solving.

Curriculum Outcomes Framework

The foundation of the curriculum outcomes framework is the general curriculum outcomes (GCOs). Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy: science, technology, society, and the environment (STSE), skills, knowledge, and attitudes. These four GCOs are common to all science courses.

General Curriculum Outcomes

GCO 1: Science, Technology, Society, and the Environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

GCO 2: Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

GCO 3: Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

GCO 4: Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key Stage Curriculum Outcomes

Key stage curriculum outcomes (KSCOs) align with the GCOs and summarize what students are expected to know and be able to do by the end of Grade 12.

GCO 1 - STSE

By the end of Grade 12, students will be expected to

- describe and explain disciplinary and interdisciplinary processes used to understand natural phenomena and develop technological solutions;
- distinguish between science and technology in terms of their respective goals, products, and values, and describe the development of scientific theories and technologies over time;
- analyze and explain how science and technology interact with and advance one another;
- analyze how individuals, society, and the environment are interdependent with scientific and technological endeavours; and
- evaluate social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages for sustainability, considering a variety of perspectives.

GCO 2 - Skills

By the end of Grade 12, students will be expected to

- ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues;
- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information;
- analyze data and apply mathematical and conceptual models to develop and assess possible explanations; and
- work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

GCO 3 - Knowledge

By the end of Grade 12, students will be expected to

- compare and contrast the reproduction and development of representative organisms;
- determine how cells use matter and energy to maintain organization necessary for life;
- demonstrate an understanding of the structure and function of genetic materials;
- analyze the patterns and products of evolution;
- compare and contrast mechanisms used by organisms to maintain homoeostasis; and
- evaluate relationships that affect the biodiversity and sustainability of life within the biosphere.

GCO 4 - Attitudes

By the end of Grade 12, students will be expected to

- value the role and contributions of science and technology in our understanding of phenomena that are directly observable and those that are not;
- appreciate that the applications of science and technology can raise ethical dilemmas;
- value the contributions to scientific and technological developments made by individuals from many societies and cultural backgrounds;
- show a continuing and more informed curiosity and interest in science and science-related issues;
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research;
- consider further studies and careers in science- and technology-related fields;
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations;
- use factual information and rational explanations when analyzing and evaluating;
- value the processes for drawing conclusions;
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas;
- have a sense of personal and shared responsibility for maintaining a sustainable environment;
- project the personal and shared social, and environmental consequences of proposed action;
- want to take action for maintaining a sustainable environment;
- show concern for safety and accept the need for rules and regulations; and
- be aware of the direct and indirect consequences of their actions.

Specific Curriculum Outcomes

Specific curriculum outcomes (SCOs) align to KSCOs and GCOs and describe what students should know and be able to do at the end of each course. They are intended to serve as the focus for the design of learning experiences and assessment tasks. SCOs are organized into units for each science course

Course Overview

SCOs for Biology 2201 have been organized into four units:

Unit i: Integrated Skills

Unit 1: Ecosystem Interactions and Population Dynamics

Unit 2: Processes that Sustain Life

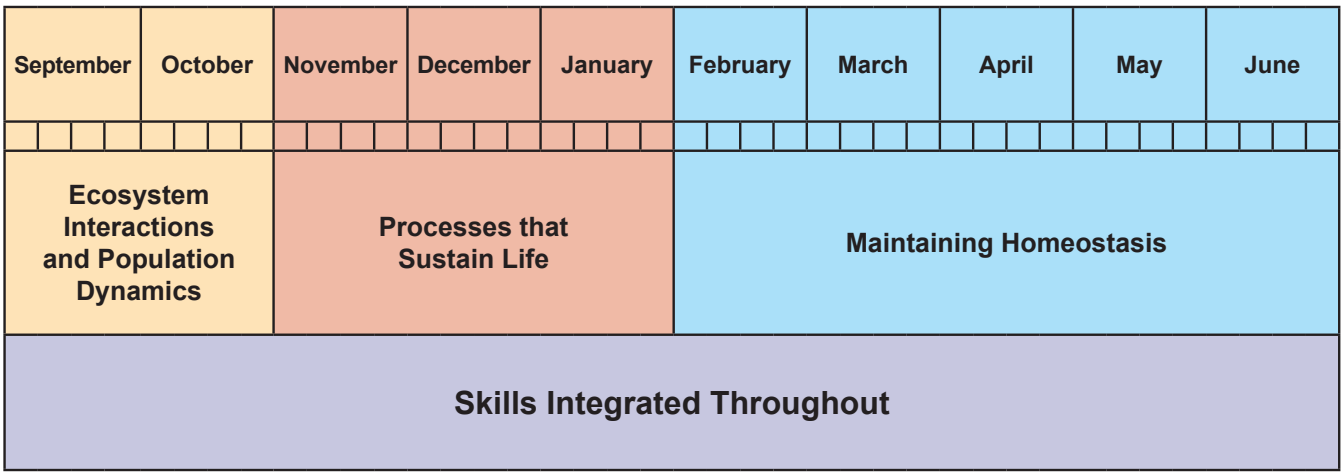
Unit 3: Maintaining Homeostasis

While not prerequisite, completion of Biology 2201 is recommended before attempting Biology 3201.

Suggested Yearly Plan

The order in which units are presented in the curriculum guide is the recommended sequence.

Note, the Integrated Skills unit (Unit i) is not intended to be taught as a separate, stand alone unit.



How to Use the Four Column Curriculum Layout

Outcomes

Column one contains specific curriculum outcomes (SCO) and accompanying delineations where appropriate. The delineations provide specificity in relation to key ideas.

Outcomes are numbered in ascending order.

Delineations are indented and numbered as a subset of the originating SCO.

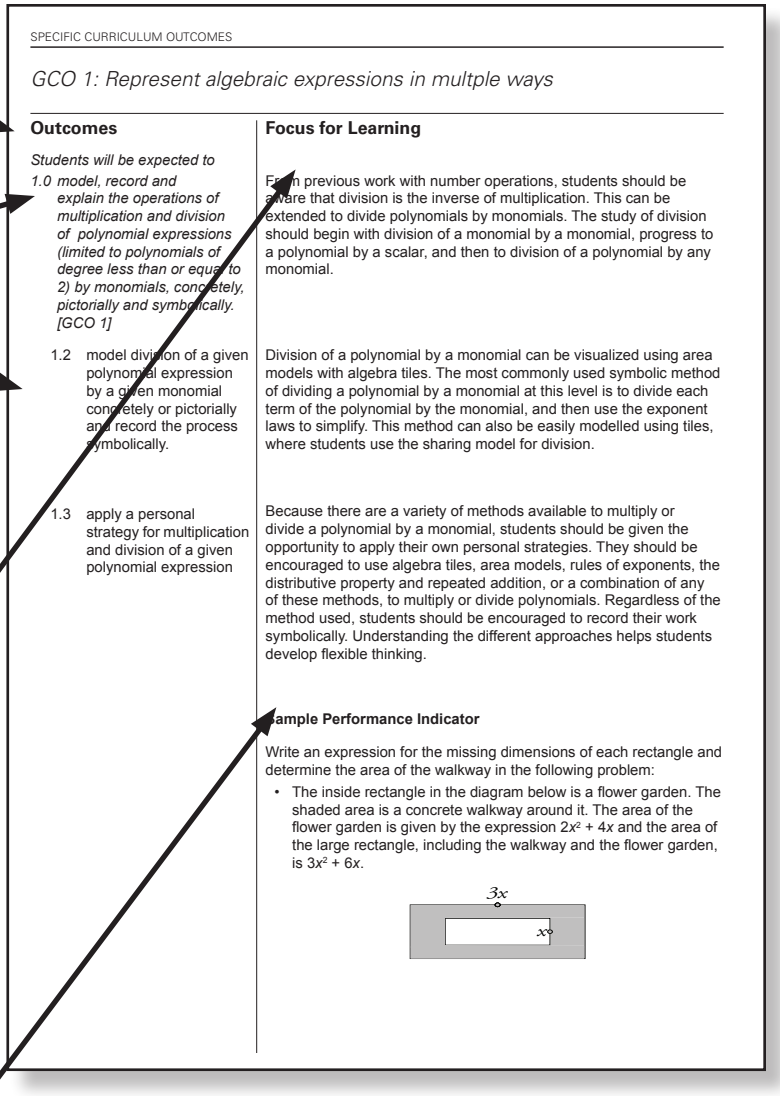
All outcomes are related to general curriculum outcomes.

Focus for Learning

Column two is intended to assist teachers with instructional planning. It also provides context and elaboration of the ideas identified in the first column.

This may include

- cautionary notes
- clarity in terms of scope
- common misconceptions
- depth of treatment
- knowledge required to scaffold and challenge student's learning
- references to prior knowledge



SPECIFIC CURRICULUM OUTCOMES

GCO 1: Represent algebraic expressions in multple ways

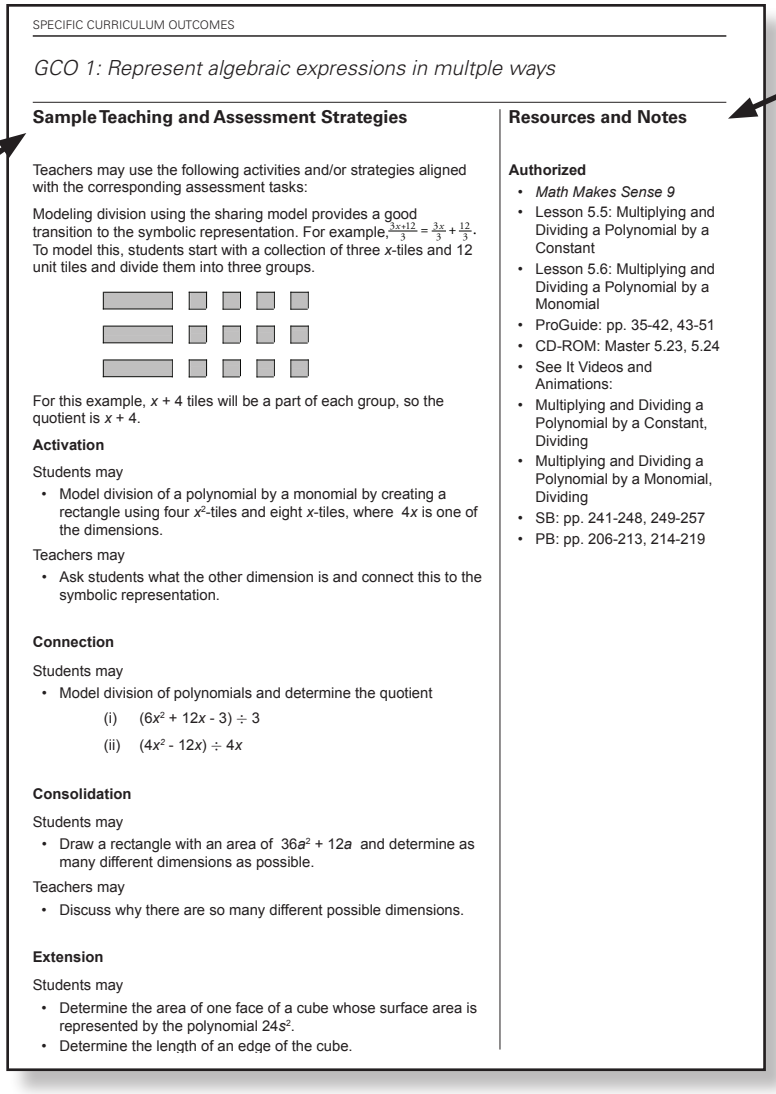
Outcomes	Focus for Learning
Students will be expected to	
1.0 model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically. [GCO 1]	From previous work with number operations, students should be aware that division is the inverse of multiplication. This can be extended to divide polynomials by monomials. The study of division should begin with division of a monomial by a monomial, progress to a polynomial by a scalar, and then to division of a polynomial by any monomial.
1.2 model division of a given polynomial expression by a given monomial concretely or pictorially and record the process symbolically.	Division of a polynomial by a monomial can be visualized using area models with algebra tiles. The most commonly used symbolic method of dividing a polynomial by a monomial at this level is to divide each term of the polynomial by the monomial, and then use the exponent laws to simplify. This method can also be easily modelled using tiles, where students use the sharing model for division.
1.3 apply a personal strategy for multiplication and division of a given polynomial expression	Because there are a variety of methods available to multiply or divide a polynomial by a monomial, students should be given the opportunity to apply their own personal strategies. They should be encouraged to use algebra tiles, area models, rules of exponents, the distributive property and repeated addition, or a combination of any of these methods, to multiply or divide polynomials. Regardless of the method used, students should be encouraged to record their work symbolically. Understanding the different approaches helps students develop flexible thinking.
	Sample Performance Indicator Write an expression for the missing dimensions of each rectangle and determine the area of the walkway in the following problem: • The inside rectangle in the diagram below is a flower garden. The shaded area is a concrete walkway around it. The area of the flower garden is given by the expression $2x^2 + 4x$ and the area of the large rectangle, including the walkway and the flower garden, is $3x^2 + 6x$. $3x$ x

Sample Performance Indicator(s)

This provides a summative, higher order activity, where the response would serve as a data source to help teachers assess the degree to which the student has achieved the outcome.

Performance indicators are typically presented as a task, which may include an introduction to establish a context. They would be assigned at the end of the teaching period allocated for the outcome.

Performance indicators would be assigned when students have attained a level of competence, with suggestions for teaching and assessment identified in column three.



SPECIFIC CURRICULUM OUTCOMES

GCO 1: Represent algebraic expressions in multple ways

Sample Teaching and Assessment Strategies

Teachers may use the following activities and/or strategies aligned with the corresponding assessment tasks:

Modeling division using the sharing model provides a good transition to the symbolic representation. For example, $\frac{3x+12}{3} = \frac{3x}{3} + \frac{12}{3}$. To model this, students start with a collection of three *x*-tiles and 12 unit tiles and divide them into three groups.

For this example, $x + 4$ tiles will be a part of each group, so the quotient is $x + 4$.

Activation

Students may

- Model division of a polynomial by a monomial by creating a rectangle using four x^2-tiles and eight *x*-tiles, where $4x$ is one of the dimensions.

Teachers may

- Ask students what the other dimension is and connect this to the symbolic representation.

Connection

Students may

- Model division of polynomials and determine the quotient
  - (i) $(6x^2 + 12x - 3) \div 3$
  - (ii) $(4x^2 - 12x) \div 4x$

Consolidation

Students may

- Draw a rectangle with an area of $36a^2 + 12a$ and determine as many different dimensions as possible.

Teachers may

- Discuss why there are so many different possible dimensions.

Extension

Students may

- Determine the area of one face of a cube whose surface area is represented by the polynomial $24s^2$.
- Determine the length of an edge of the cube.

Resources and Notes

Authorized

- *Math Makes Sense 9*
- Lesson 5.5: Multiplying and Dividing a Polynomial by a Constant
- Lesson 5.6: Multiplying and Dividing a Polynomial by a Monomial
- ProGuide: pp. 35-42, 43-51
- CD-ROM: Master 5.23, 5.24
- See It Videos and Animations:
- Multiplying and Dividing a Polynomial by a Constant, Dividing
- Multiplying and Dividing a Polynomial by a Monomial, Dividing
- SB: pp. 241-248, 249-257
- PB: pp. 206-213, 214-219

Resources and Notes

Column four references supplementary information and possible resources for use by teachers.

These references will provide details of resources suggested in column two and column three.

Suggestions for Teaching and Assessment

This column contains specific sample tasks, activities, and strategies that enable students to meet the goals of the SCOs and be successful with performance indicators. Instructional activities are recognized as possible sources of data for assessment purposes. Frequently, appropriate techniques and instruments for assessment purposes are recommended.

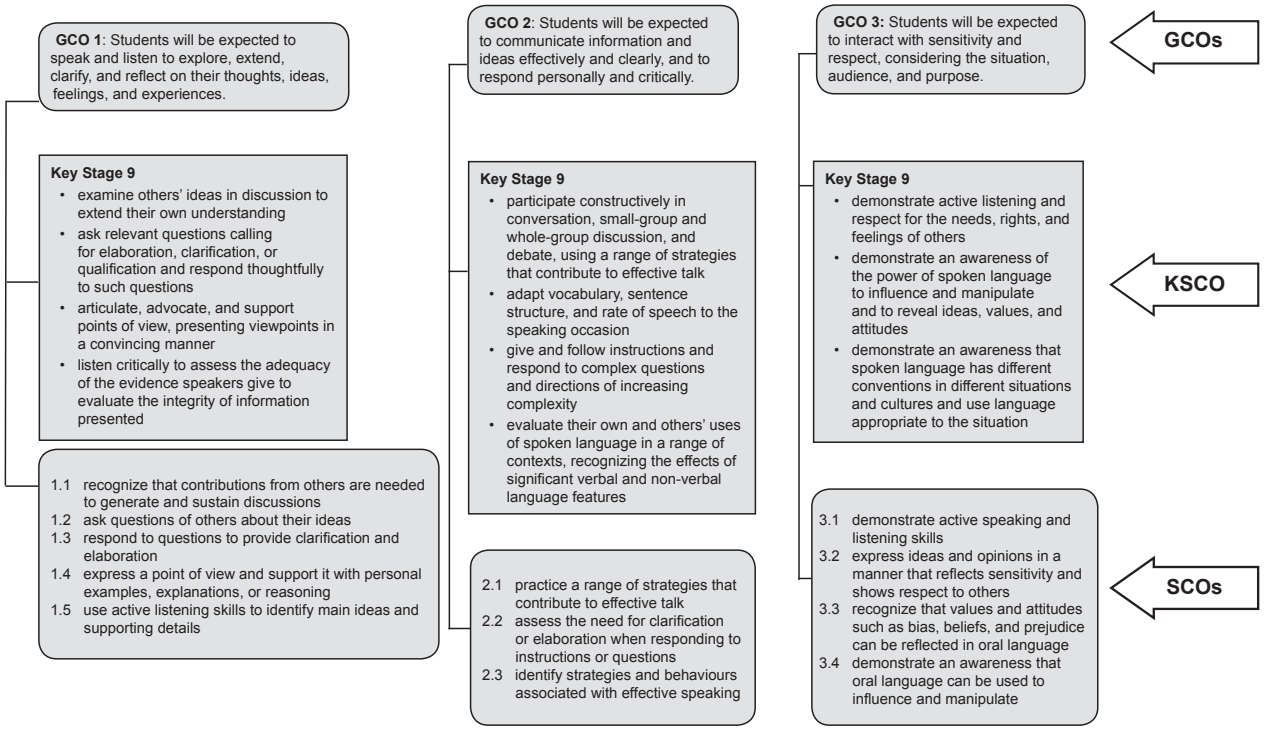
Suggestions for instruction and assessment are organized sequentially:

- Activation – suggestions that may be used to activate prior learning and establish a context for the instruction
- Connection – linking new information and experiences to existing knowledge inside or outside the curriculum area
- Consolidation – synthesizing and making new understandings
- Extension – suggestions that go beyond the scope of the outcome

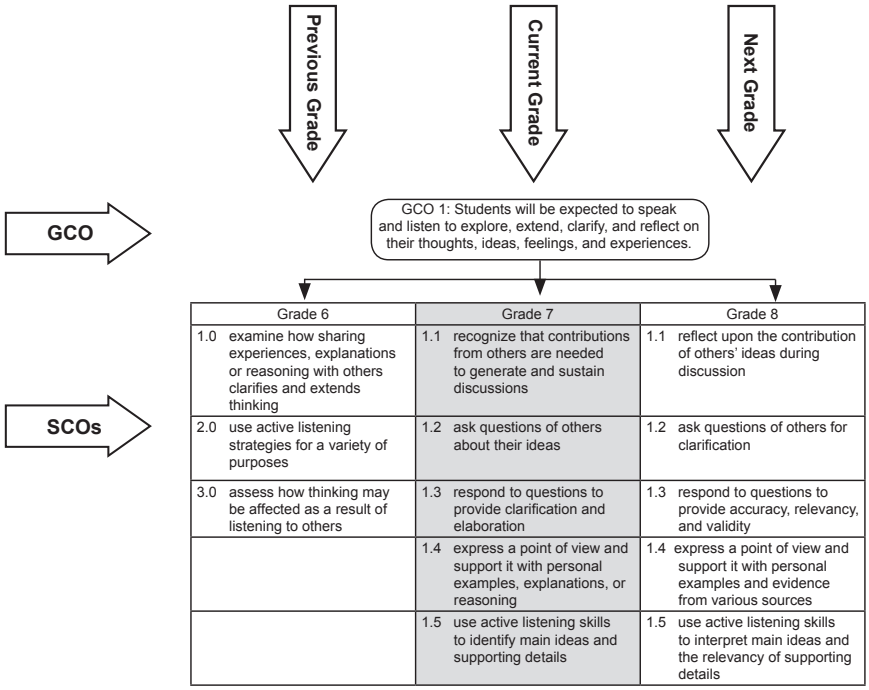
These suggestions provide opportunities for differentiated learning and assessment.

How to use a Strand Overview

At the beginning of each strand grouping there is explanation of the focus for the strand and a flow chart identifying the relevant GCOs, KSCOs and SCOs.



The SCOs Continuum follows the chart to provide context for teaching and assessment for the grade/ course in question. The current grade is highlighted in the chart.



Grade 6	Grade 7	Grade 8
1.0 examine how sharing experiences, explanations or reasoning with others clarifies and extends thinking	1.1 recognize that contributions from others are needed to generate and sustain discussions	1.1 reflect upon the contribution of others' ideas during discussion
2.0 use active listening strategies for a variety of purposes	1.2 ask questions of others about their ideas	1.2 ask questions of others for clarification
3.0 assess how thinking may be affected as a result of listening to others	1.3 respond to questions to provide clarification and elaboration	1.3 respond to questions to provide accuracy, relevancy, and validity
	1.4 express a point of view and support it with personal examples, explanations, or reasoning	1.4 express a point of view and support it with personal examples and evidence from various sources
	1.5 use active listening skills to identify main ideas and supporting details	1.5 use active listening skills to interpret main ideas and the relevancy of supporting details

Section Three:
Specific Curriculum Outcomes

Unit i: Integrated Skills

Focus

Students use a variety of skills when investigating questions, ideas, problems, and issues. While these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations.

The listing of skills is not intended to imply a linear sequence or to identify a single set of skills required in each science investigation. Every investigation has unique features that determine the particular mix and sequence of skills.

Four broad areas of skills are outlined and developed:

- Initiating and Planning - These are the skills of questioning, identifying problems, and developing initial ideas and plans.
- Performing and Recording - These are the skills of carrying out action plans, which involves gathering evidence by observation and, in most cases, manipulating materials and equipment.
- Analyzing and Interpreting - These are the skills of examining information and evidence, of processing and presenting data so that it can be interpreted, and interpreting, evaluating, and applying the results.
- Communication and Teamwork - In science, communication skills are essential at every stage where ideas are being developed, tested, interpreted, debated, and agreed upon. Teamwork skills are also important, since the development and application of science ideas is a collaborative process both in society and in the classroom.

Students should be provided with opportunities to develop and apply their skills in a variety of contexts. These contexts connect to the STSE component of the curriculum by linking to three processes for skills application:

Science inquiry - seeking answers to questions through experimentation and research.

Problem solving - seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need.

Decision making - providing information to assist the decision making process.

Unit i - Integrated Skills

Unit i, the *Integrated Skills* unit, appears at the beginning of this curriculum guide. A total of 43 skill outcomes are identified and addressed throughout high school science courses. However, all skills do not appear in each course or content unit. In Biology 2201, students are expected to develop proficiency with respect to 25 different skill outcomes listed in the outcomes framework.

Outcomes Framework

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Initiating and Planning

1.0 define and delimit problems to facilitate investigation
2.0 identify questions to investigate that arise from practical problems and issues
3.0 design an experiment identifying and controlling major variables
4.0 formulate operational definitions of major variables
5.0 develop and implement appropriate sampling procedures

Performing and Recording

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required
7.0 estimate quantities
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
9.0 use library and electronic research tools to collect information on a given topic
10.0 select and use apparatus and materials safely
11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Analyzing and Interpreting

12.0 describe and apply classification systems and nomenclatures used in the sciences
13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
14.0 identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit
15.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
16.0 compare theoretical and empirical values and account for discrepancies
17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
18.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
20.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan

Communication and Teamwork

21.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
23.0 identify multiple perspectives that influence a science-related decision or issue
24.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
25.0 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task

SCO Continuum

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Science 7-9	Science 10-12
• identify questions to investigate arising from practical problems and issues • rephrase questions in a testable form and clearly define practical problems • define and delimit questions and problems to facilitate investigation	• define and delimit problems to facilitate investigation • identify questions to investigate that arise from practical problems and issues
• design an experiment and identify major variables	• design an experiment identifying and controlling major variables
• formulate operational definitions of major variables and other aspects of their investigations	• formulate operational definitions of major variables
	• develop and implement appropriate sampling procedures
• carry out procedures controlling the major variables	• carry out procedures controlling the major variables and adapting or extending procedures where required
• estimate measurements	• estimate quantities
• organize data using a format that is appropriate to the task or experiment	• compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
• select and integrate information from various print and electronic sources or from several parts of the same source	• use library and electronic research tools to collect information on a given topic
• use tools and apparatus safely	• select and use apparatus and materials safely
• demonstrate a knowledge of WHMIS standards by using proper techniques for handling and disposing of lab materials	• demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
• use or construct a classification key	• describe and apply classification systems and nomenclatures used in the sciences
• compile and display data, by hand or computer, in a variety of formats	• compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
• predict the value of a variable by interpolating and extrapolating from graphical data • identify the line of best fit on a scatter plot and interpolate or extrapolate on the line of best fit	• identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit

Science 7-9	Science 10-12
• interpret patterns and trends in data, and infer and explain relationships among the variables	• interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
• calculate theoretical values of a variable	• compare theoretical and empirical values and account for discrepancies
• identify the strengths and weaknesses of different methods of collecting and displaying data	• evaluate the relevance, reliability, and adequacy of data and data collection methods
• identify, and suggest explanations for, discrepancies in data • identify potential sources and determine the amount of error in measurement	• identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
• state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea	• provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
• propose alternative solutions to a practical problem, select one, and develop a plan	• propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
• communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means	• select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
• select and integrate information from various print and electronic sources or from several parts of the same source	• synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
	• identify multiple perspectives that influence a science-related decision or issue
• work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise	• work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
• evaluate individual and group processes used in planning, problem solving and decision making, and completing a task	• evaluate individual and group processes used in planning, problem solving and decision making, and completing a task

Suggested Unit Plan

The *Integrated Skills* unit is not intended to be taught as a separate, stand alone unit. Rather, as skill outcomes [GCO 2] are encountered in Units 1-3, teachers should refer out to the focus for learning elaborations and teaching and assessment suggestions provided in this unit.

Provide opportunities for students to develop and apply these skills in varied contexts:

- Science Inquiry - seeking answers to questions through experimentation and research.
- Problem Solving - seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need.
- Decision Making - providing information to assist the decision making process.

The inclusion of science projects is strongly recommended to address and assess skill outcomes.

<table>
<tr><th>September</th><th>October</th><th>November</th><th>December</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th></tr>
<tr><td colspan="3">Ecosystem Interactions and Population Dynamics</td><td colspan="3">Processes that Sustain Life</td><td colspan="6">Maintaining Homeostasis</td></tr>
<tr><td colspan="10">Skills Integrated Throughout</td></tr>
</table>

Initiating and Planning

Outcomes	Focus for Learning
Students will be expected to	
1.0 define and delimit problems to facilitate investigation [GCO 2]	This skill is employed when students attempt to move from a general topic to a specific research question. Narrowing topics to facilitate investigation involves defining and delimiting. Students should • attempt to understand the nature of a problem (i.e., What are the variables of influence? What are the relationships among them?); • delimit the problem (i.e., What will be the scope of the research? What are the boundaries? What theoretical perspective will be used? Which variables will be investigated?); and • formulate a specific question to investigate. Differentiate between limit and delimit. To limit is to enforce a boundary. Delimiting is the thoughtful process of determining and setting the boundary. Initial research helps investigators to narrow and delimit their research focus (i.e., the specific problem or question they will investigate). Skill outcome 1.0 should be addressed and assessed in Unit 1 when students research a biome of personal interest and when they investigate the effects of intraspecific and interspecific competition on seedling growth. Additionally, where appropriate, it may be assessed when students initiate and plan research and scientific investigations.
2.0 identify questions to investigate that arise from practical problems and issues [GCO 2]	Science begins with a question. Scientific questions arise from • curiosity about the natural and constructed world; • personal observations of phenomena; • examination of scientific models, theories, and their predictions; • the findings of previous investigations; and • processes to solve practical problems or reach a decision on a science-related issue. Scientific questions differ from other types of questions in that their answers lie in explanations supported by empirical evidence (i.e., information acquired through observation and investigation). Students should • identify questions to investigate, • phrase questions in a form that facilitates investigation, and • evaluate questions to determine if they are testable. Often in science courses, the question to investigate is identified for students. To achieve this outcome, however, students must personally identify the question they will investigate. Skill outcome 2.0 is expected to be addressed and assessed when students examine the issue of human overpopulation and investigate its causes, social and environmental impacts, and solutions. Additionally, it may be assessed throughout the course, whenever experiments are designed or practical problems and issues are addressed.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present a general research topic (e.g., organ transplantation) and explicitly model how the topic might be narrowed down into a specific research question.

Connection

Teachers may

- Distinguish between the terms limiting and delimiting.
- Present general research topics and ask students to provide examples of how they might delimit the topic to facilitate research.
- Model the identification of questions to investigate arising from problems and issues.
- Facilitate a discussion regarding criteria to use to determine if a question is testable.

Students may

- Participate in a book walk through *NL Biology*. Locate and review investigations, identifying the question investigated and how the problem is defined and delineated to facilitate investigation.
- Review abstracts of scientific investigations as exemplars of how problems are defined and delimited to facilitate investigation and how major variables are identified and controlled.
- Use a question matrix to generate initial questions.
- Apply criteria to determine whether a question is testable within the constraints and limits of resources.

Consolidation

Students may

- Define and delimit problems and identify questions to investigate as part of a science project.
- Read or view science-related articles and videos and identify potential questions to investigate.

Resources and Notes

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Initiating and Planning

Outcomes	Focus for Learning
Students will be expected to	
3.0 design an experiment identifying and controlling major variables [GCO 2]	When initiating and planning investigations, students should • state and define questions to investigate; • identify dependent, independent, and control variables; • make hypotheses and plan experiments to test them; and • devise detailed procedures that include controls, test only one variable at a time, and ensure relevant, reliable, adequate data. Additionally, students should evaluate experimental designs to identify the major variables, and assess whether confounding variables are adequately controlled. SCO 3.0 should be assessed when students design experiments to measure the effects of intraspecific and interspecific competition, and investigate factors affecting passive transport, blood pressure, and enzyme activity. The skill may also be assessed whenever students engage in open inquiry.
4.0 formulate operational definitions of major variables [GCO 2]	Formulating operational definitions of variables is an integral skill when designing experiments. Operational definitions are procedural statements specific to each investigation. They define the process used to determine the nature of major variables and their properties. When designing an experiment to determine the effect of a factor such as physical activity on blood pressure, for example, students must operationally define physical activity and blood pressure: • What type of exercise will be performed? How long will the subject exercise? What tool will be used to measure time? At what intensity level will the exercise be performed? • What tool and unit will be used to measure blood pressure? What procedure will be followed to take measurements? How many measurements will be taken per trial? Will measurement values be averaged? Will measurement values be compared to a baseline value? The answers to these questions help to operationally define the variables and assist with devising procedures for investigations. Note, different student groups investigating the same question may operationally define the same variables in different ways. SCO 4.0 should be addressed and assessed when students design experiments to measure the effects of intraspecific and interspecific competition on seedlings and investigate the effects of factors on passive transport. Additionally, the skill may be assessed whenever students design experiments as part of open or guided inquiry.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Provide visual representations of science inquiry processes. Ask students to note similarities in their stages.
- Review the role of variables in science inquiry investigations.

Connection

Teachers may

- Provide questions to investigate and ask students to identify the independent and dependent variables, as well as confounding variables that would need to be controlled.
- Model stating predictions and hypotheses.
- Collaboratively design a fictitious experiment with students identifying and controlling major variables to model the skill.
- Distinguish between definitions and operational definitions.
- Conduct a demonstration of an experiment. Ask students to describe how the major variables are operationally defined in the experiment.

Students may

- View investigations from *NL Biology* and identify the independent and dependent variables, describing how they are operationally defined. Identify the control variables and procedures undertaken to ensure fairness.
- Review the procedures of published scientific research to identify the major variables, determine how they are operationally defined, and assess whether confounding variables have been adequately controlled.

Consolidation

Teachers may

- Provide questions to investigate and ask students to design an experiment identifying, operationally defining, and controlling major variables.

Students may

- Formulate operational definitions for major variables when designing an experiment for a science project.
- Suggest alternative ways to operationally define major variables in experiments.

Resources and Notes

Authorized

NL Science 10 (Teacher Resource [TR])

- Assessment Checklist 1 Designing an Experiment

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Initiating and Planning

Outcomes	Focus for Learning
Students will be expected to	
5.0 develop and implement appropriate sampling procedures [GCO 2]	Students are expected to develop and, where applicable, implement appropriate sample sizes, sample selection techniques, measurement procedures, and data analysis procedures. This skill develops gradually over time, as students are exposed to investigations from different disciplines. In Biology 2201, students are expected to implement appropriate sampling procedures when using transects, quadrats, and mark-recapture to measure population sizes. Students should adhere to standardized procedures (e.g., random sampling) to ensure reliability of data and data collection methods. In addition to the investigation described above, SCO 5.0 may be addressed and assessed when students design an experiment to investigate factors affecting blood pressure.
6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]	A controlled experiment tests only one variable at a time, while keeping all other variables constant, to ensure that the findings are valid and unbiased. Occasionally, when conducting an experiment, unexpected problems arise (e.g., a confounding variable is identified). In these instances, procedures should be adapted or extended to ensure fair testing. Students are expected to • carry out procedures controlling the major variables, and • adapt or extend procedures, when problems arise, to ensure fair testing. SCO 6.0 is expected to be addressed and assessed when students measure the effects of intraspecific and interspecific competition on seedlings., and investigate passive transport and blood pressure. Additionally, this skill may be assessed whenever students are expected to follow directed procedures and carry out controlled experiments.

Initiating and Planning

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Distinguish between and provide examples of probability and non-probability sampling.
- Discuss the importance of sample size when making inferences about populations.
- Describe a population that needs to be estimated (e.g., lobster population in an area) and ask students to develop appropriate sampling procedures.
- Provide examples of situations where investigative procedures might need to be adapted or extended.

Students may

- Perform random sampling activities (e.g., Activity 2.1, *NL Biology*, p. 49).
- Analyze experimental procedures describing the sampling procedures used and discussing whether they were appropriate.
- Identify and evaluate the appropriateness of sampling procedures and sample sizes from experimental designs.
- Identify examples of situations where procedures might need to be adapted or extended.
- View video of their group or classmates conducting experiments and assess whether procedures were followed and confounding variables adequately controlled.

Consolidation

Teachers may

- Use direct observations to assess students' abilities to carry out procedures and control confounding variables.

Students may

- Describe in detail the sampling techniques and procedures employed when collecting data or information as part of investigations.
- Evaluate the sampling procedures of classmates or investigations and make suggestions for improvement.
- Communicate how procedures were adapted or extended after completion of an investigation.

Resources and Notes

Performing and Recording

Outcomes	Focus for Learning
Students will be expected to	
7.0 estimate quantities [GCO 2]	Estimating quantities is useful when • it is impractical to obtain precise quantities, • approximate quantities are sufficient for a task, • measuring to the appropriate number of significant digits, • selecting measurement instruments with sufficient capacity, • extrapolating and interpolating from graphs or data sets, and • roughly checking the accuracy of calculated values. Students are expected to • estimate population sizes and densities using transect, quadrat, and mark-recapture sampling techniques; • estimate the diameter of the field of view and specimen size when using microscopes; and • estimate the first uncertain digit when taking measurements as part of investigations (e.g., blood pressure, respiratory volume, enzyme activity).
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]	Students should compile and organize their data when conducting investigations. They should select and use formats (e.g., charts, diagrams, lists, tables, log books, maps, observational journals) and data treatments, appropriate for the task, that facilitate interpretation and analysis of their data. Often, the data recording format (e.g., table) is provided to students. To achieve SCO 8.0, however, students must create their own. When choosing appropriate formats, the most important criteria is ease of future interpretation. Data treatment refers to statistical procedures used (e.g., significant figures, data grouping, calculations, measures of central tendency, error handling). In Biology 2201, students are expected to compile and organize data when • measuring population sizes using transects, quadrats, and mark-recapture sampling; • investigating factors that affect passive transport; and • measuring respiratory volume. Should different student groups select different formats or data treatments when compiling and organizing similar data, they should evaluate their effectiveness with respect to ease of interpretation. SCO 8.0 may also be assessed whenever students collect data as part of an investigation.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss situations when estimation in used in daily life (e.g., estimating temperature, total cost of a set of items, wait times).
- Review appropriate ways to organize data (e.g., formats, significant digits, units) that facilitate future interpretation.

Connection

Teachers may

- Explicitly instruct students to record all certain digits and estimate the first uncertain digit when measuring.
- Recommend that digital images of analog instrument measurements be taken and enlarged to improve estimation of the first uncertain digit.
- Where possible, provide collections of similar instruments with varying scales. Ask students to estimate values and select the instrument with the most appropriate scale, based on their estimate.
- Provide students raw, unorganized data or information from an investigation and ask them to organize it in an appropriate format.

Students may

- Practice rough estimation of measurements and measure, using the appropriate number of significant digits, to evaluate the accuracy of their estimates.
- Use interpolation and extrapolation to estimate values from graphs.
- Brainstorm alternative ways to compile and organize data or information and discuss their advantages and disadvantages.

Consolidation

Teachers may

- In context, assess students' abilities to estimate population size and density, diameter of the field of view and specimen size when using microscopes, and when using measurement instruments.
- Allow different student groups to compile and organize data in different ways. Then ask students to compare the utility of the different formats.

Students may

- Compile and organize data collected as part of a science project.

Resources and Notes

Authorized

NL Science 10 (Student Resource [SR])

- pp. 714-716
- pp. 724-725

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Performing and Recording

Outcomes	Focus for Learning
Students will be expected to	
9.0 use library and electronic research tools to collect information on a given topic [GCO 2]	Students should use a broad range of research inquiry tools and techniques to gather information when investigating questions, ideas, problems, and issues. Review relevant, acceptable use of library and electronic research tools, practices, and policies. Students should continue to develop practical skills necessary to evaluate the validity, reliability, and bias of a source. They should determine origin of material and check sources for age appropriateness, organized links, and important and accessible information. They should also be able to use advanced search techniques and keywords. A review of citing, referencing, types of information, sources, and plagiarism may be necessary. In Biology 2201, students are expected to use research tools when researching • biomes; • social and environmental impacts of human overpopulation; • the impact of disorders and diseases on systems and the body; • medicine, drugs, and other factors affecting the nervous system; • factors affecting the respiratory system; • popular diets and their impact on homeostasis; and • dialysis and organ transplantation.
10.0 select and use apparatus and materials safely [GCO 2]	Routinely review safe and appropriate handling and use of apparatus, tools, and materials. When conducting investigations, students should use apparatus, tools, and materials safely, including, but not limited to, dissection kits and microscopes. Students should also effectively use personal protective and safety equipment, as required.
11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials [GCO 2]	WHMIS (Workplace Hazardous Materials Information System) was updated in 2015. While students have prior experience with WHMIS standards and techniques, their mastery should be assessed and documented prior to conducting any investigations. Routinely review WHMIS standards and proper techniques for safe handling and disposal of lab materials (e.g., chemicals, preserved specimens). Ensure that relevant safety data sheets (SDS) are available for student use. SCO 11.0 should be addressed and assessed when conducting investigations with hazardous materials. Students should demonstrate proper handling and disposal techniques for lab materials, and effectively use personal protective and safety equipment. Note, lab materials are inclusive of live specimens and preserved specimens for microscopy and dissection.

Performing and Recording

Sample Teaching and Assessment Strategies

An overview of proper safety policies and procedures in laboratory environments for students is required before undertaking any activities. This should be part of the school emergency plan and reviewed on an annual basis.

Connection

Teachers may

- Review research and citing protocol.
- Invite a representative from Newfoundland and Labrador Public Libraries or the teacher librarian to provide an overview of library services and databases.
- Initiate discussion regarding the reliability of online information sources and the benefits of peer reviewed sources.
- Demonstrate proper techniques for handling and disposing of lab materials at the outset of investigations, including preserved specimens for dissection.
- Model accidental chemical spills in the lab and ask students to use relevant SDS to identify proper handling and disposal techniques.

Students may

- Discuss the difference between a valid source and a reliable source when conducting research (i.e., a reliable source may not necessarily be valid).
- Develop information sheets for safe use of lab materials and apparatus.
- Review and apply safe handling procedures for microscopes and microscope slides (Appendix C, *NL Biology*, p.722).
- Locate relevant safety data sheets for a chemical bottle and identify potential hazards and appropriate storage, handling, and disposal techniques.

Consolidation

Teachers may

- Assess students' demonstrated knowledge of WHMIS standards and proper techniques for handling and disposing of lab materials.

Students may

- Use research inquiry to collect background information (i.e., literature review) for a science project.
- Use research inquiry to investigate a science-related idea or issue. Ensure use of proper sources and citations including a bibliography.

Resources and Notes

Authorized

NL Science 10 (TR)

- pp. v-vii
- Assessment Checklist 7 Independent Research Skills

NL Science 10 (SR)

- pp. xiv-xvi, 722

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Analyzing and Interpreting

Outcomes	Focus for Learning
Students will be expected to	
12.0 describe and apply classification systems and nomenclatures used in the sciences [GCO 2]	Classification systems and nomenclatures are human constructs that attempt to make sense of the physical world. Note, for the purposes of Biology 2201, nomenclature is broadly defined to include all discipline-related terminology (i.e., not limited to binomial nomenclature). In Biology 2201, this outcome is addressed when students describe and apply nomenclatures used in ecological hierarchy (i.e., individual organism, population, community, ecosystem). It should be assessed, however, whenever students describe phenomena using specific terminology (e.g., ecosystem interactions, microscope use, biochemical molecules, cell types and structures, types of membrane transport, structure and function of plant tissues, structure and function of human body systems, homoeostatic feedback mechanisms).
13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]	Students should compile and display evidence and information in a variety of formats: • Diagrams are used to symbolically represent information. • Flow charts are used to represent a process. • Tables organize data and information into labelled columns and rows. • Graphs (e.g., bar, histogram, pictograph, line) help visualize relationships in data. • Scatter plots are used to determine the degree of correlation between variables. Students should select the most appropriate format to represent their evidence or information and, where possible, use digital technologies in their creation. Representations should be clear, concise, and include titles, headings, labels, scales, and units, where appropriate. Note, *Appendix A* (pp. 130-132) provides elaboration on rules and suggestions for presenting data and information in graphs, tables, and biological drawings. In Biology 2201, SCO 13.0 is specifically addressed when students • illustrate the transfer of energy through trophic levels using an energy pyramid, • construct graphs to illustrate change in population size over time, • describe population growth models for exponential and logistic growth, • create biological drawings of plant and animal cells viewed with a microscope, and • investigate enzyme activity. This skill may be assessed, however, whenever students compile and display evidence and information as part of research inquiry and designed experiments.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Describe examples of classification systems and nomenclatures used in biological sciences.

Connection

Teachers may

- Review appropriate use of diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots to compile and display data and how to draw a line of best fit.
- Stress the importance of including titles, labelling axes, and choosing appropriate scales when displaying data in a graph.
- Highlight and discuss common graphing errors (e.g., selecting inappropriate type, variables on wrong axes, incorrect scaling).

Students may

- Justify selection of a particular format to compile and display data or information from an investigation.

Consolidation

Teachers may

- Provide raw, unorganized data or information compiled from an investigation. Ask students to accurately display the data or information in an appropriate, selected format.

Students may

- Compile and display data and information from class investigations and science projects in appropriate formats, including diagrams, flow charts, tables, graphs, and scatter plots.
- Compile and display data and information using a variety of digital technologies.

Resources and Notes

Authorized

NL Science 10 (SR)

- Appendix D, p. 727

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Analyzing and Interpreting

Outcomes	Focus for Learning
Students will be expected to	
14.0 identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit [GCO 2]	Students have experience, from previous science courses, identifying a line of best fit and interpolating or extrapolating based on that line. A line of best fit (curved or straight) represents the trend in data. Students should make the smoothest curve possible, evenly balancing points that do not fit the curve above and below. Where a point is far off the line, an error may have been made. A dotted line should be used when extending the curve beyond the data set. Interpolation is the process of estimating values between points within the data set. Extrapolation is estimating values beyond the limits of the data set. Students are expected to create graphs and, where applicable, identify the line of best fit. They should interpolate and extrapolate based on that line of best fit. This skill is specifically addressed when students construct and interpret graphs illustrating changes in population size over time. It may be assessed, however, whenever students analyze and interpret scatter plots.
15.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]	Students should analyze data and apply mathematical models to develop and assess possible explanations. Analyzing data includes interpreting trends and patterns, and inferring or calculating relationships. • A trend is the general tendency of a data set to change. While individual data points may vary, the overall data trends in one direction. • Patterns refer to data or information that repeat in a predictable way. • Relationships are similar to trends, but have a clear mathematical relationship (e.g., linear relationship). Identifying trends, patterns, and relationships requires accurate representation of data in tables, graphs, and scatter plots. SCO 15.0 is specifically addressed when students interpret graphs illustrating changes in population size over time and analyze factors influencing population growth. The skill may also be assessed when students analyze data from personally designed experiments to investigate the effect of selected factors on the rate of passive transport and blood pressure.
16.0 compare theoretical and empirical values and account for discrepancies [GCO 2]	Students are expected to compare theoretical values with empirical values obtained through observation or investigation, calculate the percentage error, and account for any discrepancies. Discrepancies may be caused by confounding variables or procedural and measurement errors. Students should also suggest changes to investigations to improve the reliability of data. In Biology 2201, SCO 16.0 is addressed when students compare known population sizes with population estimates measured using sampling techniques and analysis of simulated urine data.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Present exemplars of tables and graphs illustrating typical trends and patterns in data, and linear and non-linear relationships.
- Model interpreting patterns and trends in data and inferring or calculating linear and non-linear relationships among variables.
- Demonstrate examples of discrepancies between theoretical and empirical values and use the values to calculate percent discrepancy.

Students may

- Draw lines of best fit by hand and using digital technologies.
- Identify discrepancies within and among data sets and suggest explanations for them.

Consolidation

Teachers may

- Present graphs and ask students to
  - explain what the graph is communicating,
  - interpolate and extrapolate information,
  - identify patterns or trends,
  - infer relationships among variables, and
  - calculate, where possible, linear and non-linear relationships.

Students may

- Interpret patterns and trends, and infer and calculate relationships, in data compiled and displayed as part of class investigations and science projects.

Resources and Notes

Analyzing and Interpreting

Outcomes	Focus for Learning
Students will be expected to	
17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods [GCO 2]	Students are expected to evaluate data and data collection methods or instruments with respect to • relevance (i.e., Is the data collection method or instrument appropriate for the task? Does the collected data help answer the question investigated?); • reliability (i.e., Is the data accurate? Does the data collection method or instrument tool produce consistent, reproducible data?); and • adequacy (i.e., Is the quality and quantity of the data sufficient to draw a conclusion?). Following evaluation, students should suggest changes to investigations to improve the relevance, reliability, and adequacy of data and data collection methods. They should identify outliers in data sets and justify their exclusion from analysis. SCO 17.0 is specifically addressed when students • estimate population sizes using transects, quadrats, and mark-recapture sampling techniques; and • investigate factors affecting passive transport. The skill may be assessed, however, whenever students analyze or collect data.
18.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty [GCO 2]	Error and uncertainty exist in every measurement, but, with care and refinement of procedures, they can be reduced. Students should identify and explain sources of error in measurement, including systematic and random errors. Systematic errors consistently cause measurements to be too high or too low. They may be caused by faulty or inaccurate measurement tools and instruments or their incorrect use. While difficult to identify, systematic errors can be eliminated. Random errors in measurement occur without a pattern. Some will be too high and others too low. These errors may be reduced by increasing sample size and repeating trials and averaging the measurements. Students are expected to express data and results using the appropriate number of significant digits for the measuring device and apply significant figure rules when performing calculations. These rules can be found in Appendix A. Note, scientific notation is not addressed in Mathematics curriculum. SCO 18.0 is specifically addressed when students design an experiment to investigate factors affecting passive transport. It may be assessed, however, throughout the course whenever students carry out investigations and take measurements.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Review what is meant by relevance, reliability, and adequacy of data and data collection methods and provide examples of irrelevant, unreliable, and inadequate data and methods.
- Present published scientific investigations and collaboratively evaluate the data and data collection methods.
- Demonstrate and discuss possible source of error when using specific tools and instruments for measurement.
- Differentiate between random and systematic errors.
- Discuss outliers and rationale for their exclusion from data analysis.
- Provide rules for the use of significant digits and model their use when measuring and performing calculations.

Students may

- Review student lab reports and evaluate their data and data collection methods for relevance, reliability and adequacy.
- Identify examples of potential random and systematic errors when using specific measuring tools and instruments (e.g., sphygmomanometers).
- View video of classmates carrying out investigations to identify sources of error and then make suggestions to reduce error.
- View enlarged digital images of measurements using analog instruments and discuss how the results should be expressed.

Consolidation

Teachers may

- Require students to examine and comment on sources of error when writing conclusions for investigations.

Students may

- Identify and explain ways to reduce errors in investigations.
- Review and comment on relevance, reliability, and adequacy of sampling procedures used to estimate population sizes.

Resources and Notes

Authorized

Appendices

- Appendix A

NL Science 10 (SR)

- pp. 714-716

Analyzing and Interpreting

Outcomes	Focus for Learning
Students will be expected to	
19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]	Following analysis of data and evidence, students should draw conclusions. Conclusions should • be evidence based; • relate to the hypothesis, summarizing whether it is supported or refuted; • compare empirical results with expected results; • comment on sources of error and measurement uncertainty; • discuss possible applications of findings; and • identify new questions to investigate further. This skill is specifically addressed when students investigate selected factors affecting blood pressure and the impact of temperature and pH on enzyme activity, however, it may be assessed whenever students perform investigations.
20.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan [GCO 2]	SCO 20.0 is applied in the context of problem solving processes. As part of this process, students should propose alternative solutions to practical problems, identify the strengths and weaknesses of proposed alternatives, and select a preferred solution to serve as the basis for an action plan. In Biology 2201, this skill outcome is addressed when students evaluate the strengths and weaknesses of proposed solutions to human overpopulation and its social and environmental effects. Students should • propose or research alternative solutions, • identify the strengths and weaknesses of proposed alternatives, • evaluate proposed alternatives based on solution criteria, and • select a preferred alternative to formulate a plan to address the issue or solve the problem. Graphic organizers may be helpful when evaluating the strengths and weaknesses of alternative solutions.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present images of various problem solving and decision making processes. Highlight where alternatives are identified and analyzed in the processes.

Connection

Teachers may

- Provide a checklist of expectations for writing conclusions.
- Model drawing conclusions from investigations and provide exemplars of well written conclusions.
- Model proposing and considering alternative solutions to practical problems.
- Model use of *Cost-Benefit Analysis and Consequence Mapping* learning strategies (Let's Talk Science).

Students may

- Use graphic organizers (e.g., PMI chart, t-chart) to compare the potential strengths and weakness of alternative solutions.
- Conduct research to identify and consider possible alternative solutions to problems.
- Predict the outcome of selecting possible alternative solutions.

Consolidation

Teachers may

- Provide a formal lab report with the conclusion omitted. Ask students to write a conclusion for the report.

Students may

- Provide written conclusions for investigations conducted in class and science projects.
- Use a cost-benefit analysis to identify strengths and weaknesses of alternatives solutions.

Resources and Notes

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Let's Talk Science - Learning Strategies

Communication and Teamwork

Outcomes	Focus for Learning
Students will be expected to	
21.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results [GCO 2]	In science, effective communication is critical. It requires scientists and students to appropriately select and use numbers, symbols, graphical representations, and oral and written language to communicate their questions, ideas, plans, and results. Students should use appropriate modes of representation to communicate when • asking questions about relationships among variables; • planning investigations of questions, ideas, problems, and issues; • conducting investigations into relationships among variables; • using tools and techniques to gather and record data and information; • analyzing data and applying mathematical and conceptual models to develop and assess possible solutions; • working as a team member to solve problems; and • applying the skills and conventions of science in communicating information and ideas and in assessing results. SCO 21.0 is ubiquitous throughout the Biology 2201 curriculum. It may be assessed whenever students communicate ideas, plans, and results.
22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information [GCO 2]	As part of research inquiry, students should synthesize information from multiple sources (i.e., combine elements) to make inferences. Synthesizing involves drawing together information according to identified themes or traits. It involves making connections, and reorganizing and combining ideas. This enables students to make inferences based on the information and construct clear and coherent arguments and explanations. Emphasize the importance of evaluating sources of information in terms of their relevance, reliability, and adequacy. SCO 22.0 is specifically addressed when students engage in research inquiry to investigate biomes, the social and environmental impacts of human overpopulation, popular diets, and issues surrounding organ transplants.
23.0 identify multiple perspectives that influence a science-related decision or issue [GCO 2]	Individuals may hold strong feelings about scientific, technological, social, and environmental issues. Their perspective influences their position on issues and their decisions. When analyzing issues, students should identify relevant stakeholders and seek to understand their differing perspectives (i.e., How do they define or perceive the issue? What assumptions do they make? What are their values?). Understanding and respecting differing perspectives is an essential component of effective collaboration within problem solving and decision making processes. This skill is specifically addressed when students investigate the social and environmental impacts of human overpopulation and examine issues surrounding organ transplants.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Encourage students to think aloud, orally communicating their questions, ideas, and intentions when conducting investigations.
- Request students digitally record their group communication when conducting investigations. Recordings may be used for assessment of students' communication skills.
- Use checklists to assess student use of scientific terminology when investigating.
- Provide guidelines for creating formal lab reports.
- Review how to effectively communicate findings using diagrams, flow charts, tables and graphs.
- Provide opportunities for student groups to communicate the findings of investigations in a format of their choosing. Then, compare and discuss the effectiveness of the different formats.
- Discuss the multiple perspectives that have influenced the historical acceptance of the concepts and ideas in biology.
- Present and use the *Issues and Stakeholders* learning strategy from Let's Talk Science to identify the issues and key stakeholders associated with a science-related problem or decision.

Students may

- Brainstorm ideas related to what effective science communication looks and sounds like.
- Consider the pros and cons of representing a set of data using a table or a graph.
- Brainstorm possible stakeholders and their perspectives when considering science-related decisions or issues.

Consolidation

Teachers may

- Assess effective science communication (i.e., use appropriate numeric, symbolic, graphical, and linguistic modes of representation) in formal lab reports.

Students may

- Use appropriate modes of representation to communicate ideas, plans, and results of in-class investigations and science projects.
- Use various sources to develop arguments in support of a position or course of action related to a decision or issue.
- Adopt a specific stakeholder perspective and debate science-related decisions and issues with peers.

Resources and Notes

Authorized

NL Science 10 (TR)

- Assessment Checklist 7 Independent Research Skills
- Assessment Checklist 8 Oral Presentation Skills

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Communication and Teamwork

Outcomes	Focus for Learning
Students will be expected to	
24.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]	Most scientists work in collaborative environments with other scientists and capitalize on their specialized expertise. Cooperation and teamwork are essential skills for success in these environments. Students should work cooperatively in science contexts. They should • willingly work with others and accept assigned roles; • communicate effectively, listen, and respond appropriately; • seek out other points of view and consider multiple perspectives; • suspend personal judgement and objectively evaluate the ideas of others; and • provide and accept constructive criticism. SCO 24.0 is specifically addressed during microscope and dissection labs, and when proposing courses of action on issues related to organ donation and transplantation. It may also be assessed whenever students work together in pairs or small groups to investigate questions, ideas, problems, and issues.
25.0 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task [GCO 2]	When working in pairs or small groups, students should reflect on and evaluate individual and group processes used in planning, problem solving, and decision making. How did the group, for example, • assign roles and responsibilities; • ensure respectful communication; • ensure individuals took responsibility for assigned tasks, errors made, and difficulties encountered; • ensure equal participation of all individuals; • ensure that the contributions of all individuals were valued; • address conflict or differences of opinion; and • enable everyone to participate in making decisions? How was the plan, solution, or decision influenced by these processes? Students should identify processes and procedures that proved helpful and make suggestions to improve task completion for future group activities. SCO 25.0 should be assessed whenever students work together in pairs or small groups to investigate questions, ideas, problems, and issues.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Organize students in pairs and small groups, where possible, to investigate problems, issues, and decisions.

Students may

- Share past experiences related to cooperative group work and develop a set of guidelines or best practices.

Connection

Teachers may

- Predetermine roles and responsibilities for groups to assign when carrying out tasks (e.g., manager/facilitator, recorder, presenter, questioner).
- Present and use the *Issues and Stakeholders* learning strategy from Let's Talk Science to identify the issues and key stakeholders associated with a science-related problem or decision.

Students may

- View cooperative and collaborative group rubrics and create a list of essential characteristics.
- Collaboratively develop a rubric to assess cooperation in group settings from previously established guidelines and best practices.

Consolidation

Students may

- Self and peer evaluate cooperation in science contexts when developing and carrying out plans and trouble shooting problems. Suggest processes and procedures that might improve future collaboration.

Resources and Notes

Authorized

NL Science 10 (TR)

- Assessment Checklist 3 Performance Task Self-Assessment
- Assessment Checklist 4 Performance Task Group Assessment

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Learning Strategies - Let's Talk Science

Section Three:
Specific Curriculum Outcomes

Unit 1: Ecosystem Interactions and Population Dynamics

Focus

At the biome and biosphere levels of biological organization, there are many complex interactions between biotic and abiotic factors. Building on their understanding of ecosystems and certain principles of population dynamics, it is important that students understand the many interrelationships affecting population growth, including human population growth.

This unit has a strong inquiry focus. Students will use research inquiry to compare Canadian biomes and examine human overpopulation causes, effects, and solutions. They will develop and implement population sampling techniques to estimate population size and density through first-hand field experiences and design and carry out an investigation to measure the effects of intraspecific and interspecific competition among seedlings.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 26.0 identify and describe science- and technology-based careers related to this science
- 27.0 analyze natural systems to interpret and explain their structure and dynamics
- 32.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology
- 34.0 provide examples of how science and technology are an integral part of their lives and their community
- 35.0 distinguish between scientific questions and technological problems
- 36.0 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

- 28.0 analyze interactions within and between populations
- 29.0 use the concept of the energy pyramid to explain the production, distribution, and use of food resources
- 30.0 compare Canadian biomes in terms of climate, vegetation, physical geography, and location
- 31.0 describe population growth and explain factors that influence population growth
- 33.0 evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

1.0 define and delimit problems to facilitate investigation
2.0 identify questions to investigate that arise from practical problems and issues
3.0 design an experiment identifying and controlling major variables
4.0 formulate operational definitions of major variables
5.0 develop and implement appropriate sampling procedures
6.0 carry out procedures controlling the major variables and adapting or extending procedures where required
7.0 estimate quantities
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
9.0 use library and electronic research tools to collect information on a given topic
12.0 describe and apply classification systems and the nomenclatures used in the sciences
13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
14.0 identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit
15.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
16.0 compare theoretical and empirical values and account for discrepancies
17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
20.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
23.0 identify multiple perspectives that influence a science-related decision or issue

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- appreciate that the applications of science and technology can raise ethical dilemmas
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- consider further studies and careers in science- and technology-related fields
- use factual information and rational explanations when analyzing and evaluating
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- want to take action for maintaining a sustainable environment
- be aware of the direct and indirect consequences of our actions

SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 1206	Biology 2201	Biology 3201
Sustainability of Ecosystems	*Ecosystem Interactions and Population Dynamics*	*Evolutionary Change and Diversity*
• explain why ecosystems with similar characteristics can exist in different geographical locations • explain various ways natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem • illustrate and explain the cycling of matter through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen • describe the mechanisms of bioaccumulation and explain its potential impact on the viability of and diversity of consumers at all trophic levels • analyze the impact of external factors on an ecosystem • explain how the biodiversity of an ecosystem contributes to its sustainability • explain why different ecosystems respond differently to short-term stresses and long-term changes	• analyze interactions within and between populations • use the concept of the energy pyramid to explain the production, distribution, and use of food resources • compare Canadian biomes in terms of climate, vegetation, physical geography, and location • describe population growth and explain factors that influence population growth • evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources	• analyze evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction • use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy

Suggested Unit Plan

The *Ecosystem Interactions and Population Dynamics* unit is positioned at the beginning of Biology 2201 to capitalize on opportunities for first-hand field experiences when exploring local ecosystems and implementing sampling techniques to estimate population size and density.

<table>
<tr><th>September</th><th>October</th><th>November</th><th>December</th><th>January</th><th>February</th><th>March</th><th>April</th><th>May</th><th>June</th></tr>
<tr><td colspan="2">Ecosystem Interactions and Population Dynamics</td><td colspan="3">Processes that Sustain Life</td><td colspan="5">Maintaining Homeostasis</td></tr>
<tr><td colspan="10">Skills Integrated Throughout</td></tr>
</table>

Hierarchical Levels Scientists Use to Describe the Biosphere

Outcomes	Focus for Learning
Students will be expected to	
26.0 identify and describe science- and technology-based careers related to this science [GCO 1]	Students are expected to identify and describe science- and technology-based careers related to biology. As the unit progresses, they should examine careers related to the study of biomes, ecosystem interactions, resource production, distribution and use, and population dynamics (e.g., population ecologist, climatologist, agronomist, resource manager, eco-economist, nutritionist). Interactions within and the sustainability of ecosystems was introduced and addressed in Science 7 and Science 1206.
12.0 describe and apply classification systems and the nomenclatures used in the sciences [GCO 2]	In Biology 2201, students should apply hierarchical level nomenclature to describe the biosphere. They should • define ecology; • describe and explain the interrelationships among individual organisms, species, populations, communities, and ecosystems; • recognize that ecosystems vary in size depending on the focus of research; and • describe and explain the interrelationships among ecosystems, biomes, and the biosphere. Refer to the *Integrated Skills* unit for elaboration of SCO 12.0. Note, explaining how organisms are classified into domains and kingdoms, and named using binomial nomenclature, are not expectations of Biology 2201. Binomial nomenclature should be introduced, however, to facilitate communication about living things using scientific names.
	Attitude Encourage students to consider further studies and careers in science- and technology-related fields. [GCO 4]
	Sample Performance Indicator Select a local ecosystem. Research and/or make field observations about the individuals, populations, and communities that live in the ecosystem, and their interactions. Prepare a presentation about your ecosystem to share with others.

Hierarchical Levels Scientists Use to Describe the Biosphere

Sample Teaching and Assessment Strategies

Activation

Students may

- Make a list of all the different plants, animals, and fungi they observe evidence of during a 15 minutes trip around their school.
- Create a concept map of their ecosystem-related knowledge.
- Complete unit preparation questions related to ecological hierarchies and classification of organisms (*NL Biology*, p. 4).

Connection

Teachers may

- Invite individuals in biology-related careers to present to students.
- Present visual field guides of flora and fauna in local ecosystem.
- Present articles or videos depicting specific ecosystems. Ask students to describe the individual organisms, populations, and communities that live in the ecosystem.
- Create a word wall of unit terminology for student reference.

Students may

- Explore science- and technology-based careers related to ecosystem interactions and population dynamics (Career Focus, *NL Biology*, pp. 100-101).
- Apply hierarchical level nomenclature when describing local terrestrial and aquatic ecosystems.
- Brainstorm factors that sustain a population within an ecosystem.
- Discuss whether a lichen covered rock, fallen tree, or a decomposing whale might be considered an ecosystem.
- Create a personal print or digital glossary of important terminology and add to it as the unit progresses.

Consolidation

Students may

- Create a career profile page for a relevant science- or technology-based career. Include a “day in the life” paragraph. Profiles may be housed in a print or digital portfolio which is added to as the course progresses.
- Use a variety of coins, or similar small items, to create an analogy comparing and contrasting individual organisms, populations, communities, and ecosystems.

Resources and Notes

Authorized

NL Biology
(Teacher Resource [TR])

- Unit 1 pp. 1-5

NL Biology
(Student Resource [SR])

- pp. 2-11, 100-101

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Career Profiles - Let’s Talk Science

How Energy Enters and Flows Through the Biosphere

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

28.0 analyze interactions within and between populations [GCO 3]

29.0 use the concept of the energy pyramid to explain the production, distribution, and use of food resources [GCO 3]

13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

Focus for Learning

In Science 1206, students explained how matter cycles through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen. The focus in Biology 2201 is the flow of energy through the biosphere. Students should

- explain how energy enters the biosphere through the processes of photosynthesis and chemosynthesis;
- describe how energy is converted through the activities of producers (i.e., autotrophs) and consumers (i.e., heterotrophs);
- analyze and explain what happens to energy as it transfers through trophic levels (i.e., first trophic level, second trophic level, third trophic level, quaternary trophic level);
- illustrate and describe the transfer of energy through trophic levels using an energy pyramid; and
- predict and explain how changes within one trophic level may affect a higher or lower trophic level and energy transfer through the ecosystem.

Note, skill outcome 13.0 should be assessed when students construct energy pyramids to illustrate energy transfer through the biosphere.

Attitude

Encourage students to use factual information and rationale explanations when analyzing and evaluating. [GCO 4]

Sample Performance Indicator

Analyze energy transfer in various human diets (e.g., meat-based, vegetarian, pescetarian) using energy pyramids. Explain how the production of food resources for these diets might influence the number of humans that Earth can support.

How Energy Enters and Flows Through the Biosphere

Sample Teaching and Assessment Strategies

Activation

Students may

- Complete unit preparation questions related to interactions among organisms (*NL Biology*, p. 4-5).
- Compare and contrast photosynthesis and cellular respiration.

Connection

Teachers may

- Discuss the importance of phytoplankton to aquatic ecosystems.
- Describe how the first and second laws of thermodynamics relate to the transfer of energy through the biosphere.
- Facilitate a discussion regarding the limitations of various models used to illustrate the flow of matter and energy through ecosystems.
- Assess the effectiveness of student-constructed energy pyramids in communicating information.

Students may

- Relate trophic levels (i.e., first trophic level, second trophic level, etc.) to previously learned terminology used to describe feeding relationships
  - herbivore, carnivore, omnivore; and
  - producer, primary consumer, secondary consumer.
- Describe how they personally gain, use, and lose their energy.
- Construct energy pyramids from provided data.
- Add specific terminology related to energy transfer in the biosphere to their personal glossary.

Consolidation

Students may

- Compare and contrast how matter and energy move through the biosphere.
- Examine food webs and predict what might happen if organisms at one trophic level are removed or negatively affected by an environmental change (Activity 1.3, *NL Biology*, p. 27).
- Discuss whether energy pyramid can be inverted.
- Consider how the introduction of a non-native species might impact energy pyramids.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 7-12

NL Biology (SR)

- pp. 17-29

Biomes

Outcomes

Students will be expected to

30.0 compare Canadian biomes in terms of climate, vegetation, physical geography, and location [GCO 3]

1.0 define and delimit problems to facilitate investigation [GCO 2]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information [GCO 2]

Focus for Learning

Students are expected to research a biome of personal interest. Information gathered should include, but is not limited to,

- location,
- climate,
- physical geography,
- dominant flora and fauna, and
- other abiotic and biotic factors of importance to the biome.

Skill outcomes 1.0, 9.0, and 22.0 should be addressed and assessed as part of this research investigation. SCOs 13.0, 21.0, 24.0, and 25.0 may also be assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Students should

- identify the locations of Canadian terrestrial biomes (i.e., tundra, boreal forest, temperate deciduous forest, prairie grassland);
- describe the abiotic and biotic conditions in Canadian terrestrial biomes and explain how these conditions affect the ecosystem;
- understand that the distribution pattern of a species is largely due to abiotic factors and their range of tolerance with respect to those factors;
- describe the abiotic and biotic conditions in aquatic biomes (i.e., marine, estuaries, and freshwater); and explain how these conditions affect the ecosystem; and
- explain why ecotones are biodiverse.

Attitude

Encourage students to acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Sample Performance Indicator

Present the findings of research on a biome of personal interest in an appropriate format of your choosing.

Biomes

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present visuals of different terrestrial and aquatic biomes and ask students to identify the biome and predict its abiotic and biotic conditions, and potential interactions.

Connection

Teachers may

- Limit the biomes researched to Canadian terrestrial and aquatic biomes. A cooperative jigsaw method may be used to facilitate research and communication of specific biome information to classmates.
- Present articles or videos describing specific biomes. Ask students to identify their principle abiotic and biotic conditions.
- Use collaboratively developed rubrics to assess skill outcomes.

Students may

- Analyze global, national, and regional maps depicting the distribution of biomes.
- Analyze Figure 1.21 (*NL Biology*, p. 31) and interpret patterns in terrestrial biomes.
- Explain what determines the range of tolerance of a species.
- Respond to the statement “The biotic factors of a biome are determined by its abiotic factors”.
- Compare different formats selected by classmates to communicate the findings of their biome research, identifying strengths and weaknesses.

Consolidation

Students may

- Compare two or more Canadian terrestrial biomes using a graphic organizer.
- Debate which abiotic condition(s) is most important to aquatic biomes.
- Discuss the potential impact of climate change on biome distribution.

Extension

Students may

- Compare abiotic and biotic conditions in different marine biome zones (i.e., neritic, bathyal, abyssal, and intertidal zones).
- Compare abiotic and biotic conditions in different freshwater zones (i.e., littoral, limnetic, and benthic zones).

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 13-17
- Assessment Checklist 7 Independent Research Skills

NL Biology (SR)

- pp. 30-43

Notes

The magnifying glass icon is used throughout the unit to indicate investigations.

Describing Characteristics of Populations

Outcomes

Students will be expected to

31.0 describe population growth and explain factors that influence population growth [GCO 3]

5.0 develop and implement appropriate sampling procedures [GCO 2]

7.0 estimate quantities [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

16.0 compare theoretical and empirical values and account for discrepancies [GCO 2]

17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods [GCO 2]

Focus for Learning

Ecologists use quantitative measurements to study and describe populations.

Students should

- define population size (*N*) and population density (*Dp*);
- describe and compare techniques used to estimate population sizes (i.e., sampling using transects, quadrats, and mark-recapture);
- conduct separate investigations to estimate population size and density using each of the following sampling techniques:
  1. Transects (e.g., estimate the population size and density of balsam fir trees in a forested area).
  2. Quadrats (e.g., estimate the population size and density of sea snails on a beach).
  3. Mark-recapture (e.g., estimate the size of the student population within a school).

  While each technique can be modelled within the classroom, first-hand field experiences are the expectation.

  Skill outcomes 5.0, 7.0, 8.0, 17.0, and, where applicable, 16.0 should be addressed and assessed. Note, to achieve SCO 8.0, students must create their own data table. SCOs 6.0, 13.0, 18.0, 19.0, 21.0, 24.0, and 25.0 may also be assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.
- solve problems to estimate population size and density for fictitious populations;
- compare and contrast uniform, random, and clumped distribution patterns; and
- explain how population distribution patterns relate to resource distribution, resource abundance, and interactions between population members.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Sample Performance Indicator

1. Random Island has a total area of approximately 310 km^2. Develop and describe appropriate sampling procedures to reliably estimate the island's moose population size and density.
2. Compare resource distribution and resource abundance for typical populations representing the three distribution patterns.

Describing Characteristics of Populations

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Facilitate Activity 2.1 (*NL Biology*, p. 49) to discuss the importance of random sampling and ensuring that data is not biased.
- Facilitate in class activities to model the estimation of population size and density using different sampling techniques. Ask students to compare their estimated population sizes with the actual numbers, where possible, and evaluate the effectiveness of the sampling process.
  - quadrats (e.g., estimate confetti population using floor tiles);
  - transects (e.g., Activity 2.3, *NL Biology*, p. 52); and
  - mark-recapture (e.g., estimate white kidney bean population by replacing captured sample with red kidney beans and recapturing.
- Create quadrats for in class modelling activities using 24 can cardboard carrier trays.
- Invite individuals in careers related to fisheries, forestry, and wildlife to present to students on population sampling processes.
- Provide examples of positive, negative, and neutral interactions between population members and describe how they result in clumped, uniform, and random distribution patterns.

Students may

- Explain why counting each individual organism in a population is impractical.
- Calculate discrepancies between actual and estimated populations, when appropriate.
- Develop and implement a mark-recapture sampling procedure to estimate the population of coins in a coin bank.
- Practice solving problems to estimate population size and density of fictitious populations (e.g., Activity 2.2, *NL Biology*, p. 50).

Consolidation

Students may

- Develop reliable methods to estimate the size and density of various populations (e.g., coyote, white spruce, blue shark, capelin, caribou, eel grass, osprey, pine marten, snow crab).
- Evaluate the effectiveness of sampling procedures with respect to bias and the reliability and adequacy of data.
- Investigate how distribution patterns might influence estimates of population size (Activity 2.4, *NL Biology*, pp. 53-54).

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 18-24

NL Biology (SR)

- pp. 44-54

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/teaching-and-learning-strategies.html
  - Population Labs

Describing Changes in Population Size

Outcomes

Students will be expected to

31.0 describe population growth and explain factors that influence population growth [GCO 3]

13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

14.0 identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit [GCO 2]

15.0 interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables [GCO 2]

Focus for Learning

In Science 1206, students examined density dependent and independent factors influencing population equilibrium and were introduced to the concept of a carrying capacity.

In Biology 2201, students should

- define demography;
- identify and describe the factors that change population size (i.e., births [*b*], deaths [*d*], immigration [*i*], emigration [*e*]);
- calculate changes in population size, $\Delta N = (b+i) - (d+e)$;
- construct and interpret graphs to illustrate change in population size over time, identifying the curved line of best fit, where appropriate;
- define biotic potential and relate the concept to a species' fecundity;
- compare and describe the population growth models for exponential and logistic growth;
- identify and explain factors that limit population growth (i.e., environmental resistance);
- compare and contrast *r*- and *K*-selected life strategies; and
- use the life strategy of a species to predict its success in specific habitats.

When constructing and interpreting graphs illustrating change in population growth, skill outcomes 13.0, 14.0, and 15.0 should be assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Note, human population growth is addressed later in the unit.

Sample Performance Indicators

- Sketch and explain the predicted population growth curve for
  - an insect species capable of infesting an area when growing at its biotic potential, and
  - a mammal in a limited environment.
- A population of hares is at the carrying capacity of its habitat when several mating pairs of foxes are introduced. Predict and explain how the populations of both species will change over time. Construct a double line graph to illustrate your prediction.
- Many threatened, endangered, and at risk species have a *K*-selected life strategy. Explain why populations with this strategy are likely at risk.

Describing Changes in Population Size

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Relate population growth rate to the slope of its growth curve.
- Describe examples of local and regional population explosions and crashes.

Students may

- Brainstorm factors that might limit population growth and classify them as density-dependent or density-independent.
- Examine population change data for specific communities and relate to factors such as births, deaths, immigration, and emigration.
- Construct graphs of population data to illustrate change in population size over time (e.g., Launch Lab, *NL Biology*, p. 45) and identify the curved line of best fit.
- Describe environmental resistance and explain how it relates to population growth.

Consolidation

Students may

- Solve problems involving change in population size calculations. For example,
  - A meadow vole population grew from 150 to 245 in one year. If 103 voles were born, 43 emigrated, and 56 immigrated, what was the total mortality for the year?
- Complete Investigation 2.A (*NL Biology*, pp. 64-65) to estimate the population size of spotted turtles using mathematical models.
- Compare and contrast exponential and logistic growth models.
- Sketch and describe the population growth curves for introduced species such as moose, coyotes, and European green crab. Explain factors that might influence their population growth.
- Using a graphic organizer, compare and contrast the characteristics of populations with typical *r*-selected and *K*-selected life strategies
- Argue the validity of the statement “all habitats have a carrying capacity”.
- Complete Investigation 2.D (*NL Biology*, p. 77) to calculate and interpret population density and changes in bear population sizes.

Extension

Students may

- Research and report on a local plant or animal that has a *r*-selected or *K*-selected life strategy.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 24-27

NL Biology (SR)

- pp. 58-67

Interactions in Ecological Communities

Outcomes

Students will be expected to

28.0 analyze interactions within and between populations [GCO 3]

31.0 describe population growth and explain factors that influence population growth [GCO 3]

1.0 define and delimit problems to facilitate investigation [GCO 2]

3.0 design an experiment identifying and controlling major variables [GCO 2]

4.0 formulate operational definitions of major variables [GCO 2]

6.0 carry out procedures controlling the major variables and adapting or extending procedures where required [GCO 2]

32.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology [GCO 1]

Focus for Learning

Students should

- describe interactions among population members (intraspecific) and among members of different populations (interspecific) within a community;
- distinguish between and explain examples of intraspecific and interspecific competition; and
- design and carry out investigations, in small groups, to measure the effects of intraspecific and interspecific competition among seedlings (e.g., Investigation 2.B, *NL Biology*, pp. 70-71).

  Skill outcomes 1.0, 3.0, 4.0, and 6.0 should be assessed as part of this student designed investigation. Additionally, teachers may assess students' abilities to
  - compile, organize, and display data and evidence (8.0, 13.0);
  - interpret and evaluate the reliability of data (15.0, 17.0);
  - explain sources of error and draw conclusions (18.0, 19.0);
  - communicate ideas, plans, and results (21.0); and
  - evaluate individual and collaborative group processes (25.0).

  Refer to the Integrated Skills unit for elaboration of these SCOs.
- distinguish between and classify examples of symbiotic relationship types (i.e., commensalism, mutualism, parasitism);
- analyze and explain how factors such as competition, symbiosis, and the introduction of non-native species influence population growth;
- examine cases where non-native species were intentionally introduced to an area, including as a form of biological population control (e.g., Investigation 2.E, *NL Biology*, p. 78); and
- analyze the risks and benefits to society and the environment of non-native species introductions.

Attitudes

Encourage students to

- appreciate that the applications of science and technology can raise ethical dilemmas, and
- be aware of the direct and indirect consequences of our actions. [GCO 4]

Sample Performance Indicators

1. Construct a graph to illustrate predicted population cycles for parasite-host relationships. Describe the pattern and provide a hypothesis to explain it.
2. Design an experiment to measure the effect of intraspecific competition on adult goldfish. Devise a detailed procedure that operationally defines the independent and dependent variables and includes controlled variables.

Interactions in Ecological Communities

Sample Teaching and Assessment Strategies

The student-designed experiments to investigate competition among seedlings provide a significant opportunity for rigorous assessment of students' abilities to plan and conduct investigations, record and analyze data, communicate findings, and work collaboratively.

Connection

Teachers may

- Present simplified graphs of predator-prey population cycles. Ask students to interpret the graphs, identifying patterns in population cycles and describing hypotheses to explain them.
- Provide a variety of seeds, potting materials, and containers for students to use in designing their investigations. Hydroponic kits may also be used.

Students may

- Compare interspecific and intraspecific competition using a Venn diagram.
- Create tables to compile and organize data from their investigations.
- Construct graphs to display data from their investigations of intraspecific and interspecific competition, where appropriate.
- Create a foldable to compare and contrast the different types of symbiotic relationships.
- Classify examples of symbiotic relationships.
- Evaluate the experimental designs of classmates and make suggestions for improvement.

Consolidation

Students may

- Devise a detailed procedure to measure the effect of intraspecific competition on adult cabbage plants. Operationally define major variables and include controlled variables.
- To combat sea lice infestations in salmon aquaculture farms, the introduction of a non-native shrimp species has been proposed. Analyze the risks and benefits to society and the environment of introducing the shrimp species and debate whether the introduction should proceed.
- Explain to novice gardeners how planting different types of seeds together and planting density might affect seed germination and seedling growth.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 27-33
- Assessment Checklist 1 Designing an Experiment
- Assessment Checklist 2 Laboratory Report

NL Biology (SR)

- pp. 68-79

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

Human Population Growth

Outcomes

Students will be expected to

33.0 evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources
[GCO 3]

34.0 provide examples of how science and technology are an integral part of their lives and their community
[GCO 1]

2.0 identify questions to investigate that arise from practical problems and issues
[GCO 2]

20.0 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
[GCO 2]

23.0 identify multiple perspectives that influence a science-related decision or issue
[GCO 2]

35.0 distinguish between scientific questions and technological problems
[GCO 1]

36.0 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability
[GCO 1]

Focus for Learning

Students should

- understand that prior to the Industrial revolution the human population was stable, but it is now growing exponentially;
- analyze current and projected human population growth rates;
- analyze and explain differences in population growth rates and population pyramids for developed and developing countries;
- analyze and explain how average ecological footprints differ for individuals from developed and developing countries;
- define biocapacity and explain how this estimate is influenced by technological development (i.e., products and processes); and
- compare the average ecological footprint and biocapacity of regional human populations and explain the impact on natural resources.

Students are expected, in pairs or small collaborative groups, to

- use research inquiry to examine the issue of human overpopulation, its causes, social and environmental effects, and potential solutions;
- identify the strengths and weaknesses of potential solutions; and
- propose a course of action on the issue, taking multiple perspectives into account, including that of sustainability.

Skill outcomes 2.0, 20.0, and 23.0 should be addressed and assessed as part of this investigation. SCOs 9.0, 13.0, 19.0, 21.0, 22.0, 24.0, and 25.0 may also be assessed. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Examining the issue of human overpopulation also provides a context for students to demonstrate understanding of STSE interrelationships.

Attitudes

Encourage students to

- have a sense of personal and shared responsibility for maintaining a sustainable environment, and
- want to take action for maintaining a sustainable environment.
[GCO 4]

Sample Performance Indicator

1. Communicate the findings of your research regarding the causes and social and environmental effects of human overpopulation, in an appropriate format. Present your proposed plan of action to address the issue.
2. Debate proposed solutions to human overpopulation (e.g., one- and two-child policies, promoting family planning, female empowerment, education, urbanization).

Human Population Growth

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss Figure 2.26 (*NL Biology*, p. 80) depicting global human population growth from 5000 B.C.E. to 2000 C.E. Ask students to predict what could have enabled the huge exponential growth.

Connection

Teachers may

- Ask students to interpolate and extrapolate information from graphs depicting global and regional human population growth.

Students may

- Analyze and interpret graphs depicting the phases of demographic transition (Figure 2.28, *NL Biology*, p. 82).
- Analyze, interpret, and compare population pyramids for various countries.
- Identify environmental issues related to the growing human population.

Consolidation

Students may

- Complete Activity 2.5 (*NL Biology*, p. 83), analyzing data to predict how different factors will affect human population growth.
- Complete Activity 2.6 (*NL Biology*, p. 85) to compare population growth rates in different counties.
- Calculate their ecological footprint using various online ecological footprint calculators (Investigation 2.F, *NL Biology*, pp. 86-87).

Extension

Students may

- Research the bubonic plague outbreak and report findings to classmates.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 1 pp. 33-42
- Assessment Checklist 3 Performance Task Self-Assessment
- Assessment Checklist 4 Performance Task Group Assessment
- Assessment Checklist 7 Independent Research Skills
- Assessment Checklist 8 Oral Presentation Skills

NL Biology (SR)

- pp. 80-97

Section Three:
Specific Curriculum Outcomes

Unit 2: Processes that Sustain Life

Focus

Much knowledge about living systems has been derived by studying cells, cellular metabolism, and physical processes that occur within a cell. Students should have an appreciation for the complexity of life at the cellular and molecular levels of organization.

This unit has an STSE and inquiry focus. Students examine the nature of and relationship between science and technology as they explore cell theory and the development and improvement of the microscope. They use microscopes to compare and contrast different types of cells and investigate passive transport across cell membranes and factors affecting the rate of transport.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

26.0 identify and describe science- and technology-based careers related to this science
37.0 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge
38.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions
39.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology
41.0 analyze why and how a particular technology was developed and improved over time
42.0 identify various constraints that result in tradeoffs during the development and improvement of technologies

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge**.**

40.0 explain the cell theory
43.0 compare and contrast prokaryotic and eukaryotic cells, and plant cells and animal cells
44.0 describe cell structures visible with the light and electron microscopes
45.0 identify chemical elements and compounds commonly found in living systems
46.0 identify the role of some compounds, such as water, glucose, and ATP
47.0 identify and describe the components and function of important biochemical compounds, including carbohydrates, lipids, and proteins
48.0 describe how organelles manage various cell processes, including passive transport, active transport, and membrane-assisted transport
49.0 compare and contrast matter and energy transformations associated with the processes aerobic respiration and photosynthesis

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

3.0 design an experiment identifying and controlling major variables
4.0 formulate operational definitions of major variables
7.0 estimate quantities
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
10.0 select and use apparatus and materials safely
11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods
18.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
21.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
24.0 work cooperatively with team members to develop and carry out a plan, and trouble shoot problems as they arise

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the role of science and technology in our understanding of phenomena that are directly observable and those that are not.
- value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds.
- show a continuing and more informed curiosity and interest in science and science-related issues.
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research.
- consider further studies and careers in science- and technology-related fields.
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations.
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas.

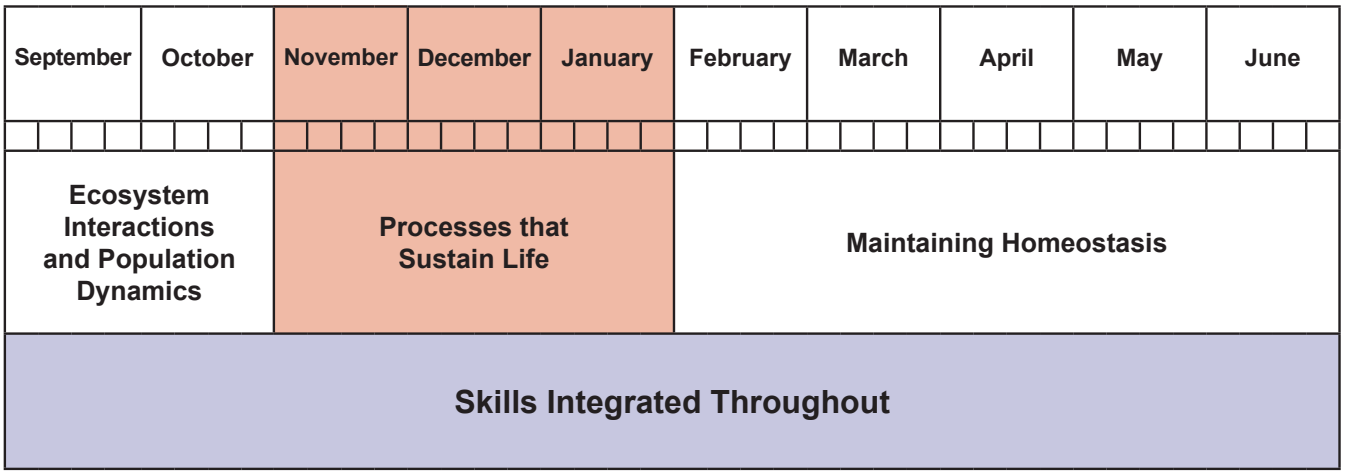
SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 8	Biology 2201	Biology 3201
Cells, Tissues, Organs, and Systems	*Processes that Sustain Life*	*Genetic Basis of Heredity and Evolutionary Change and Biodiversity*
• illustrate and explain that the cell is a living system that exhibits all the characteristics of life • distinguish between plant and animal cells • explain that growth and reproduction depend on cell division • explain the structural and functional relationships between and among cells, tissues, organs, and systems in the human body • relate the needs and functions of various cells and organs to the needs and functions of the human organism as a whole	• explain the cell theory • compare and contrast prokaryotic and eukaryotic cells, and plant cells and animal cells • describe cell structures visible with the light and electron microscopes • identify chemical elements and compounds commonly found in living systems • identify the role of some compounds, such as water, glucose, and ATP • identify and describe the components and function of important biochemical compounds, including carbohydrates, lipids, and proteins • describe how organelles manage various cell processes, including passive transport, active transport, and membrane-assisted transport • compare and contrast matter and energy transformations associated with the processes aerobic respiration and photosynthesis	• describe in detail mitosis and meiosis • describe and illustrate the role of chromosomes in the transmission of hereditary information • compare and contrast the structures of DNA and RNA and explain their roles in protein synthesis • evaluate and describe evidence to support the theory of evolution by natural selection • demonstrate an understanding of fundamental principles of taxonomy • examine the anatomy and physiology of representative organisms to identify and describe trends in evolutionary complexity

Suggested Unit Plan

Unit 2, *Processes that Sustain Life*, develops students' knowledge of cellular components and processes. This knowledge is critical to understand how living systems maintain homeostasis in Unit 3.



Developing the Cell Theory

Outcomes

Students will be expected to

37.0 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge
[GCO 1]

38.0 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions
[GCO 1]

39.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology
[GCO 1]

40.0 explain the cell theory
[GCO 3]

Focus for Learning

The historical development of the cell theory provides a context to develop and assess students' understanding of the nature of science and the development of scientific knowledge.

Students should

- examine historical evidence for and against abiogenesis,
- recognize the importance of communicating the results of scientific endeavours,
- explain how evidence from Pasteur's experiments settled the debate on abiogeneisis,
- explain how general acceptance of biogeneisis represented a paradigm shift,
- analyze and describe how advancements in microscopy contributed to the development of the cell theory, and
- explain the cell theory.

Attitudes

Encourage students to

- value the contributions to scientific and technological development made by individuals from many societies and cultural backgrounds, and
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations. [GCO 4]

Sample Performance Indicator

Prepare a presentation explaining the roles of evidence, theories, and paradigms in the development of scientific knowledge related to biogenesis.

Developing the Cell Theory

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Facilitate a placemat activity to ascertain students' prior knowledge of cells.

Connection

Teachers may

- Describe the experiment of Francesco Redi and his findings and discuss the importance of a control group.
- Ask students to search to identify significant individuals who contributed to advancements in microscopy and the development of cell theory and note their cultural background.
- Present videos depicting the history of biogenesis and cell theory.

Students may

- Complete Activity 4.1 (*NL Biology*, p. 151) to examine historical evidence for and against abiogenesis.
- Describe the famous experiment of Louis Pasteur and its findings.
- Consider how the question "if a tree falls in the forest and no one is there to hear it, does it make a sound?" relates to the importance of communicating the results of scientific endeavours.
- Analyze Figure 4.4 (*NL Biology*, p. 152) representing a time line of advances in microscopy and the development of cell theory and recognize how they are interconnected.

Consolidation

Students may

- Prepare for and participate in a debate on the idea that life arises from life.
- Describe the cell theory and explain how it supports biogenesis and contradicts abiogenesis.
- Describe how advancements in microscopy enhanced scientific understanding of cells.

Extension

Students may

- Research individuals whose ideas, research, or discoveries contributed to the development of cell theory.

Resources and Notes

Authorized

NL Biology
(Teacher Resource [TR])

- Unit 2 pp. 22-25
- Assessment Checklist 8 Oral Presentation Skills

NL Biology
(Student Resource [SR])

- pp. 148-153

Development of the Microscope

Outcomes

Students will be expected to

41.0 analyze why and how a particular technology was developed and improved over time
[GCO 1]

42.0 identify various constraints that result in tradeoffs during the development and improvement of technologies
[GCO 1]

7.0 estimate quantities
[GCO 2]

10.0 select and use apparatus and materials safely
[GCO 2]

24.0 work cooperatively with team members to develop and carry out a plan, and trouble shoot problems as they arise
[GCO 2]

Focus for Learning

Students were introduced to microscopy in Science 8 and used microscopes to produce clear images of cells. In Biology 2201, students are expected to

- distinguish between magnification, resolution, and depth of field;
- analyze how microscopy has improved over time;
- identify the limitations of various microscope technologies (e.g., compound light microscope, fluorescence microscopy, transmission electron microscope, scanning electron microscope, atomic force microscopy); and
- use a compound light microscope to effectively and accurately collect data and information about cells.

Students should use a compound light microscope to view prepared slides. As part of this investigation, they should

- safely handle the microscope and microscope slides;
- focus the microscope using low-, medium-, and high-power;
- calculate total magnification and the diameter of the field of view for low-, medium-, and high-power objective lenses; and
- estimate the size of objects viewed under the microscope.

Skill outcomes 7.0, 10.0, and 24.0 should be assessed as part of this microscope investigation. Refer to the *Integrated Skills* unit for elaboration of these SCOs.

Note, a microscope investigation comparing plant and animals cells follows in the next series of outcomes. Teachers may choose to combine both investigations into one activity.

Attitude

Encourage students to value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not. [GCO 4]

Sample Performance Indicators

1. Participate in a group preparation and presentation of research on the technological evolution of the microscope.
2. Safely focus a compound light microscope to view a prepared slide under high-power. Calculate total magnification and estimate the size of the object viewed.

Development of the Microscope

Sample Teaching and Assessment Strategies

The use of lab station tests to assess students' microscopy-related skills and knowledge of cell types and structures is recommended.

Activation

Students may

- Review the parts of a compound light microscope and safe handling procedures (Appendix C, *NL Biology*, pp. 722-723).
- Compare and contrast images made with electron and light microscopes.

Connection

Teachers may

- Discuss limitations of specific microscope technologies with respect to magnification, resolution, and depth of field.
- Use a flex camera placed over the eyepiece of a microscope to capture and project images. Use of a dual view microscope would enable students to view what is observed while focusing.

Students may

- Compare and contrast stereomicroscopes and light microscopes.
- Practice estimating the size of objects viewed under various objective lenses.
- Use mobile device cameras to capture images viewed through the eyepiece of the microscope.

Consolidation

Teachers may

- Assess students' ability to use a compound light microscope, including safely focusing the microscope and producing clear images. Students may submit digital pictures of focused images for assessment, obtained by placing a mobile device camera lens against the microscope eyepiece.

Students may

- Engage in Launch Lab: Look a Little Closer (*NL Biology*, p. 149).
- Use graphic organizers to compare and contrast microscopes.

Extension

Students may

- Research modern microscopes, identifying the source of illumination or energy, highest magnification and resolution, specimen preparation procedures, and common uses.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 2 pp. 25-26

NL Biology (SR)

- pp. 154-157, 722-726

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

Notes

The magnifying glass icon is used throughout the unit to indicate investigations.

Cell Types and Structures

Outcomes

Students will be expected to

43.0 compare and contrast prokaryotic and eukaryotic cells, and plant cells and animal cells
[GCO 3]

44.0 describe cell structures visible with the light and electron microscopes
[GCO 3]

11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
[GCO 2]

13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
[GCO 2]

21.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
[GCO 2]

Focus for Learning

Observable differences between plant cells and animal cells was addressed in Science 8. In Biology 2201, students are expected to

- distinguish between prokaryotic cells and eukaryotic cells;
- compare and contrast plant cells and animal cells, in terms of structural differences and observable microscopic features;
- identify and describe cell structures visible with light and electron microscopes (i.e., cell membrane, cell wall, cytoplasm, cytosol, nucleus, nucleolus, ribosome, endoplasmic reticulum [rough and smooth], vesicle, Golgi apparatus, vacuole, lysosome, mitochondria, chloroplast);
- describe the function of cell structures;
- recognize that organelles work together in a cell to carry out life functions.

Students should complete an investigation using a compound light microscope effectively and accurately to collect data regarding plant and animal cells (e.g., Investigation 4.A, *NL Biology*, pp. 167-169). They should

- view prepared slides of animal cells,
- prepare and view stained wet mounts of plant cells, and
- create biological drawings of the cells viewed (Appendix D, *NL Biology*, p. 727).

Additionally, students may irrigate their plant cell wet mounts with salt water. This should enable them to observe plasmolysis which is addressed later in the unit.

Assess skill outcomes 11.0, 13.0, and 21.0 as part of the investigation. SCO 21.0 relates to students' use of techniques to produce clear, concise biological drawings. Using, for example, stippling to indicate darker areas, double lines to indicate thickness, and carefully labelling structures, titling the drawing (include an estimate of specimen size), and indicating magnification in parentheses. Teachers may also choose to assess SCOs 7.0, 8.0, 10.0, 18.0, and 24.0. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Sample Performance Indicator

Prepare a wet mount of a green onion stem. Examine the specimen under high-power and create a labeled biological drawing of the cells viewed, including magnification and estimated size.

Cell Types and Structures

Sample Teaching and Assessment Strategies

The use of lab station tests to assess students' skills (e.g., preparing wet mounts, biological drawings, estimation of specimen size) and knowledge of cell types and structures is recommended.

Connection

Teachers may

- Present magnified images of prokaryotic and eukaryotic cells, discussing their complexity and identifying visible organelles.
- Present representations of typical animal and plant cells.
- Use a flex camera placed over the microscope eyepiece to project images on an interactive white board.
- Relate cellular organelles and their functions to the parts of a school, factory, or city.
- Facilitate a game of *Who Am I?* for cellular organelles.
- Present electron micrographs of cell organelles.

Students may

- Use microscopy to view prepared slides of prokaryotic and eukaryotic cells and identify all visible structures. View a variety of specimens to illustrate that while there are similarities in cell structures, all cells are not identical.
- Practice making biological drawings of cells viewed.
- Compare animal and plant cells using a graphic organizer.
- Invent a cellular organelle game (Activity 4.3, *NL Biology*, p. 165).
- Capture pictures of cells taken through the ocular lens with mobile devices.
- Create similes to describe the function of cell organelles (e.g., the Golgi apparatus is like a post office because it sorts and packages materials).

Consolidation

Students may

- Create a "How to" video to explain how to prepare a wet mount.
- Create and explain models of animal and plant cells.
- Create a foldable organizer to identify and describe cell structures and their functions.
- Describe examples of how cellular organelles work together to carry out life functions.

Extension

Students may

- Research the discovery of cellular organelles and their function

Resources and Notes

Authorized

NL Biology (TR)

- Unit 2 pp. 26-32

NL Biology (SR)

- pp. 158-171, 727

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

Biological Molecules in Cells

Outcomes

Students will be expected to

45.0 identify chemical elements and compounds commonly found in living systems [GCO 3]

46.0 identify the role of some compounds, such as water, glucose, and ATP [GCO 3]

47.0 identify and describe the components and function of important biochemical compounds, including carbohydrates, lipids, and proteins [GCO 3]

26.0 identify and describe science- and technology-based careers related to this science [GCO 1]

Focus for Learning

This series of knowledge outcomes highlights the connection between chemistry and cellular function. While presented collectively, teachers may choose to address aspects of these outcomes at various points during the unit. The role of glucose, for example, might be addressed when comparing and contrasting matter and energy transformations associated with the processes of aerobic respiration and photosynthesis.

Students should

- define biochemistry;
- identify chemical elements and compounds commonly found in living systems;
- recognize that living systems depend on chemical reactions and energy changes that occur in cells;
- identify the role of water in living systems (i.e., provides a medium for most chemical reactions, transports dissolved substances throughout the system, as a reactant or product in many of life's chemical reactions);
- distinguish between hydrophobic and hydrophilic;
- identify the important energy carrying role of glucose and ATP (i.e., adenosine triphosphate);
- describe carbohydrates, lipids, and proteins as important biochemical compounds (Note, nucleic acids are addressed in Biology 3201);
- identify examples and describe the functions of carbohydrates, lipids, and proteins;
- identify and describe career opportunities related to human biochemistry.

Attitude

Encourage students to consider further studies and careers in science- and technology-related fields. [GCO 4]

Sample Performance Indicator

Create a concept map of important biochemical compounds, including carbohydrates, lipids, and proteins. Describe their components and functions, and identify examples.

Biological Molecules in Cells

Sample Teaching and Assessment Strategies

Prerequisite chemistry concepts, addressed in Science 9 and Science 1206, should be reviewed (i.e., elements and compounds, atomic structure, chemical bonding, chemical reactions and equations).

Activation

Teachers may

- Use nutrition as the context to introduce biochemical compounds.
- Ask students to personally define carbohydrates, lipids, and proteins to activate their prior knowledge.

Students may

- Complete unit preparation questions related to chemistry (*NL Biology*, pp. 108-109).

Connection

Teachers may

- Relate chemistry concepts to “real life” and biology.
- Describe the polar nature of water molecules and relate to hydrophobic and hydrophilic substances.

Students may

- View and interpret Figure 3.2 (*NL Biology*, p. 112) representing the progression from atoms to biological molecules, organelles, and cells.
- Diagram and explain what happens when ATP undergoes a hydrolysis reaction.
- Create a visual representation of biochemistry-related careers.

Consolidation

Teachers may

- Facilitate Investigation 3.A (*NL Biology*, pp. 132-133) to qualitatively detect and identify the presence of carbohydrates, proteins, and lipids.

Students may

- Using a graphic organizer, compare the components, function, and examples of carbohydrates, lipids, and proteins.
- Create a career profile page for a relevant biochemistry career and add it to your print or digital portfolio.

Extension

Students may

- Create models of important biochemical compounds.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 2 pp. 4-13

NL Biology (SR)

- pp. 110-134
- pp. 717-721

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Career Profiles - Let’s Talk Science

Cell Membrane Structure and Transport

Outcomes

Students will be expected to

48.0 describe how organelles manage various cell processes, including passive transport, active transport, and membrane-assisted transport [GCO 3]

3.0 design an experiment identifying and controlling major variables [GCO 2]

4.0 formulate operational definitions of major variables [GCO 2]

8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]

17.0 evaluate the relevance, reliability, and adequacy of data and data collection methods [GCO 2]

18.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty [GCO 2]

Focus for Learning

Students should

- describe the relationship between cell surface area and cell size;
- describe the parts of the cell membrane (i.e., phospholipids, proteins, cholesterol, carbohydrates) and their structures and functions;
- describe passive membrane transport processes (i.e., simple diffusion, facilitated diffusion, and osmosis);
- distinguish between hypotonic, hypertonic, and isotonic; and
- describe the effects of osmosis on plant and animal cells.

Students are expected to engage in a two-part investigation of passive transport. Initially, students should follow a directed procedure to observe passive transport of a substance across a selectively permeable membrane. Then, for the second part, they should design and carry out their own experiment to determine how factors (e.g., solute type, solute concentration, temperature) affect the rate or amount of passive transport (e.g., Investigation 4.B, *NL Biology*, pp.178-179).

Skill outcomes 3.0, 4.0, 8.0, 17.0, and 18.0 should be assessed in conjunction with this two-part investigation. Additionally, teachers may assess students' abilities to

- identify questions and carry out controlled procedures (2.0, 6.0);
- estimate values and compile and display evidence (7.0, 13.0);
- safely use and dispose of lab materials (10.0, 11.0);
- identify relationships in data and draw conclusions (15.0, 19.0);
- communicate ideas, plans, and results (21.0); and
- work cooperatively and evaluate groups processes (24.0, 25.0).

Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Students should

- compare and contrast the processes of active transport and passive transport,
- recognize the role of ATP in active transport, and
- describe and distinguish between the membrane-assisted processes of endocytosis and exocytosis.

Attitude

Encourage students to acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Sample Performance Indicator

Prepare a formal lab report for the experiment they designed and carried out to determine how a selected factor affects the rate or amount of passive transport.

Cell Membrane Structure and Transport

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Facilitate investigations modelling the relationship between cell surface area and volume.
- Model how cell size affects transport efficiency by immersing potato cubes of various sizes in a methylene blue solution, then cutting in half after sufficient time has elapsed.
- Introduce the fluid mosaic model as scientists' current understanding of cell membrane structure.
- Demonstrate a concentration gradient in liquids or gases.
- Provide dialysis tubing or low-quality, plastic sandwich bags to investigate transport across semipermeable membranes.
- Create model cells for use in transport investigations by filling plastic sandwich bags with gelatin and added starch.
- Demonstrate osmosis by hydrating dried fruit.

Students may

- Discuss how the properties of the biochemical compounds in the cell membrane might affect cell membrane transport.
- Design and carry out an experiment to determine if cut vegetables should be stored in tap or salted water (*NL Biology*, p. 176).
- Create visual representations to explain the difference between hypotonic, hypertonic, and isotonic.
- Use microscopy to view plant cells irrigated with salt water.
- Kinesthetically model, in large groups, endocytosis and exocytosis using slow-motion versions of red rover.

Consolidation

Students may

- Create a model to explain how cell membranes work using classmates to represent different biochemical compounds.
- Create a graphic organizer to compare passive, active, and membrane assisted transport.
- Design and carry out quantitative investigations of passive transport using, for example, gummy candy, gelatin cell models, or potato pieces.
- Explain why ATP is required for active transport.

Extension

Students may

- Investigate how our understanding of the structure and behaviour of membranes evolved (*NL Biology*, p. 173).
- Research the sodium-potassium pump as an example of active transport (*NL Biology*, p.181).

Resources and Notes

Authorized

NL Biology (TR)

- Unit 2 pp. 32-38
- Assessment Checklist 1 Designing an Experiment
- Assessment Checklist 2 Laboratory Report

NL Biology (SR)

- pp. 161, 172-183

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/teaching-and-learning-strategies.html
  - Passive Transport Lab

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

Energy Transformations in Cells

Outcomes

Students will be expected to

49.0 compare and contrast matter and energy transformations associated with the processes of aerobic respiration and photosynthesis [GCO 3]

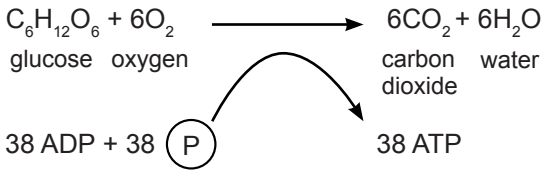
46.0 identify the role of some compounds, such as water, glucose, and ATP [GCO 3]

Focus for Learning

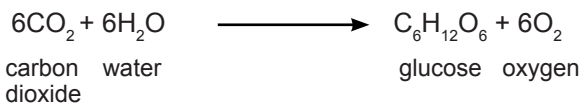
The processes of cellular respiration and photosynthesis were addressed in Science 1206. The focus for learning was how these processes cycle oxygen and carbon through the ecosystem.

In Biology 2201, students should

- describe ATP hydrolysis and its role in cellular activities;
- distinguish between aerobic and anaerobic respiration;
- identify ATP producing stages of aerobic respiration (i.e., glycolysis, Krebs cycle, oxidative phosphorylation);
- summarize the overall process of aerobic respiration;



- describe the production of sugar in plants, identifying the stages (i.e., light dependent reactions, Calvin cycle) and the role of ATP and NADPH;
- summarize the overall process of photosynthesis; and



- describe the complementary nature of the processes of aerobic respiration and photosynthesis.

Note, detailed descriptions of glycolysis, oxidative phosphorylation, light dependent reactions, and the Krebs and Calvin cycles are not an expectation of Biology 2201.

Attitude

Encourage students to show a continuing and more informed curiosity and interest in science and science-related issues. [GCO 4]

Sample Performance Indicator

Describe the processes of aerobic respiration and photosynthesis, including the associated matter and energy transformations.

Energy Transformations in Cells

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Facilitate a place mat activity to assess students' prior knowledge of photosynthesis and cellular respiration.

Students may

- Complete the Launch Activity, Seeing Green (*NL Biology*, 189).

Connection

Teachers may

- Discuss with students the significance of Joseph Priestley and his experimental findings that plants "revitalized" enclosed volumes of air.
- Diagram the formation and breakdown of ATP.
- Discuss cellular activities that require ATP.

Students may

- Demonstrate that plants undergo cellular respiration by placing a plant within a closed system (e.g., recycled plastic bottle bell jar) and observing over an extended period of time.
- Compare the structure and function of chloroplasts and mitochondria (i.e., organelles involved in the processes of aerobic respiration and photosynthesis).
- Reflect on and discuss the analogy that ATP is the "molecular currency" of the cell.
- Discuss how a lack or overabundance of a compound (i.e., glucose, oxygen, carbon dioxide, water) might affect the process of aerobic respiration in a living system.

Consolidation

Students may

- Visually represent the processes of aerobic respiration and photosynthesis.
- Hypothesize which types of cells might have high concentrations of mitochondria.
- Visually represent and describe how aerobic respiration and photosynthesis are complementary processes.

Extension

- Research the process of anerobic respiration and communicate findings to classmates.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 2 pp. 38-54

NL Biology (SR)

- pp. 184-211

Section Three:
Specific Curriculum Outcomes

Unit 3: Maintaining Homeostasis

Focus

All living organisms struggle to maintain an internal balance in response to the constant pressure of internal and external phenomena. Students are provided with a variety of opportunities to study different factors affecting the homeostasis of natural systems. Through this study, students begin to appreciate the complexity of mechanisms involved in homoeostatic regulation.

This unit has a strong STSE focus and emphasizes the concepts of systems and interactions. Students use research and guided and directed scientific inquiry to investigate factors and issues affecting an organism's systems.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

27.0 analyze natural systems to interpret and explain their structure and dynamics
32.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology
36.0 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability
41.0 analyze why and how a particular technology was developed and improved over time
55.0 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot
57.0 analyze society's influence on scientific and technological endeavours
61.0 debate the merits of funding specific scientific or technological endeavours
62.0 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge**.**

50.0 explain how systems help maintain homeostasis
51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved
52.0 explain how tropisms help to maintain homeostasis
53.0 analyze the impact of factors on the homeostasis of the nervous system
54.0 evaluate the impact of disorders and diseases on homeostasis
56.0 explain the importance of fitness to the maintenance of homeostasis
58.0 describe the impact of environmental factors on homeostasis
59.0 explain the role of enzymes in metabolism
60.0 explain the importance of nutrition to the maintenance of homeostasis

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

3.0 design an experiment identifying and controlling major variables
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
9.0 use library and electronic research tools to collect information on a given topic
10.0 select and use apparatus and materials safely
11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
16.0 compare theoretical and empirical values and account for discrepancies
19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
23.0 identify multiple perspectives that influence a science-related decision or issue
24.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
25.0 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task

GCO 4 (Attitudes): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- appreciate that the applications of science and technology can raise ethical dilemmas
- show a continuing and more informed curiosity and interest in science and science-related issues
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- consider further studies and careers in science- and technology-related fields
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations
- use factual information and rational explanations when analyzing and evaluating
- value processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- project the personal, social, and environmental consequences of proposed action
- show concern for safety and accept the need for rules and regulations

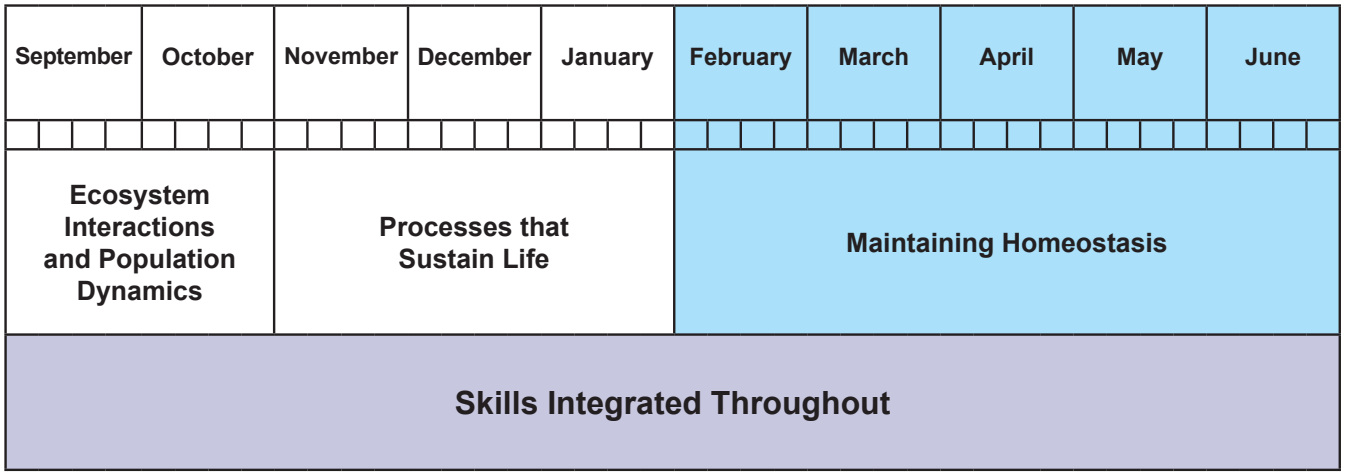
SCO Continuum

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Science 8	Biology 2201	Biology 3201
Cells, Tissues, Organs, and Systems	*Maintaining Homeostasis*	*Cell Reproduction and the Continuity of Life, Genetic Basis of Heredity,* and *Evolutionary Change and Biodiversity*
• illustrate and explain that the cell is a living system that exhibits all the characteristics of life • distinguish between plant and animal cells • explain that growth and reproduction depend on cell division • explain the structural and functional relationships between and among cells, tissues, organs, and systems in the human body • relate the needs and functions of various cells and organs to the needs and functions of the human organism as a whole • describe the basic factors that affect the functions and efficiency of the human respiratory, circulatory, digestive, excretory, and nervous systems • describe examples of the interdependence of various systems of the human body	• explain how systems help maintain homeostasis • analyze homeostatic phenomena to identify the feedback mechanisms involved • explain how tropisms help to maintain homeostasis • analyze the impact of factors on the homeostasis of the nervous system • evaluate the impact of disorders and diseases on homeostasis • explain the importance of fitness to the maintenance of homeostasis • describe the impact of environmental factors on homeostasis • explain the role of enzymes in metabolism • explain the importance of nutrition to the maintenance of homeostasis	• examine the process of cell division and its significance • analyze and describe the structure and function of human female and male reproductive systems • explain the human reproductive cycle • evaluate, considering ethical issues, the consequences of medical treatments • describe factors that may lead to mutations in a cell's genetic information • explain circumstances that lead to genetic diseases • examine the anatomy and physiology of representative organisms to identify and describe trends in evolutionary complexity

Suggested Unit Plan

Maintaining Homeostasis builds on knowledge of cellular components and processes from Unit 2, to examine the homeostasis of plant and human systems. The order in which the systems are presented is the suggested order.



Homeostasis and Feedback Mechanisms

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]

Focus for Learning

Students are expected to analyze living systems to interpret and explain their structure and function. Systems analyzed include plant systems and the human nervous, endocrine, circulatory, respiratory, digestive, and excretory systems. Note, the systems are presented in the recommended order. Teachers may, however, choose to address these systems in a different order.

When analyzing systems, students should focus on explaining how the system helps to maintain homeostasis in the body, and identifying the feedback mechanisms involved.

Students should

- describe homeostasis,
- explain how systems maintain homeostasis through negative feedback mechanisms, and
- explain the difference between negative and positive feedback mechanisms.

Attitude

Encourage students to show a continuing and more informed curiosity and interest in science and science-related issues. [GCO 4]

Homeostasis and Feedback Mechanisms

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Assess students' prior knowledge of systems and organization, human body systems, and plant cells, tissues, and organs, using the "What You Should Recall About..." section questions (*NL Biology*, pp. 214-215).

Connection

Teachers may

- Use a pan-balance or metre stick balanced on a fulcrum-like object to help students visualize homeostasis.
- Explain how a negative feedback mechanism works using the regulation of room temperature by a thermostat as an example. Ask students to predict how the human body might regulate body temperature.
- Illustrate a general negative feedback mechanism, identifying the role of the sensor, effector, and control centre.
- Explain how a fever caused by an infection may induce a harmful, positive feedback mechanism.

Students may

- Brainstorm variables plants might require to remain constant within their internal environment to maintain health.
- Brainstorm variables the human body maintains within a narrow range (e.g., body temperature, blood glucose level, blood pH).

Consolidation

Students may

- Illustrate how a negative feedback mechanism works using the terms stimulus, sensor, effector, and control centre.

Resources and Notes

Authorized

NL Biology
(Teacher Resource [TR])

- Unit 3 pp. 1-7

NL Biology
(Student Resource [SR])

- pp. 212-215, 218-220

Plant Systems and Homeostasis

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]

52.0 explain how tropisms help maintain homeostasis [GCO 3]

Focus for Learning

Analyzing transformations associated with photosynthesis at the end of Unit 2, provides a segue to address homeostasis in plants at the beginning of this unit. Teachers may, however, choose to address this system in a different order.

Students should

- identify and describe the structure and function of
  - meristematic tissue,
  - dermal tissue (include epidermis, guard cells, root hairs),
  - ground tissue, and
  - vascular tissue (include xylem and phloem);
- view prepared slides of plant root, stem, and leaf tissues with a light microscope and identify cells and structures (i.e., cuticle, epidermal cells, guard cells, stoma, root hairs, meristematic tissue);
- describe the functions of roots, stems, and leaves;
- explain how water and minerals are transported through xylem (i.e., transpiration);
- explain how molecules produced by the plant are transported through phloem (i.e., translocation);
- recognize that plants produce hormones which regulate growth and response to the environment;
- identify auxins, cytokinins, gibberellins, ethylene, and abscisic acid as plant hormones and describe their functions;
- describe the positive feedback mechanism involved in the ripening of fruits; and
- define tropisms (i.e., phototropism, gravitropism, thigmotropism) and explain how these growth responses help maintain homeostasis.

Attitude

Encourage students to value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not. [GCO 4]

Sample Performance Indicator

Create an annotated diagram which describes in detail the structure and dynamics of plant systems involved in capturing and transporting the light energy, carbon dioxide, and water required by plants to produce their own food.

Plant Systems and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Provide a variety of different plants for examination. Ask students to compare and contrast their shoot and root systems.

Connection

Teachers may

- Facilitate a stations lab where students view prepared slides of roots, stems, and leaves, supplemented, if necessary, by digital images sourced from the Internet. At each station, students can be guided to observe and identify cells and structures such as the cuticle, epidermal cells, guard cells, stoma, root hairs, and meristematic tissue.
- Ask students to interpret and explain Figure 11.15 and Figure 11.17 (*NL Biology*, pp. 426, 428).
- Present video clips sourced from the Internet depicting tropisms.

Students may

- Create a personal glossary of plant-related terminology as a reference. Glossaries may include sketches and short-form notes.
- Germinate pea or bean seeds to observe and describe their structures. Plant the seedlings and use them to model photo-, gravi-, and thigmotropism as they grow.
- Search the Internet and view animations of transport in plants.
- Model the process of transpiration by placing white carnations or celery stalks in water coloured with food colouring.

Consolidation

Students may

- Search the Internet for tips on accelerating the ripening of fruit and investigate to verify their effectiveness. Explain how they relate to feedback mechanisms.
- Describe how sucrose is transported in plants from source to sink. How might seasons affect the locations of source and sink?
- During drought-like conditions some plants begin to wilt. Predict which part of the plant might first exhibit evidence of wilting and explain why.
- Create a concept map of factors that affect plant growth.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 111-123

NL Biology (SR)

- pp. 408-441

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Nervous System and Homeostasis

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

53.0 analyze the impact of factors on the homeostasis of the nervous system [GCO 3]

9.0 use library and electronic research tools to collect information on a given topic [GCO 2]

22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information [GCO 2]

Focus for Learning

Students should identify organ systems of the human body (See Figure 5.1, *NL Biology,* p. 218). The nervous, endocrine, circulatory, respiratory, digestive, and excretory systems are the focus of this unit.

Students should

- explain why the human nervous system is critical for maintaining homeostasis in the body;
- describe the organization of the nervous system;
- describe the structures of the neural impulse transmission pathway (i.e., sensory receptor, sensory neuron, interneuron, motor neuron, effector) and their functions; and
- describe the structure and function of a reflex arc.

Students are expected to perform an experiment to investigate the physiology of reflex arcs. Investigation 9.A (*NL Biology*, p. 339) provides a suggested procedure.

Students should

- describe the structure of a neuron, include dendrites, cell body, axon, axon terminals, myelin sheath, Schwann cell, and nodes of Ranvier;
- explain the transmission of an action potential along a neuron and between neurons, include resting membrane potential, polarization, depolarization, threshold potential, repolarization, synapse, and neurotransmitter (Note, students are not expected to explain the sodium-potassium exchange pump); and
- describe the functions of selected neurotransmitters, include acetylcholine, cholinesterase, dopamine, serotonin, endorphins, and norepinephrine.

Students are expected to select a medication, drug, or other factor related to the nervous system (e.g., stress, exercise, technology use) and research its effects. They should analyze and explain its impacts on the nervous system and body.

In addition to SCOs 9.0 and 22.0, teachers may assess 13.0, 17.0, and 24.0. Refer to the *Integrated Skills* unit for elaboration.

Attitude

Encourage students to acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Sample Performance Indicator

Prepare a presentation to communicate research findings related to the impact of a medication, drug, or other factor on the nervous system.

The Human Nervous System and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Show videos sourced from the Internet to introduce the system.

Students may

- Engage in the *You, Robot?* Launch Lab (*NL Biology*, p. 333) to experience the complex nature of the human nervous system.

Connection

Teachers may

- Present images sourced from the Internet to help students visualize the structure of a neuron.
- Discuss how the human body responds to stress.
- Provide prepared slides of neural tissue, supplemented, if necessary, by images sourced from the Internet, for students to examine.
- Discuss the functions of additional neurotransmitters (e.g., GABA, glutamate).

Students may

- Represent the divisions of the nervous system in a flow chart.
- Create a personal glossary of nervous system terminology.
- Differentiate between the structures and function of the central and peripheral nervous systems.
- View prepared slides of nervous system structures.
- Differentiate between sensory, motor, and interneurons.
- Annotate images of neurons, identifying structures and their functions.

Consolidation

Teachers may

- Refer students to Activities 9.1 and 9.2 (*NL Biology*, pp. 351-352) to help guide their research to address SCO 53.0.
- Describe a reflex arc in detail using an example.
- Annotate an image of a neuron to explain how an impulse is propagated along its length.
- Annotate an image of a neural synapse to explain how an impulse is transmitted from one neuron to another neuron.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 66-79
- Assessment Checklist 7 Independent Research Skills

NL Biology (SR)

- p. 218
- pp. 332-365

Notes

The magnifying glass icon is used throughout the unit to indicate investigations.

The Human Nervous System and Homeostasis

Outcomes

Students will be expected to

10.0 select and use apparatus and materials safely [GCO 2]

11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials [GCO 2]

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]

55.0 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot [GCO 1]

Focus for Learning

Students are expected to dissect and observe features of a mammalian brain. Investigation 9.D (*NL Biology*, pp. 361-362) provides a sample procedure for dissection. Students' safe use of dissection tools and personal protective equipment, proper handling and disposal of specimens, and cooperation within groups should be assessed. Refer to the *Integrated Skills* unit for elaboration of these skills. Note, virtual dissection or video may be used as an alternative for individual students who object to dissection or have cultural or ethical concerns.

Students should

- identify and explain the functions of the spinal cord and brain structures of (i.e., cerebellum, medulla oblongata, pons, midbrain, thalamus, hypothalamus, cerebrum, corpus callosum, meninges);
- identify the components of the peripheral nervous system;
- explain the role the somatic (voluntary) system plays in the functioning of the body;
- explain how the autonomic (involuntary) system helps maintain homeostasis; and
- compare the functions of the sympathetic and parasympathetic divisions of the autonomic nervous system (fight-or-flight versus rest-and-digest).

Students are expected to research and summarize a nervous system-related disorder or disease of interest (Eating disorders should not be addressed). The summary may include

- information regarding affected structures and impacts;
- symptoms, causes, and risk factors;
- diagnosis and prognosis; and
- current treatments, cures, and future treatments on the horizon.

SCO 54.0 will be readdressed as new systems are analyzed. Summaries should be compiled in a portfolio for later submission.

Class discussion regarding the use of life support to maintain body function and decisions to withdraw its use provide an opportunity to discuss the social context of science and technology. Students should examine questions and problems arising from discussion and distinguish those that can be answered or solved by science and technology from those that cannot.

Attitude

Encourage students to show concern for safety and accept the need for rules and regulations. [GCO 4]

Sample Performance Indicator

Create a detailed concept map to explain the structure and function of the human nervous system.

The Human Nervous System and Homeostasis

Sample Teaching and Assessment Strategies

For many students, this will be their first experience with dissection. Inform students of all safety precautions. Extreme care must be taken when using dissection instruments, particularly scalpels, and necessary personal protective equipment (i.e., gloves, goggles, lab coats) should be worn at all times.

Connection

Teachers may

- Demonstrate the function of cerebrospinal fluid by placing an egg in a plastic container just large enough to contain it. Fill the container with water and shake it.

Students may

- Create a model of the human brain using modelling clay. Models may be labelled with toothpick label flags.
- Create a table to summarize the structures of the human brain and their functions.
- Analyze and explain Figure 9.34 *(NL Biology*, p. 368).
- Represent the divisions of the nervous system in a flow chart. Annotate the chart with the key features of each division.
- Collaboratively create a list of central and peripheral nervous system disorders and diseases.

Consolidation

Teachers may

- Develop and facilitate a lab station test to assess students' skills and knowledge of the human nervous system.
- Facilitate a class mini-conference where students present to peers their summary of a nervous system disorder or disease.
- Present nervous system-related medical scenarios and ask students to use their understanding of the systems structure and function to explain them.
- Assign the feature *Maintaining and Terminating Human Life* (*NL Biology*, p. 370) to help address SCO 55.0.

Students may

- Explain what is meant by the phrase "antagonistic actions" with respect to the sympathetic and parasympathetic divisions of the autonomic nervous system.
- Imagine a stressful situation and describe the physiological effects stimulated by the sympathetic nervous system.
- Research and discuss "brain death" diagnosis criteria.
- Engage in Activity 9.3 (*NL Biology*, p. 360) to design and test a model helmet to prevent chronic traumatic encephalopathy.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 79-90
- Assessment Checklist 7 Independent Research Skills

NL Biology (SR)

- pp. 354-373

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/teaching-and-learning-strategies.html
  - Dissection Lab

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Endocrine System and Homeostasis

Outcomes	Focus for Learning
Students will be expected to	
27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1] *50.0 explain how systems help maintain homeostasis [GCO 3]* *51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]*	Students should • explain how the human endocrine system contributes to homeostasis in the body; • compare and contrast the nervous and endocrine systems; • identify major endocrine glands, the hormones they secrete, and their effects on target tissues/organs, including - hypothalamus - hypothalamic-releasing and hypothalamic-inhibiting hormones, - pineal - melatonin, - pituitary - human growth hormone (hGH), thyroid-stimulating hormone (TSH), antidiuretic hormone (ADH), and adrenocorticotropic hormone (ACTH), - thyroid - thyroxine and calcitonin, - parathyroid - parathyroid hormone (PTH), - adrenal - cortisol, aldosterone, epinephrine, and norepinephrine, - pancreas - insulin and glucagon, and - ovaries and testes; (Note, ADH and aldosterone are addressed with the excretory system. Hormones targeting reproductive tissues and organs are addressed in Biology 3201.) • explain the relationship between the hypothalamus and pituitary gland; • describe the regulation of the thyroid gland, and its role in homeostasis; • describe the negative feedback mechanisms involved in the regulation of calcium in the blood; • explain how the adrenal glands regulate short and long-term stress responses, identifying feedback mechanisms involved; and • explain how insulin and glucagon regulate blood glucose levels and help maintain homeostasis in the body.
54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]	Students are expected to research and summarize an endocrine-related disorder or disease of interest (Refer to previous elaboration on p. 106) and add their summary to their portfolio. **Attitude** Encourage students to use factual information and rational explanations when analyzing and evaluating. [GCO 4] **Sample Performance Indicator** Create a flow chart to explain how the human body maintains homeostasis of blood glucose levels.

The Human Endocrine System and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Ask students to write down key words that they associate with the endocrine system to assess their prior knowledge.

Students may

- Engage in the *Modern Stress* Launch Lab (*NL Biology*, p. 375) to monitor a body change that occurs in response to a stressful situation.

Connection

Teachers may

- Revisit the use of a pan-balance or metre stick balanced on a fulcrum-like object as a model of homoeostasis to help students visualize what is happening when hormone levels are higher or lower than normal during stages of the feedback cycle.
- Present images sourced from the Internet to help students visualize the structures of the endocrine system.
- Distinguish between tropic and non-tropic hormones.
- Discuss endocrine disruptors as an example of how environmental factors impact homeostasis within an organism (See *NL Biology*, p. 383).

Students may

- Create a personal glossary of endocrine system terminology.
- Explain the function of hormones in the endocrine system.
- View prepared slides of endocrine system structures.
- Complete Investigation 10.B (*NL Biology*, p. 389) to evaluate the use of hormone therapy in the treatment of humans.
- Explain how the thyroid gland is like a metabolic thermostat.
- Analyze and interpret Figure 10.25 (*NL Biology*, p. 399).
- Create a list of endocrine system disorders and diseases.

Consolidation

Students may

- Create flow charts to explain homeostatic phenomena (e.g., ACTH regulation) and identify feedback mechanisms involved.
- Analyze the sleep/wake cycle and the feedback mechanism that controls the hormone melatonin.
- Compare and contrast how the endocrine system regulates short- and long-term stress responses.
- Analyze blood glucose data (Activity 10.1, *NL Biology*, p. 400) to identify healthy patterns and infer the effects of diabetes.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 91-110

NL Biology (SR)

- pp. 374-407

The Human Circulatory System and Homeostasis

Outcomes

Students will be expected to

10.0 select and use apparatus and materials safely [GCO 2]

11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials [GCO 2]

24.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]

Focus for Learning

Students are expected to dissect and observe the features of a mammalian heart. Investigation 7.A (*NL Biology*, pp. 282-283) provides a sample procedure for dissection. Students' safe use of dissection tools and personal protective equipment, proper handling and disposal of specimens, and cooperation within groups should be assessed. Refer to the *Integrated Skills* unit for elaboration of these skills. Note, virtual dissection or video may be used as an alternative for individual students who object to dissection or have cultural or ethical concerns.

Students should

- describe the main functions of the human circulatory system and explain how these functions help maintain homeostasis;
- describe the structure of the heart (i.e., atria, ventricles, septum, vena cava, pulmonary artery, pulmonary vein, aorta, valves);
- describe the structure and function of blood vessels (i.e., arteries, veins, capillaries);
- describe the action of the heart and the circulation of blood through the pulmonary, systemic, and coronary pathways;
- explain how an electrical signal triggers the pumping of the heart;
- explain the function of plasma, red blood cells, white blood cells, and platelets;
- explain the role of blood and blood vessels in regulating body temperature, including vasoconstriction and vasodilation;
- explain the role of capillaries in energy and material exchange; and
- identify the clotting of blood as a positive feedback mechanism.

Attitude

Encourage students to work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Sample Performance Indicator

Imagine you are a blood cell. Kinesthetically travel through the pulmonary, systemic, and coronary pathways, orally describing the structure and dynamics of the heart and vessels as you circulate.

The Human Circulatory System and Homeostasis

Sample Teaching and Assessment Strategies

Remind students of all dissection safety precautions. Extreme care must be taken when using dissection instruments, particularly scalpels, and necessary personal protective equipment (i.e., gloves, goggles, lab coats) should be worn at all times.

Activation

Teachers may

- Ask students who have completed first aid or cardiopulmonary resuscitation (CPR) courses to share what they learned.
- Show videos sourced from the Internet to introduce the system.

Students may

- Engage in the *Listen to Your Heart* Launch Lab (*NL Biology*, p. 277) to become familiar with the anatomy of the circulatory system and technology used to monitor the heart.

Connection

Teachers may

- Use virtual heart dissection images to familiarize students with dissection procedures before they engage in actual dissections.

Students may

- Create a personal glossary of circulatory system terminology.
- Describe how the structure of arteries, veins, and capillaries relates to their function.
- View prepared slides of circulatory system structures, including blood.
- Label and colour (oxygenated and deoxygenated) diagrams of the circulatory system and heart and trace the path of blood flow.
- Relate the sound of a beating heart to the action of heart valves.
- Investigate eligibility criteria to donate blood.

Consolidation

Students may

- Make a summary table of the function of the various parts of the circulatory system.
- Analyze Figure 7.9 (*NL Biology*, p. 286) describing the circulation of blood through the pulmonary, systemic, and coronary pathways.
- Explain how vasoconstriction and vasodilation help to regulate body temperature.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 35-50
- Assessment Checklist 3 Performance Task Self-Assessment
- Assessment Checklist 4 Performance Task Group Assessment

NL Biology (SR)

- pp. 276-305

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/teaching-and-learning-strategies.html
  - Dissection Lab

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Circulatory System and Homeostasis

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

3.0 design an experiment identifying and controlling major variables [GCO 2]

19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

56.0 explain the importance of fitness to the maintenance of homeostasis [GCO 3]

57.0 analyze society's influence on scientific and technological endeavours [GCO 1]

Focus for Learning

Students are expected to design and conduct a rigorous experiment to determine how blood pressure changes with exposure to a factor selected for investigation. Heart rate may be included. Investigation 7.B (*NL Biology*, p. 288) provides a sample experimental plan.

This student designed and conducted experiment provides an opportunity to assess a significant number of skill outcomes. In addition to designing an experiment (SCO 3.0) and providing a statement that answers the question (SCO 19.0), teachers may assess students' abilities to

- identify questions to investigate (2.0);
- formulate operational definitions of variables (4.0);
- develop and implement appropriate sampling procedures (5.0);
- carry out procedures controlling variables and adapting or extending procedures where required (6.0);
- estimate quantities and compile and organize data (7.0, 8.0);
- compile and display evidence and interpret patterns, trends and relationships in data (13.0, 15.0);
- evaluate the relevance, reliability, and adequacy of data and data collection methods (17.0);
- identify and explain sources of error and uncertainty in measurement (18.0);
- select and use appropriate modes of representation to communicate ideas, plans, and results (21.0); and
- work cooperatively and evaluate group processes (24.0, 25.0).

Refer to the *Integrated Skills* unit for elaboration of these skills.

Students should explore cardiovascular fitness and explain the importance of fitness to maintaining homeostasis. A low resting heart rate is considered an indicator of cardiovascular fitness.

Discussions about the importance of cardiovascular fitness provide an opportunity to analyze society's influence on science and technology. More specifically, students should examine how the value society places on cardiovascular fitness influences the scientific research being funded and the technologies being developed.

Attitude

Encourage students to value processes for drawing conclusions. [GCO 4]

Sample Performance Indicator

Prepare a formal lab report for their personally designed and conducted experiment to determine how blood pressure is affected by a factor selected for investigation.

The Human Circulatory System and Homeostasis

Sample Teaching and Assessment Strategies

Students will require instruction in the proper use of a digital sphygmomanometer, or a manual sphygmomanometer with a stethoscope, to measure blood pressure.

Teachers should approve student designed experiments before they are carried out. All experiments should be low risk for human participation.

Connection

Teachers may

- Ask students to recall heart rate investigations carried out in previous grade levels and identify factors of influence.
- Discuss the connection between most cardiovascular problems and lifestyle choices.

Students may

- Use Assessment Checklist 1 *Designing an Experiment* (*NL Biology* TR) to guide the development of their experiment.
- Use Assessment Checklist 2 *Laboratory Report* (*NL Biology* TR) to guide preparation of their formal lab report.
- Identify personal technologies that can be used to measure cardiovascular health and fitness.

Consolidation

Teachers may

- Facilitate investigations to determine the effect of selected factors on the heart rate of live Daphnia. Ensure ethical treatment of live animals.

Students may

- Conduct an Internet search to identify current research and technology related to cardiovascular health and fitness.
- Complete Activity 7.1 (*NL Biology*, p. 290) to identify and analyze technological solutions associated with cardiovascular disease.
- Present the findings of their experimental research to an authentic audience (e.g., classmates, parents).
- Design and conduct an experiment to determine how long it takes for their heart rate to return to its resting rate after exercise. How quickly heart rate returns to normal is a measure of cardiovascular fitness.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 35-50
- Assessment Checklist 1 Designing an Experiment
- Assessment Checklist 2 Laboratory Report

NL Biology (SR)

- pp. 276-305

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Circulatory System and Homeostasis

Outcomes	Focus for Learning
Students will be expected to	
58.0 describe the impact of environmental factors on homeostasis [GCO 3]	Factors in the external environment that affect an organism's homeostasis are widely considered to be physical, chemical, or biological stresses. The nervous, endocrine, and circulatory/immune systems play significant roles in responding to these stresses and maintaining homeostasis. Note, SCO 58.0 will be readdressed in the respiratory and digestive system sections, with reference to allergic responses. Teachers may, however, choose to address allergic responses now, in conjunction with immune responses. Students should • describe how the circulatory system protects against pathogens and toxic substances introduced into the body; • describe the role of white blood cells in the body's immune response, include macrophages, lymphocytes, and antibodies; • explain why an immune response helps to maintain homeostasis;
41.0 analyze why and how a particular technology was developed and improved over time [GCO 1]	• analyze why and how technologies such as antibiotics and vaccinations were developed and improved over time; and • examine the important role vaccinations play in maintaining a healthy society.
32.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology [GCO 1]	Discussions about antibiotic use and vaccinations provide an opportunity to address aspects of the nature of technology and the relationship between science, technology, and society: • Technology is developed to meet society's needs and improve quality of life. • Technologies change over time. • Introducing technology has both intended and unintended consequences. • Societies make decisions about technologies based on the needs of the society and on the risks and benefits of technology. • Cultural beliefs and practices and societal norms can affect decisions about the use and development of technologies.
54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]	Students are expected to research and summarize a circulatory system-related disorder or disease of interest (Refer to previous elaboration on p. 106) and add their summary to their portfolio. **Attitude** Encourage students to appreciate that the applications of science and technology can raise ethical dilemmas. [GCO 4] **Sample Performance Indicator** Analyze and respond to a vaccination-related article sourced from the Internet.

The Human Circulatory System and Homeostasis

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Show videos sourced from the Internet to introduce the immune system and examine the body's immune response.
- Discuss the human immune system's lines of defense.
- Discuss innate and acquired immunity and the role of macrophages, lymphocytes, and antibodies.
- Provide information and resources about immunization in Canada, including a list of available vaccines.
- Discuss what is meant by herd immunity.

Students may

- Add immune-related terminology to their personal glossary of circulatory system terminology.
- Search for and examine timelines depicting the history of vaccines or immunization.
- Research how penicillin was discovered and discuss the quote "In the fields of observation chance favours only the prepared mind".
- Describe how antibiotics work in concert with the immune system.
- Collaboratively create a list of cardiovascular and blood disorders and diseases.

Consolidation

Teachers may

- Discuss the issues of antibiotic overuse and resistance.
- Discuss mandatory vaccination policies.
- Invite public health personnel to present current information on vaccinations and related topics.

Students may

- Explain how a child vaccinated for measles is protected when they come in contact with the virus.
- Research and analyze the risks and benefits to society of widespread use of antibacterial soaps and other products.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 35-50

NL Biology (SR)

- pp. 276-305

The Human Respiratory System and Homeostasis

Outcomes	Focus for Learning
Students will be expected to	
27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1] *50.0 explain how systems help maintain homeostasis [GCO 3]*	Students should • describe the function of the human respiratory system in maintaining homeostasis; • describe the structures of the upper and lower respiratory tracts and their functions (i.e., nasal cavity, pharynx, epiglottis, trachea, bronchi, bronchioles, alveoli, lung, diaphragm); • explain the mechanics of breathing, and • distinguish among tidal volume, inspiratory reserve volume, expiratory reserve volume, vital capacity, and residual volume.
8.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]	Students are expected to measure their respiratory volume using a spirometer. Investigation 6.B (*NL Biology,* p. 260) provides a sample procedure. Students will require instruction in the proper use of a spirometer to measure respiratory volume and calculate vital capacity. In addition to skill outcome 8.0, teachers may assess SCOs 5.0, 6.0, 7.0, 13.0, 15.0, 19.0, and 25.0. Refer to the *Integrated Skills* unit for elaboration of these skills.
56.0 explain the importance of fitness to the maintenance of homeostasis [GCO 3]	The importance of fitness to respiratory health should be discussed. Students should recognize that vital capacity can be used as a measure of fitness (i.e., the extent to which an individual can ventilate their lung surface).
58.0 describe the impact of environmental factors on homeostasis [GCO 3]	Factors in the external environment, such as cigarette smoke, vaping fumes, allergens (e.g., dust, mould) and other airborne chemicals, are further examples of environmental stresses that affect homeostasis. Students should • describe the effects of these environmental factors on the respiratory and other body systems, and • describe the respiratory system's allergic response.
54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]	Students are expected to research and summarize a respiratory system-related disorder or disease of interest (Refer to previous elaboration on p. 106) and add their summary to their portfolio.

Sample Performance Indicator

1. A patient experiences symptoms including a tightening of muscles surrounding the upper respiratory tract, swelling and inflammation of the tract, and an increased production of mucus. Explain how these symptoms might affect the patient's breathing and homeostasis of their respiratory system and other body systems.
2. Create an infographic to communicate findings of research on the effects of an environmental stress (e.g., cigarette smoke, vaping fumes, allergen, airborne chemical) on respiratory health and maintenance of homeostasis in the body.

The Human Respiratory System and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Show videos sourced from the Internet to introduce the system.

Students may

- Engage in the *Modelling Your Lungs* Launch Lab (*NL Biology*, p. 251) to examine or build a functioning model of the human respiratory system and to review the mechanics of breathing.

Connection

Teachers may

- Distinguish between breathing and respiration.
- Use models, such as clusters of grapes and inverted birch trees, to explain structures of the human respiratory system.

Students may

- Create a personal glossary of respiratory system terminology.
- View prepared slides of respiratory system structures.
- Analyze Figure 6.2 (*NL Biology,* p. 253) and describe the functions of the labelled structures.
- Analyze and interpret spirographs.
- Carry out Investigation 6.A *The Alveoli Area Advantage* (*NL Biology*, p. 259) to describe the structure and dynamics of the system and the mechanisms of gas exchange and respiration.
- Carry out Investigation 6.C *Breathing Rate and Oxygen Demand* (*NL Biology*, p. 261) to determine the effect of exercise on the circulatory and respiratory systems.
- Collaboratively create a list of respiratory system disorders and diseases.

Consolidation

Students may

- Use a flow chart to explain the mechanics of breathing.
- Present research findings on the effects of cigarette smoke, vaping fumes, allergens, or other airborne chemicals to an authentic audience.

Extension

Students may

- Design and carry out an experiment to determine the effect of factors on vital capacity.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 20-34

NL Biology (SR)

- pp. 250-275

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Digestive System and Homeostasis

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

59.0 explain the role of enzymes in metabolism [GCO 3]

51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]

3.0 design an experiment identifying and controlling major variables [GCO 2]

11.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials [GCO 2]

13.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]

Focus for Learning

Students should

- describe the structures of the human digestive system and their functions (i.e., mouth, salivary gland, esophagus, stomach, small intestine, liver, pancreas, gall bladder, large intestine, rectum, anus);
- describe the mechanical and chemical processing of food through the digestive system and into the blood stream;
- describe the digestion and absorption of carbohydrates, proteins, and lipids;
- explain the role of salivary amylase, carbohydrases, pepsin and hydrochloric acid, peptidases, bile, lipases, and bicarbonate in metabolism; and
- explain how the nervous and endocrine systems coordinate the activities of the digestive tract, and describe the feedback mechanisms of gastrin, secretin, and cholecystokinin (CCK).

Students are expected to design and conduct experiments to investigate the influence of temperature and pH on enzyme activity. Investigation 3.B (*NL Biology,* pp. 142-144) provides a suggested experimental plan to investigate the activity of the enzyme catalase.

These student-designed and conducted experiments provide a significant opportunity to assess skill outcomes. In addition to assessing students' abilities to design experiments (SCO 3.0), safely handle and dispose of lab materials (SCO 11.0), display evidence (SCO 13.0), and draw conclusions (SCO 19.0), teachers may assess their abilities to

- operationally define variables (4.0),
- carry out controlled procedures (6.0)
- compile and organize data to facilitate interpretation (8.0),
- evaluate the reliability and adequacy of data and methods (17.0),
- explain sources of error and uncertainty in measurements (18.0),
- communicate plans, ideas, and results (21.0), and
- work cooperatively and evaluate group processes (24.0, 25.0).

Refer to the *Integrated Skills* unit for elaboration of these skills.

Sample Performance Indicators

1. Create a physical model of the human digestive system and orally describe the mechanical and chemical processes a bolus of food experiences as it moves through the digestive system and into the blood stream.
2. Prepare a formal lab report for your personally designed and conducted experiments to determine how temperature and pH affect enzyme activity.

The Human Digestive System and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Show videos sourced from the Internet to introduce the system and show how food is digested.
- Review carbohydrates, lipids, proteins, and their functions.

Students may

- Engage in the launch lab, *Technology Provides Tools to Learn More* (*NL Biology*, p. 217), to identify organs of the human digestive system.

Connection

Teachers may

- Present images sourced from the Internet to help students visualize the structures of the digestive system.
- Describe the tube-within-a-tube body structure of the human body where the inner tube is the digestive system.
- Divide students such that half the class investigates how temperature affects enzyme activity and the other half investigates how pH affects enzyme activity. Ask students to share their findings with classmates.
- Provide a list of materials available for students to use when designing and carrying out their experiment on enzyme activity.

Students may

- Create a personal glossary of digestive system terminology.
- Design and construct a working model to demonstrate peristalsis.
- View prepared slides of digestive system structures.
- Complete Activity 5.3 (*NL Biology*, p. 225), analyzing historical data to determine observations and results.

Consolidation

Students may

- Using index cards, create a flowchart that traces the movement of a bolus of food through the various structures of the digestive system. Indicate the structure on one side of the index card and explain the digestive processes involved within the structure on the other side of the card.
- Create a foldable to explain the chemical digestion of carbohydrates, lipids, and proteins.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 5-19
- Assessment Checklist 1 Designing an Experiment
- Assessment Checklist 2 Laboratory Report

NL Biology (SR)

- pp. 216-249

Teaching and Learning Strategies

- www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/teaching-and-learning-strategies.html
  - Enzyme Activity Lab

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

The Human Digestive System and Homeostasis

Outcomes

Students will be expected to

60.0 explain the importance of nutrition to the maintenance of homeostasis [GCO 3]

54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]

57.0 analyze society's influence on scientific and technological endeavours [GCO 1]

22.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information [GCO 2]

Focus for Learning

Students should

- recognize and discuss the relationship between health and nutritional decisions, including allergic responses to foods;
- understand the role of vitamins and minerals in maintaining health and homeostasis; and
- research and summarize a digestive system-related disorder or disease of interest (Refer to previous elaboration on p. 106) and add their summary to their portfolio.

The topic of nutrition provides another opportunity to address the social context of science and technology, specifically how society influences scientific research and the development of products and processes related to diet and nutrition.

Students should investigate different popular diets (e.g., Paleo, raw food, gluten-free, Mediterranean, ketogenic) and their possible health benefits. Information examined should include

- foods that are part of the diet and those that are restricted;
- proposed health benefits and possible side effects; and
- medical reasons for recommending or not recommending the diet.

The importance of scientific research to support claims made about diets should be discussed. Students should evaluate the reliability of each information source examined.

Refer to the *Integrated Skills* unit for elaboration of SCO 22.0.

Attitude

Encourage students to

- consider further studies and careers in science- and technology-related fields; and
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations. [GCO 4]

Sample Performance Indicator

Infer how a particular diet might affect the homeostasis of a body system.

The Human Digestive System and Homeostasis

Sample Teaching and Assessment Strategies

Connection

Teachers may

- Facilitate a discussion regarding the effects of widespread use of protein powders or other supplements.

Students may

- Collaboratively create a list of digestive system disorders and diseases.
- Examine Table 5.4 (*NL Biology*, p. 237) to identify the function and possible sources of selected vitamins and minerals.
- Examine different food labels and compare their nutritional information.
- Use grocery store flyers to evaluate and compare the cost of foods that would be considered part of a healthy diet with those that would not. Discuss the social implications of your findings.

Consolidation

Students may

- Investigate the availability of nutritional supplements (i.e., vitamins and minerals) at a local pharmacy. How many different forms of a supplement are available? How do they differ? Why might the cost of supplements vary? What is the bioavailability of different supplements? Is taking nutritional supplements necessary?
- Compare Canada's food guide with different popular diets.
- Examine research on which revisions to Canada's food guide were made.
- Complete the STSE case study *Eating Well: Assessing the Benefits of Functional Foods* (*NL Biology* , pp. 242-243) and debate whether they would support a school ban on the sale of conventional snack food in favour of functional foods.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 14-17

NL Biology (SR)

- pp. 236-246

The Human Excretory System and Homeostasis

Outcomes

Students will be expected to

27.0 analyze natural systems to interpret and explain their structure and dynamics [GCO 1]

50.0 explain how systems help maintain homeostasis [GCO 3]

51.0 analyze homeostatic phenomena to identify the feedback mechanisms involved [GCO 3]

16.0 compare theoretical and empirical values and account for discrepancies [GCO 2]

54.0 evaluate the impact of disorders and diseases on homeostasis [GCO 3]

Focus for Learning

Students should

- identify the main structures and functions of the human excretory system (i.e., kidneys, ureters, bladder, urethra);
- identify how the lungs, skin, and liver contribute to the excretory function;
- identify the structures of the nephron (i.e., Bowman's capsule, glomerulus, proximal tubule, loop of Henle, distal tubule, and collecting duct) and their functions;
- explain the processes involved in urine formation and maintaining the composition of blood plasma (i.e., glomerular filtration, tubular reabsorption, tubular secretion, water reabsorption); and
- describe how the kidneys help maintain homeostasis, and the feedback mechanisms involved, with respect to water (i.e., ADH) and ions (i.e., aldosterone).

Analyzing the physical and chemical composition of urine enables reasoned inferences and hypotheses to be made about a person's health. Students are expected to engage in an investigation to collect and interpret data in the analysis of simulated urine. Investigation 8.B (*NL Biology,* pp. 322-323) provides a suggested procedure that includes tests for colour, odour, clarity, pH, and the presence of protein and glucose.

In addition to SCO 16.0 (comparing collected values to theoretical values), teachers may assess skill outcomes 7.0, 8.0, 10.0, 11.0, 17.0, 19.0, 22.0, 24.0, and 25.0. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

Students should research and summarize an excretory-related disorder or disease of interest (Refer to prior elaboration on p. 106) and add their summary to their portfolio.

Sample Performance Indicator

Using index cards, create a flowchart that traces the flow of urine through the various structures in the excretory system. Indicate the structure on one side of the index card and explain the urine formation processes involved within the structure on the other side of the card.

The Human Excretory System and Homeostasis

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Show videos sourced from the Internet to introduce the system.
- Review the processes of diffusion, osmosis, and active transport.

Connection

Teachers may

- Describe the kidney as having three regions. The renal cortex, renal medulla, and renal pelvis.
- Present images sourced from the Internet to help students visualize the structure of the excretory system, kidney, and nephron.
- Discuss the importance of urinalysis in diagnosing medical conditions, disorders, and diseases.

Students may

- Create a personal glossary of excretory system terminology.
- Label structures in images of the excretory system, kidney, and nephron.
- Make a summary table of the functions of the various structures of the nephron.
- View prepared slides of excretory system structures.
- Collaboratively create a list of excretory system disorders and diseases.

Consolidation

Students may

- Dissect and observe the features of a mammalian kidney (Investigation 8.A, *NL Biology*, p. 311).
- Describe how the excretion of metabolic waste connects to the digestive, respiratory, and circulatory systems.
- Create a four tab foldable to review the processes involved in urine formation and regulation of blood plasma composition (i.e., glomerular filtration, tubular reabsorption, tubular secretion, water reabsorption).
- Create a nephron puzzle. Cut a large image of a nephron into pieces and annotate the back of each piece with the urine formation processes involved at that location.
- In an illustration, represent how ADH controls the amount of water excreted or reabsorbed in urine.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 pp. 51-65

NL Biology (SR)

- pp. 306-331

Suggested

Resource Links: www.k12pl.nl.ca/curr/10-12/science/science-courses/biology-2201/resource-links.html

- Science supply companies (websites)

Social Context of Science and Technology

Outcomes

Students will be expected to

61.0 debate the merits of funding specific scientific or technological endeavours [GCO 1]

62.0 construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives [GCO 1]

36.0 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability [GCO 1]

23.0 identify multiple perspectives that influence a science-related decision or issue [GCO 2]

24.0 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise [GCO 2]

25.0 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task [GCO 2]

Focus for Learning

SCOs 61.0 and 62.0 can be addressed using the STSE case study *Make a Decision* (*NL Biology,* p. 326).

Students should, in small collaborative groups,

- investigate current medical treatments and research in dialysis technology, human kidney transplants, and bioartificial kidney transplants;
- establish and apply criteria to evaluate the merits of funding improvements in dialysis technology versus kidney transplants, either human or bioartificial;
- decide which treatment area to recommend for funding; and
- construct arguments to support and defend the decision, using research evidence.

Research about kidney transplants should be extended to address issues related to patient eligibility and priority, organ procurement, organ allocation, and donor registration and consent. Students should collaboratively debate ethical questions arising as a consequence of these issues and propose a course of action. For example:

- Should behaviours such as smoking, addiction, drug abuse, or previous noncompliance with medical regimens influence decisions regarding eligibility for organ transplant?
- Should factors such as the cause of organ failure, presence of other systemic diseases, or first versus repeat transplants be considered in decisions regarding eligibility or priority?
- Should available organs be allocated on the basis of medical urgency, the likelihood of finding a transplant in future, projected survival, time on the wait list, patient age, or geography?
- Should living organ donors be compensated for their donation?
- Should organ donation require opt in or opt out consent?
- Should a patient's priority on a transplant wait list increase if a living relative donates an organ to a transplant pool?

Refer to the *Integrated Skills* Unit for elaboration of these skill SCOs.

Attitudes

Encourage students to

- appreciate that the applications of science and technology can raise ethical dilemmas; and
- project the personal, social, and environmental consequences of proposed action. [GCO 4]

Sample Performance Indicator

Construct arguments for and against an issue related to transplant patient priority, allocation of organs, or donor consent.

Social Context of Science and Technology

Sample Teaching and Assessment Strategies

Prior to engaging students in a class debate, teachers should establish debate rules and expectations for respectful listening and communication.

Connection

Teachers may

- Demonstrate, using a dialysis tube, how dialysis works.
- Differentiate between hemodialysis and peritoneal dialysis.
- Invite guest speakers to present to class on topics related to kidney disorders and diseases, dialysis, and organ transplants.
- Discuss how medical research and development of treatment technology are funded.
- Present images of decision making processes sourced from the Internet.
- Discuss how consent for organ donation is indicated in our province.

Students may

- Collaboratively discuss criteria to evaluate the merits of medical treatments and research.
- Differentiate between the terms treatment and cure.

Consolidation

Teachers may

- Facilitate a discussion to elicit ethical questions arising from the issue of organ donation and transplantation.

Students may

- Debate the merits of funding scientific or technological endeavours related to other systems:
  - Should brain imaging technology research or paralysis-related stem cell research be funded?
  - Should improvements in personal glucose monitoring technology, diabetic diets research, or research into insulin-producing cell transplants be funded?
- Debate the
  - age of consent to register as an organ donor,
  - use of embryonic stem cells to grow bioartificial organs for transplant, and
  - transplantation of organs or tissues from transgenic animals.

Resources and Notes

Authorized

NL Biology (TR)

- Unit 3 p. 60
- Assessment Checklist 3 Performance Task Self-Assessment
- Assessment Checklist 4 Performance Task Group Assessment
- Assessment Checklist 7 Oral Presentation Skills

NL Biology (SR)

- pp. 323-326

Appendix A:
Scientific Conventions

Scientific Conventions

Scientific information should be communicated according to accepted scientific conventions. These conventions include significant figures, formulas, units, and data (graphs, diagrams, tables). The Department of Education and Early Childhood Development follows the conventions below for public exams.

Significant Figures

Any number used in a calculation should contain only figures that are considered reliable; otherwise, time and effort are wasted. Figures that are considered reliable are called significant figures. Scientific calculations generally involve numbers representing actual measurements. In a measurement, significant figures in a number consist of:

Figures (digits) definitely known + one estimated figure (digit)

They are often expressed as “all of the digits known for certain plus one that is uncertain”.

Significant Figure Rules

1. All non-zero digits are significant.
2. Zero rules
   - Trailing zeros (i.e., at the end to the right) of a measurement may or may not be significant:
     - If it represents a measured quantity, it is significant (e.g., 25.0 cm - the zero is significant; the decimal is clearly indicated).
     - If immediately to the left of the decimal, it is not significant (e.g., 250 cm or 2500 cm - zeros are not significant; both have 2 significant digits as there is uncertainty whether zeros are measured values).
     - If the trailing zeros in 250 cm and 2500 cm are significant, the measurements must be written in scientific notation (e.g., 2.50×10^2 cm or 2.500×10^3 cm - zeros are significant). Note, scientific notation is not part of the K-12 mathematics program.
   - A zero, between two non-zero digits in a measurement, is significant (e.g., 9.04 cm - the zero is significant).
   - Leading zeros (i.e., at the beginning to the left) are never significant (i.e., they do not represent a measured quantity), they merely locate the decimal point (e.g., 0.46 cm and 0.07 kg - the zeros are not significant).
3. Rounding with Significant Figures

   In reporting a calculated measured quantity, rounding an answer to the correct number of significant figures is important if the calculated measurement is to have any meaning. The rules for rounding are listed below.
   - If the figure to be dropped is less than 5, eliminate it:
     - rounding 39.949 L to three significant figures results in 39.9 L
     - rounding 40.0 g to two significant figures results in 4.0×10^1 g
   - If the figure to be dropped is greater than or equal to 5, eliminate it and raise the preceding figure by 1:
     - rounding 39.949 L to four significant figures results in 39.95 L
     - rounding 39.949 L to two significant figures results in 4.0×10^1 L

4. Multiplying and Dividing with Significant Figures

   In determining the number of significant figures in a measurement that is calculated by multiplying or dividing, the measurement with the least number of significant figures should be identified. The final calculated measurement should contain the same number of significant figures as the measurement with the least number of significant figures.

   $$2.1 \text{ cm} \times 3.24 \text{ cm} = 6.8 \text{ cm}^2$$

   Since 2.1 cm contains two significant figures and 3.24 contains three significant figures, the calculated measurement should contain no more than two significant figures.

5. Adding and Subtracting with Significant Figures

   In determining the number of significant figures when adding or subtracting, the final calculation should be rounded to the same precision as the least precise measurement.

   $$42.56 \text{ g} + 39.460 \text{ g} + 4.1 \text{ g} = 86.1 \text{ g}$$

   Since 4.1 g has only one decimal place, the calculated measurement must be rounded to one decimal place.

6. Performing a Series of Calculations with Mixed Operations

   When a series of calculations is performed, it is important to remember that multiplication/division and addition/subtraction are governed by separate significant figure rules. Rounding only occurs at the last step.

   When calculations involve both of these types of operations, the rules must be followed in the same order as the operations. Rounding still only occurs at the last step of the calculation.

   $$\frac{(0.428 + 0.0804)}{0.009800}$$

   The addition is first, 0.428 + 0.0804 = 0.5084. Following the rules for addition/subtraction, the answer should have three significant figures, but rounding is the last step. Therefore, 0.5084 is used in the next step, 0.5084 ÷ 0.009800 = 51.87755. Following the rules for multiplication/addition, the answer should have four significant figures (but rounding is the last step). The sum of the numerator has three significant figures, and the denominator has four, so the final answer is rounded to three significant figures, 51.9.

   In problems requiring multiple calculations (e.g., calculating final velocity and then using that value to calculate time), it is recommended that rounding only occur in the final calculation. Also, to improve accuracy and consistency, an extra digit should be carried in all intermediate calculations. Students may find it helpful to write the extra digit as a subscript (e.g., 39.5_4 [3 significant figures + 1 extra].

7. Calculating with Exact Numbers

   Sometimes numbers used in a calculation are exact rather than approximate. This is true when using defined quantities, including many conversion factors, and when using pure numbers. Pure or defined numbers do not affect the accuracy of a calculation. You may think of them as having an infinite number of significant figures. Calculating with exact numbers is important when dealing with conversions or calculating molar ratios in chemistry.

8. Scientific Constants

   Treat scientific constants as significant digits because they are rounded values (i.e., actual measured or defined values have many decimal places [e.g., the speed of light constant, 3.00×10^8 m/s, is a rounded value based on the defined value, 299 792 458 m/s]).

9. Significant Figures in Logarithms

   When determining the number of significant figures from a logarithm function, only the digits to the right of the decimal should be counted as significant figures.

   - What is the pH of a sample of orange juice that has 2.5×10^{-4} mol/L hydronium ions?
     The measurement 2.5×10^{-4} mol/L has two significant figures. The power of ten indicates where the decimal is located (i.e. 0.00025). The pH of the sample is $-\log(2.5 \times 10^{-4}) = 3.602\,059$. The digit to the left of the decimal is derived from the power of ten, therefore, it is not significant. Only two digits to the right of the decimal are significant. The answer should be recorded as 3.60.
   - What is the hydronium ion concentration of orange juice with pH = 2.25?
     The pH value, 2.25, has two significant figures. The hydronium ion concentration is equal to the antilogs of -2.25. This value is 0.0056234 mol/L, which, when rounded to two significant figures, becomes 0.0056 mol/L or 5.6×10^{-3} mol/L.

Formulas and Units

A constructed response question that requires numerical calculations often uses formulas or equations as the starting point to its solution. Proper use of formulas and units in science indicates a thorough understanding of the logic to solve a problem. For any solution that requires the mathematical manipulation of a formula, the formula should be stated at the beginning, followed by workings that clearly indicate the mathematical computations necessary to find the solution.

For most cases in science, a SI unit follows a measured value because it describes the value. Three exceptions to this are pH, equilibrium constants, and index of refraction. The final answer of a solution for a constructed response question that requires the mathematical manipulation of a formula always has a unit with the value. The workings of a solution that lead to the final answer do not have to show units.

Data

Data is generally presented in the form of graphs, tables, and drawings. When these formats are used several scientific conventions should be followed.

Graphs

Graphs represent relationships between numerical information in a pictorial form. Two kinds of graphs are commonly used in science courses in Newfoundland and Labrador:

- Line graph
  - used to display the relationship between continuous data
  - demonstrates a progression of values or shows how one variable changes in relation to another variable (e.g., growth of a child with age)

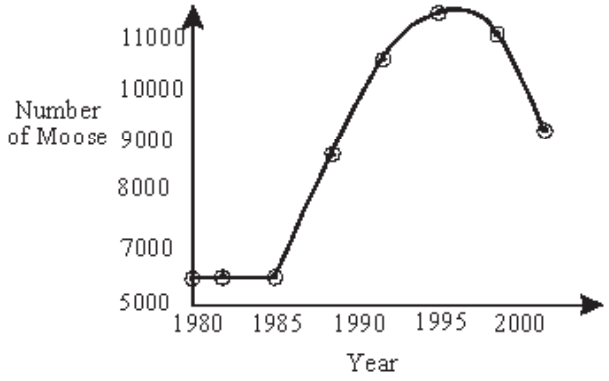
  Note: When equations are graphed, a line or curve of best-fit must be drawn.

- Bar graph
  - used to display discrete or discontinuous data
  - consists of parallel bars whose lengths are proportional to quantities given in a set of data. The items compared are plotted along the horizontal axis and appropriate measurement is plotted along the vertical axis (e.g., populations of different types of protists in a lake).

Graphing Rules

1. The graph must have a title. The title represents the relationship between the two variables.
2. The independent variable is on the horizontal *x*-axis.
3. The dependent variable is on the vertical *y*-axis.
4. Each axis is specifically labelled with units (if applicable) according to the variable it represents and values are provided with equal increments. The scale does not have to be the same on both axes, but the scales must accommodate the ranges of the two variables (i.e., the graph line or series of bars must fill ≥ 75% of the available space).
   Note: It is not necessary that both axes start at zero. See example below.
5. When data are plotted, a circle should be placed around each point to indicate a degree of error. The graph may show exact numbers or a general relationship. A best-fit line or curve must be used in line and scatter graphs.
6. A legend may be used to identify individual lines on a multi-line graph.

Moose Population in Newfoundland and Labrador (1980 - 2000)



Tables

Tables represent numerical or textual information in an organized format. They show how different variables are related to one another by clearly labelling data in a horizontal or vertical format. As with graphs, tables must have a title that represents the relationship between the variables.

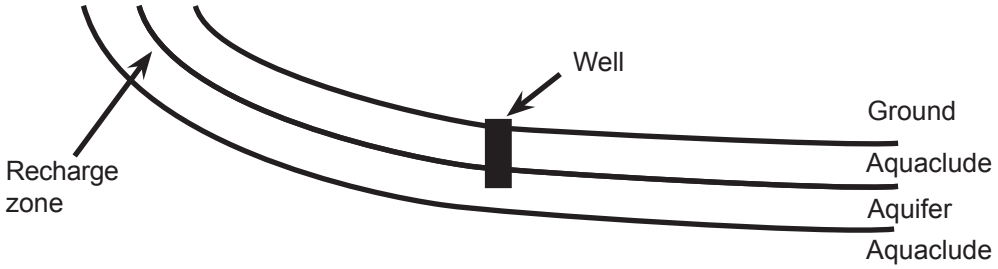
Moose Populations in Newfoundland and Labrador (1980 - 2000)

Year	Number of Moose
1980	5789
1985	6057
1990	8823
1995	11 156
2000	9315

Drawings

Biological drawings that indicate a scale are not required. Diagrams, however, may often be used to aid explanations. These should be clear and properly labelled to indicate important aspects of the diagram.

Geological Conditions Necessary for an Artesian Well



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